IMPACTS ANALYSIS

<u>Habitat Loss and Fragmentation</u>

CHAPTER 5: FIRE

Wildfire is the principle natural disturbance in the sagebrush ecosystem, causing loss and fragmentation of sagebrush habitats. Fire kills most varieties of sagebrush that sage-grouse depend upon and sagebrush habitats take decades to recover from fire (Young and Evans 1989, p. 204; Maier *et al.* 2001, p. 701; Ziegenhagen and Miller 2009, p. 201; Baker 2011, pp. 189–196). Although fire is a natural disturbance process in sagebrush ecosystems, the introduction of invasive annual grasses has altered the fire return interval, particularly in the drier portions of the Great Basin and Columbia Basin (MZs III, IV, V, and VI) and can effectively prevent sagebrush recovery after burning (Miller *et al.* 2011, pp. 179–184). In these areas fire has been identified as a primary factor associated with sage-grouse population declines (Hulet 1983, cited in Connelly *et al.* 2001, p. 973; 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, pp. 424–425; Knick and Hanser 2011, pp. 395, 399–403). Furthermore, the effects of climate change (see ***Climate Change*** chapter) and invasive plants interact to compound and increase the severity of impacts to sage-grouse from the threat of fire (see ***Threat Interactions*** section). Efforts to ameliorate this threat are materializing but we do not know the extent to which these proposed treatments will alleviate the fire and invasives threats to sage-grouse.

American Indians used fire to manipulate the landscape as early as the 1500s (Williams 2004, p. 10). Historic accounts suggest fires set by American Indians occurred primarily in grasslands and adjacent dry forests (Barrett *et al.* 2005, pp. 32–33), not in sagebrush habitats. Lightning ignitions were the primary source of fires in the West prior to European settlement (Barrett *et al.* 2005, pp. 32–33).

A high degree of variability likely occurred in the historic fire patterns in sagebrush ecosystems (Miller and Eddleman 2001, p. 16; Zouhar *et al.* 2008, p. 154; Baker 2011, pp. 189–196; Bukowski and Baker 2013, p. 546). The historical sagebrush systems likely consisted of extensive sagebrush habitat dotted by small areas of grassland. This ecosystem was maintained by long interludes of numerous small fires, accounting for little burned area, punctuated by large fire events that consumed large expanses (Baker 2011, pp. 196–197; Bukowski and Baker 2013, pp. 559–561). This conclusion is evidenced by the fact that most sagebrush species have not developed evolutionary adaptations such as re-sprouting and heat-stimulated seed germination found in other shrub-dominated systems, like chaparral, that are exposed to relatively frequent fire events (Baker 2011, p. 196). Additionally, the spatially discontinuous native Wyoming big sagebrush communities, with widely-spaced shrubs and the low fuel load of the interspersed native annuals and perennial bunchgrasses did not provide sufficient fuels to carry large-scale wildfires (Whisenant 1990, p. 6; D'Antonio and Vitousek 1992, pp. 74–75; Brooks and Pyke 2001, p. 5; Miller and Eddleman 2001, p. 17; Miller *et al.* 2011, p. 167).

Mean fire return interval, or the average number of years between two successive fires, is difficult to quantify in large sagebrush expanses. Because fire kills most sagebrush species, they do not record evidence of prior burns (i.e., fire scars) as do forested systems (Bukowski and Baker 2013, p. 547). As a result, a clear picture of the complex spatial and temporal pattern of historical fire regimes in most sagebrush communities is not available. Widely variable estimates of historical fire return intervals have been described in the literature. Depending on the species of sagebrush and other site-specific characteristics, fire return intervals from 10 to over 300 years have been reported for sagebrush habitats (McArthur 1994, p. 347; Peters and Bunting 1994, p. 33; Miller and Rose 1999, p. 556; Kilpatrick 2000, p. 1; Frost 1998, cited in Connelly *et al.* 2004, p. 7-4; Zouhar *et al.* 2008, p. 154; Baker 2011, pp. 190–197; Bukowski and Baker 2013, entire). In general, mean fire return intervals in low-lying, xeric, Wyoming big sagebrush communities range from over 100 to 350 years, and return intervals decrease to 50 to over 200 years in more mesic areas, in mountain big sagebrush communities 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. 194-195; Miller *et al.* 2011, p. 166; Bukowski and Baker 2013, entire).

The studies cited above typically estimate the historical fire rotation by examining fire scars on woodlands in areas adjacent to sagebrush and required corrections to estimate the reduced fire frequency within the sagebrush versus woodland areas. Other methods used include estimations from macroscopic charcoal in sediments and estimations based on sagebrush recovery time (Baker 2006, pp. 179–181; Miller *et al.* 2011, p. 164–165; Baker 2013, pp. 189–196). All these methods are unable to provide information about fire size or patchiness (Baker 2011, pp. 189–196; Baker 2013, p. 17; Brukowski and Baker 2013, p. 547). To address these unknowns, Bukowski and Baker (2013, entire) reviewed General Land Office (GLO) survey notes on the historical vegetation for over two million hectares (over five million acres). This information supports the hypotheses that historically there were many small fires interspersed with a few large fires in sagebrush ecosystems and that historic fire regimes in sagebrush were primarily controlled by weather or climate rather than local fuel conditions. Historical fire regimes encompassed a range of sizes and intensities. Larger, more intense fires resulted in larger unburned areas and smaller, less intense fires showed a finer-scale mosaic of unburned areas (Bukowski and Baker 2013, p. 558). General Land Office survey data suggest over 80 percent of historic sagebrush landscapes consisted of large, contiguous areas of sagebrush with occasional small interruptions by woodlands, smaller burned areas, areas of sagebrush intermixed with trees, and other shrublands, which is in contrast to the highly fragmented sagebrush landscapes of today (Bukowski and Baker 2013, pp. 559–561).

Current fire regimes were impacted by the influx of Euro-Americans to the western U.S., in the mid- to late 1800s, causing significant changes to the vegetation composition and structure of the sagebrush ecosystem (Chambers *et al.* 2014, p. 3). Improperly managed grazing practices (e.g., timing, duration, and/or intensity) led to a decrease in native perennial grasses and forbs and reduced the abundance of fine fuels (Knapp 1996 in Chambers *et al.* 2014, p. 3; Miller and Eddleman 2001, p. 17; Miller *et al.* 2011, p. 181). Fewer native perennials, in combination with climatic fluctuations favorable to tree regeneration (i.e., increased water use efficiency associated with carbon dioxide fertilization), and recovery from past disturbance, led to an increased abundance of shrubs and trees at mid to high elevations (i.e., more mesic mountain big sagebrush communities), including *J. occidentalis* (western Juniper), *J. osteosperma* (little Utah juniper), and *P. monophylla* (pinyon pine) (Baker 2011, pp. 197–199; Miller *et al.* 2011, pp. 168–169; Chambers *et al.* 2014, p. 3). The change in vegetation and fuel structures initially caused a reduction in fire frequency and size (Chambers *et al.* 2014, p. 3). While the practice of fire suppression has been implicated as a cause of conifer encroachment (Miller *et al.* 2011, p. 167; Davies *et al.* 2011, p. 2574), evidence suggests this activity does not explain the recent expansion of conifers into sagebrush habitats (Vale 1975, p. 33; Baker 2011, p. 199; Bukowski and Baker 2013, p. 560). However, it is likely that all of the factors discussed above played a part in the expansion of conifer woodlands over the last century. Regardless of the cause, conifer encroachment into sagebrush is continuing and is resulting in the loss and fragmentation of sagebrush habitats (see ***Conifer Encroachment*** chapter).

Conversely, at lower elevations (i.e., more xeric Wyoming big sagebrush communities) the decreased competition of native perennial grasses and forbs due to improperly managed grazing has facilitated the invasion of non-native annual grasses, particularly cheatgrass and *Taeniatherum caput-medusae* (medusahead). In many areas, these invasive annuals have created a bed of continuous, fine fuels across the sagebrush landscape (D'Antonio and Vitousek 1992, p. 73; Knapp 1996, p. 45; Brooks *et al.* 2004, entire; Davies *et al.* 2011, p. 2575; Miller *et al.* 2011, p. 167). This increase in fuel load and the lower fuel moisture content of the invasive annual grasses has resulted in more frequent, higher intensity fires (Brooks *et al.* 2004, pp. 679–680). Moreover, invasive annual grasses expand rapidly after fire disturbances, become a readily burnable fuel source, and ultimately lead to a recurrent fire cycle that prevents sagebrush reestablishment (D'Antonio and Vitousek 1992, p. 73; Brooks and Pyke 2001, p. 5; Brooks *et al.* 2004, p. 678; Zouhar *et al.* 2008, p. 41; Eiswerth *et al.* 2009, p. 1324; Miller *et al.* 2011, p. 163–170).

This increase in fine fuels from non-native annual grasses across the sagebrush landscape causes fires in Wyoming big sagebrush communities to burn hotter and more evenly than historic times (Miller *et al.* 2011, p. 167). Hotter and more expansive fires likely burn larger contiguous areas of sagebrush and leave fewer pockets of unburnt sagebrush that would be available to recolonize the burned areas. Historically, fires in sagebrush either left unburnt areas of sagebrush within larger fires or only burned small patches of sagebrush that were easily recolonized by the remaining adjacent sagebrush ecosystem (Bukowski and Baker 2013, p. 558). Factors contributing to the rate of sagebrush recovery include the amount of and distance from unburned habitat, abundance and viability of seed in the seed bank (sagebrush seeds are typically only viable for one to three seasons; hotter fires may render seeds in the seed bank unviable), rate of seed dispersal, and pre- and post-fire weather, which influences seed germination and establishment (Young and Evans 1989, p. 204; Maier *et al.* 2001, p. 701; Ziegenhagen and Miller 2009, p. 201). , Big sagebrush varieties, the most widespread species of sagebrush, can take up to 150 years to reestablish (Braun 1998, p. 147; Cooper *et al.* 2007, p. 13; Lesica *et al.* 2007, p. 264; Baker 2011, p. 195). Furthermore, it is difficult and usually ineffective to restore an area to sagebrush after invasive annual grasses become established (Paysen *et al.* 2000, p. 154; Connelly *et al.* 2004, pp. 7-44 to 7-50; Pyke 2011, pp. 544–545; Chambers *et al.* 2014, entire). The cycle of fire disturbance and subsequent invasion of annual grasses, which increases wildfire and annual grass invasion risks, converts high-diversity native communities into low-diversity communities dominated by invasive plants that are unsuitable for sage-grouse.

Recent fire rotation calculated and compared to estimates of historical fire rotations, suggests that increased fire rotations since 1980 are presumably outside the historic range of variability and far shorter in floristic regions where Wyoming big sagebrush is common (Baker 2011, entire). This analysis included MZs III, IV, V, and VI, all of which have extensive invasions of annual grasses (Baker 2011, entire). Modern fire rotation in mountain big sagebrush is similar to, or slightly shorter than, previous fire rotation estimates and historical fire rotations (Baker 2013, pp. 16–17; Bukowski and Baker 2013, p. 558). However, the time frame of fire data examined by may not be long enough to detect trend relative to the long historical fire cycles of sagebrush ecosystems (Baker 2013, p. 17; Bukowski and Baker 2013, p. 558).

In addition to wildfires occurring in sagebrush habitat throughout the range of sage-grouse, land managers use prescribed fire to obtain desired management objectives for a variety of wildlife species and domestic livestock. However, the efficacy of such treatments in sagebrush habitats to enhance sage-grouse populations has been questioned (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 of prescribed fire is the loss and possible fragmentation of sage-grouse habitat (Beck *et al.* 2009, p. 400). However, prescribed fire treatments reduces fire risk in the presence of housing developments or intact expanses of sagebrush habitat, and in these instances, benefits may be realized. Land management agencies will likely continue to use prescribed fire and other methods to treat sagebrush in the future.

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 annual grasses, the negative aspects of this approach outweigh the positive (Baker 2011, p. 201). Fire treatments designed to thin or reduce sagebrush, with its potential negative effects, would not be as beneficial to the species as efforts made to expand areas of contiguous sagebrush. Likewise, using fire to remove trees in sagebrush habitats is likely inappropriate based on the historical presence of pinyon-juniper in these communities, the possibility of invasive plants establishing after a fire, and mechanical means of removal being available. Pinyon-juniper abundance likely fluctuated over time in response to fire and other environmental conditions, at times occupying approximately 20 percent of the sagebrush landscape historically (Baker 2013, p. 8).

Between 1997 and 2006, more than 370,000 ha (914,000 ac) of public lands were treated with prescribed fire to address management objectives for many different species, mostly in Oregon and Idaho, and an additional 124,200 ha (306,900 ac) were treated mechanically over this same time period, primarily in Utah and Nevada (Knick *et al.* 2011, pp. 224–228). However, these acreages represent all habitat types and thus overestimate negative impacts to sage-grouse and sagebrush ecosystems. Quantifying the amount of sagebrush-specific habitat treatments is difficult as centralized reporting by Federal agencies is not typically categorized by habitat. However, agencies under the Department of the Interior (DOI) report species of special interest, including sage-grouse, which may occur in proximity to a prescribed treatment. Between 2003 and 2008, approximately 133,500 ha (330,000 ac) of sage-grouse habitat were burned by land managers within the DOI, that is approximately 22,000 ha (55,000 ac) annually. In 2012, the BLM treated 12,706 ha (31,398 ac) with prescribed fire. In 2013, they reported 2,348 ha (5,803 ac) treated with prescribed fire for sage-grouse fuels treatments and 9,784 ha (24,177 ac) in 2014 (Havlina *et al.* 2014, p. 22). These acreages do not reflect lands burned by agencies under the USDA (e.g., USFS). Ultimately, the amount of sagebrush habitat treated by land managers appears to represent a relatively minor loss when compared to loss incurred by wildfire. However, in light of the significant habitat loss due to wildfire, and the evidence that suggests these treatments are not beneficial to sage-grouse, the rationale for using such treatments to improve sage-grouse habitat deserves further scrutiny.

Current Impacts

Fire occurring within the range of sage-grouse can cause direct loss of habitat and habitat function due to reduced cover and forage resulting in negative impacts to breeding, feeding, and sheltering opportunities for the species (Call and Maser 1985, p. 17). In addition to the direct habitat loss caused by fire, fire can also create a functional barrier to sage-grouse movements and dispersal, which compounds the influence fire can have on populations and population dynamics (Fischer *et al.* 1997, p. 89). In some cases, fire can isolate sage-grouse populations, thereby increasing their risk of extirpation (Knick and Hanser 2011, p. 395; Wisdom *et al.* 2011, p. 469).

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; Nelle *et al.* 2000, p. 586; Beck *et al.* 2009, p. 400; Johnson *et al.* 2011, p. 424; Knick and Hanser 2011, p. 395). The extent and abundance of sagebrush habitats, the proximity to burned habitat, and the degree of connectivity among sage-grouse groups strongly affects persistence (Aldridge *et al.* 2008, p. 987; Doherty *et al.* 2008, p. 191; Johnson *et al.* 2011, p. 424; Knick and Hanser 2011, pp. 403–404; Wisdom *et al.* 2011, p. 461). Most sagebrush species are killed by fire and require decades to recover. Until habitats fully recover, sage-grouse either partially or completely avoid using of burned areas in xeric Wyoming big sagebrush ecosystems (Fischer *et al.* 1996, p. 196; Connelly *et al.* 2000c, p. 90; Nelle *et al.* 2000, p. 590; Beck *et al.* 2009, p. 9).

Small increases in the amount of burned habitat surrounding a lek influence the probability of lek abandonment (Knick and Hanser 2011, pp. 395–396). Looking at the environmental variables of the percent sagebrush on the landscape, percent burned area, amount of habitat edge, and composite layer representing the "human footprint"; burned area within 54 km (33.6 mi) of a lek and the human footprint within 5 km (3.1 mi) of a lek were the primary factors in predicting lek extirpation (Knick and Hanser 2011, p. 395). Hulet (1983, cited in Connelly *et al.* 2000a, p. 973) documented the loss of leks as a result of fire. Additionally, fire had a negative effect on lek trends in the Snake River Plain (MZ IV) and Southern Great Basin (MZ III) (Johnson *et al.* 2011, p. 422). In southeastern Idaho, sage-grouse populations were generally declining across the entire study area, but declines were more severe in post-fire years (Connelly *et al.* 2000c, p. 93). Consequently, fire can directly cause negative trends on leks and can lead to lek extirpation.

Throughout the breeding season, herbaceous understory vegetation plays a critical role as a source of forage and cover for sage-grouse females and chicks. The response of herbaceous understory vegetation to fire varies with differences in species composition, pre-burn site condition, fire intensity, and pre- and post-fire patterns of precipitation. 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; Gates 1983, cited in Connelly *et al.* 2000c, p. 90; Sime 1991, cited in Connelly *et al.* 2000a, p. 972). In northwestern Nevada, wildfires were effective at changing the mountain big sagebrush community structure from shrub-dominated to one dominated by native grasses and forbs 2 to 3 years post-burn (Davis and Crawford 2014, pp. 3–6). Other studies have demonstrated that burning can promote the recovery of many forb species used by sage-grouse (e.g., McDowell 2000, pp. 45–46; Wrobleski and Kauffman 2003, pp. 85–89; Beck *et al.* 2009, pp. 397–399).

Conversely in Wyoming big sagebrush communities, both Connelly *et al.* (2000c, p. 90) and Fischer *et al.* (1996, p. 196) found that prescribed burns did not improve brood-rearing habitat. Hess and Beck (2012, p. 90) found that prescribed burning reduced the canopy cover and height of Wyoming big sagebrush and the site was not sufficiently recovered to meet sage-grouse breeding habitat needs 19 years after treatment. Hence, fires in these xeric locations may negatively affect brood-rearing habitat (Connelly and Braun 1997, p. 11). Additionally, habitat restoration in these sites can be difficult due to low precipitation, warm soil temperatures, and low resistance to invasive annual grasses (Chambers *et al.* 2014, pp. 20, 24–25).

In general, any short-term flush of understory perennial grasses and forbs within burned sites is lost after 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, 588; Paysen *et al.* 2000, p. 154; Wambolt *et al.* 2001, p. 250). Any short-term benefits gained by releasing understory vegetation from competition with a shrub overstory to produce additional food sources are negated by the loss of overstory sagebrush structure essential to sage-grouse life-history needs. For example, prescribed fires in mountain big sagebrush communities at Hart Mountain National Antelope Refuge caused a short-term increase in forbs, but reduced sagebrush cover, making habitat less suitable for nesting (Rowland and Wisdom 2002, p. 28). Small fires may maintain a suitable habitat mosaic by reducing shrub encroachment and encouraging understory growth. However, without nearby sagebrush cover, the utility of these sites is questionable (Woodward 2006, p. 65; Nelle *et al.* 2009, p. 590). 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. Additionally, Byrne (2002, p. 27) reported avoidance of burned sagebrush habitat by nesting, brood-rearing, and broodless females. Disturbances, such as fire, that remove sagebrush extent and limit habitat availability (cover and forage) appear to influence the probability of local sage-grouse population persistence (Beck *et al.* 2012, p. 452).

In addition to altering plant community structure, fires can influence invertebrate food sources (Schroeder *et al.* 1999, p. 5). Ants (Hymenoptera), grasshoppers (Orthoptera), and beetles (Coleoptera) are an essential component of juvenile sage-grouse diets, especially in the first 3 weeks post-hatch (Johnson and Boyce 1991, p. 90). The effect of fire on insect populations likely varies due to a host of environmental factors. Because few studies have been conducted, and the results of those available vary, the specific magnitude and duration of the effects of fire on insect communities is still uncertain (Pyle 1992, p. 14; Fischer *et al.* 1996, p. 197; Connelly *et al.* 2000c, p. 90; Nelle *et al.* 2000, p. 589–590; Davis and Crawford 2014, p. 5).

Location and Extent

From 1980 to 2007, the number of fires and total area burned increased in all MZs across the occupied range of sage-grouse, with the exception of the Snake River Plain (MZ IV) (Miller *et al.* 2011, pp. 169, 176). Additionally, average fire size increased in the Southern Great Basin (MZ III) during this same time period. However, predicting the amount of habitat that will burn during an ‘‘average” fire year is difficult due to the highly variable nature of fire seasons. The National Interagency Fire Center (NIFC) compiles nationwide annual wildfire statistics for Federal and State agencies. Relatively calm fire years occurred in 1983 and 1988, where approximately 526,000 ha (1.3 million ac) burned. This increased almost 10-fold in 2006, 2007, and 2012, when approximately 3.8 million ha (9.3 million ac) burned each year (NIFC 2015a, p. 1).

The USGS analyzed data from the NIFC on fires within designated sage-grouse PHMAs and GHMAs from 2000 through 2012. Fires occurring during this time frame and within the occupied range, disproportionately affected the Great Basin region (MZ III, IV, and V; data from MZ VI was not included). From 2000 through 2012, 14.2 percent of PHMA and 17.1 percent of GHMA burned in the Snake River Plain (MZ IV). Within the Northern Great Basin (MZ V), 17.5 percent of PHMA and 5.8

percent of GHMA burned. For the Southern Great Basin (MZ III), 1.8 percent of PPH and 5.8 percent of PGH burned (Manier *et al.* 2013).

Evidence of a significant relationship exists between an increase in fire occurrence caused by cheatgrass invasion in the Snake River Plain (MZ IV) and Northern Great Basin (MZ V) since the 1960s (Miller *et al.* 2011, p. 167) and in northern Nevada and eastern Oregon since 1980 (MZs IV and V). The extensive distribution and highly invasive nature of these annual grasses poses increased fire risk and permanent loss of sagebrush habitat; as areas disturbed by fire are highly susceptible to further invasion and ultimately habitat conversion to an altered community state (Miller *et al.* 2011, p. 182). For example, the risk of fire increases from approximately 46 to 100 percent when ground cover of cheatgrass increases from 12 to 45 percent or more (Link *et al.* 2006, p. 116). In the Great Basin (MZs III, IV, and V), approximately 58 percent of sagebrush habitats are at moderate to high risk of cheatgrass invasion during the next 30 years (Suring *et al.* 2005, p. 138). The BLM estimated that approximately 11.9 million ha (29 million ac) of public lands in the western distribution of the sage-grouse (Washington, Oregon, Idaho, Nevada, Utah) were infested with weeds as of 2000 (BLM 2007a, p. 3-28). The most dominant invasive plants consist of grasses in the *Bromus* genus, which represent nearly 70 percent of the total infested area (BLM 2007a, p. 3-28).

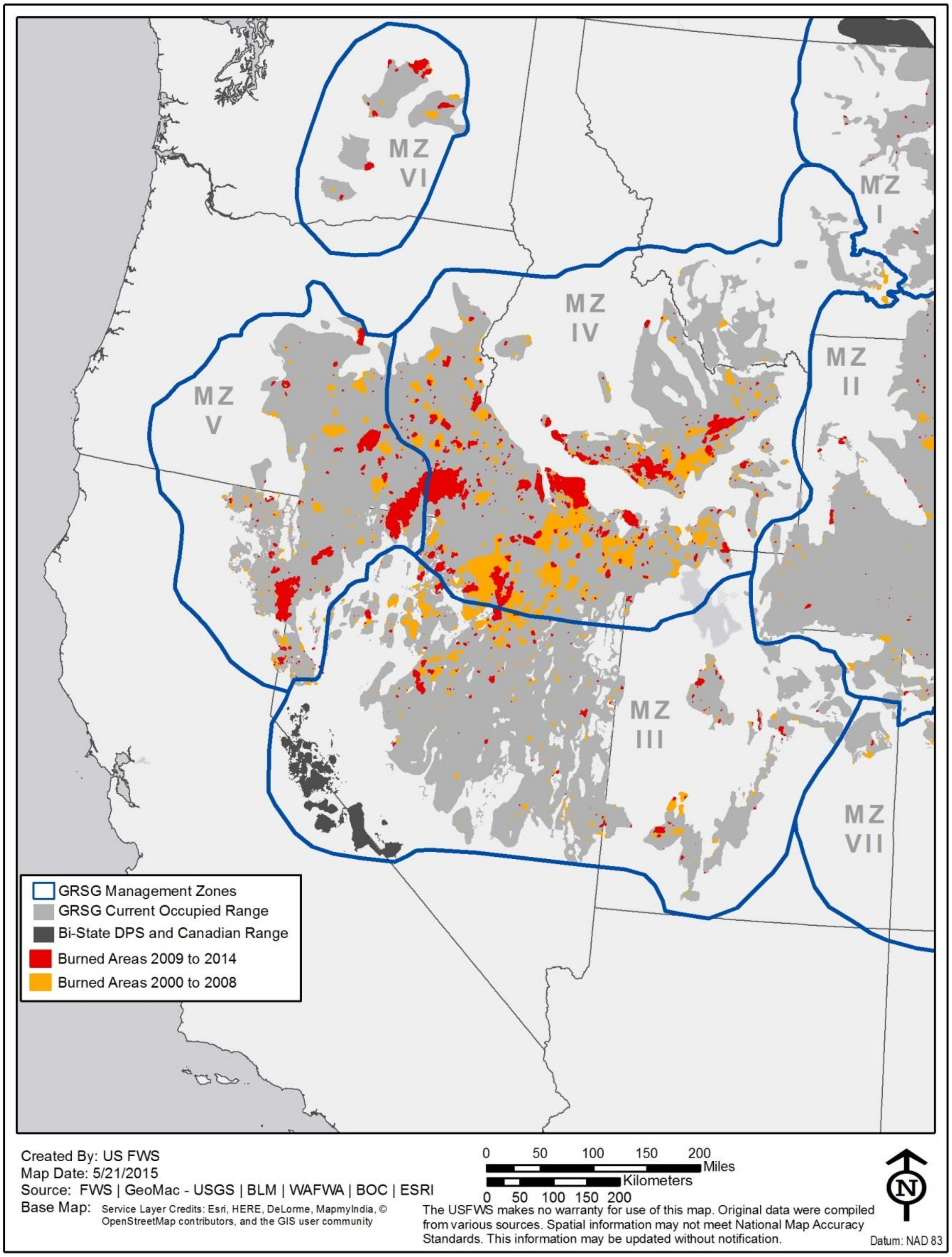

Figure 5-1. Fires from 2000 to 2014 in the Great Basin Management Zones (III, IV, V, VI) in occupied greater sage-grouse range.

[INSERT TABLE]

Table - Acres/Percent of Fires (2009-2014) in Occupied Range by MZ
Table - Acres/Percent of Fires (2009-2014) in Breeding Distribution by MZ
Table - Summation of Popl'n Index in Fires (2009-2014) by MZ

Projected Future Impacts

Our summary of previous research clearly indicates that when sagebrush is lost to wildfire at landscape scales, sage-grouse populations negatively respond (Hulet 1983, cited in Connelly *et al.* 2001, p. 973; 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, pp. 424–425; Knick and Hanser 2011, pp. 395, 399–403). However, strong negative effects within impacted regions, do not necessarily translate to large scale population impacts across vast areas such as the entire Great Basin. We would expect high levels of future impacts to occur if current sage-grouse population centers overlap areas with high probabilities of being lost to fire in the future. Conversely, we would expect future impacts to be low, if current sage-grouse population centers do not overlap areas with high probabilities of being lost to fire. We investigated three potential data sources to understand sage-grouse population exposure to future habitat loss from wildfire: (1) Monitoring Trends in Burn Severity (MTBS); (2) FSim; and (3) the WAFWA Resiliency and Resistance Matrix (R&R).

We did not believe either the MTBS or FSim data sources were adequate to project future fire losses. The MTBS is used to identify national trends in burn severity. However, the MTBS has typically been assessed and mapped operationally for rapid response needs (e.g., to support post-fire stabilization and rehabilitation efforts), thus it does not include spatial predictions of where future fires will occur. Therefore, while useful in understanding the amount and trends in habitat lost per year to fire, MTBS cannot be directly linked to our sage-grouse population of breeding habitat models. The second data source we investigated was FSim. Although FSim does provide spatial estimates of wildfire likelihood and intensity, FSim is generally used to estimate burn probabilities over very large landscape areas (e.g., continental scales). Both our sage-grouse breeding habitat model and relative abundance models demonstrate clustering at much finer scales than the Great Basin [Refer back to figures of pops and habitats by MZ here]. Further, FSim fire probability classifications are based on forest fire ecology, not sagebrush-steppe fire ecology. We did not use FSim to project future habitat losses to fire because of the coarse scale of FSim predictions and because we were unclear of all the assumptions required to project a forest fire ecology model into the sagebrush-steppe ecosystem. We therefore did not use either MTBS or FSim to predict future sagebrush losses from fire.

We believe recent work from the WAFWA Wildfire and Invasive Species Initiative Working Group (Initiative; see ***Non-regulatory Conservation Efforts*** section) can serve as a platform to predict future fire losses. This group has a developed a strategic approach (Chambers *et al.* 2014, entire) that integrates both landscape prioritization and site-scale decisions tools for the conservation of sagebrush habitats within the Great Basin. Chambers *et al.* (2014, entire) used soil temperature and moisture regimes as an indicator of landscapes resilience to disturbance and resistant to invasive annual grasses. This work classified different ecological soil and moisture regimes (see Figure 11 from Chambers *et al.* 2014, p. 16) into three categories of resiliency and resistance to fire and invasive species disturbance.

The R&R work and subsequent refinements to soil classes through the Fire and Invasive Species Assessment Tool or FIAT process (Maestas and Campbell 2014, entire), is the foundation on which the Service will assess the potential impacts of habitat loss and fragmentation due to wildfire and invasive plants. Discussions with scientists within the Initiative, agreed that using the R&R matrix could be used as a surrogate to evaluate the risk of fire and invasive species. For example, areas with low R&R values tend to be more prone to invasion by cheatgrass and large catastrophic wildfires because these ecosystems have relatively lower resilience to disturbance and higher climate suitability for invasive annual grasses. Given the R&R paradigm and current trends in acreages of the sagebrush ecosystem burning (e.g., Table10.5 from Miller *et al*. 2011, p. 176), it appears low R&R areas have a lesser likelihood of providing ecological benefits within the sagebrush ecosystem in the future. We quantified the amount of predicted breeding habitat and the relative percent of sage-grouse populations within the three classes of the R&R matrix (see Table 2 from Chambers *et al.* 2014, p. 20). We chose this option because understanding the proportions of habitats likely to recover post-disturbance versus those likely to permanently transitioning to a different ecological state are important to placing context to the threat of fire and invasives to sage-grouse populations.

We found the percent of sage-grouse populations and predicted breeding habitat with low R&R varied by MZ (Tables 5-1 and 5-2). We found that MZ IV had the highest amount of both breeding habitat and populations within high and moderate resistance classes. Sage-grouse within are X & X times larger than MZs III and V populations respectively. We found X% of birds were within moderate and high resistance categories across the entire Great Basin irrespective of MZs.

Table 5-1. Percent of the Great Basin Greater Sage-grouse Management Zone Populations which occur within the three classes of Resiliency and Resistance to Invasive species and Fire

	MZ III[a]	**MZ IV**	**MZ V**
Wetland/Riparian	2%	2%	2%
High Resistance	20%	43%	8%
Moderate Resistance	30%	35%	54%
Total of High & Moderate Resistance	**52%**	**79%**	**63%**
Low Resistance	48%	21%	37%

[a] Area excludes the Bi-State Greater Sage-grouse populations.

Table 5-2. Percent of the Great Basin Greater Sage-grouse Management Zone Breeding Habitat Area which occur within the three classes of Resiliency and Resistance to Invasive species and Fire.

	MZ III[a]	**MZ IV**	**MZ V**
Wetland/Riparian	2%	2%	1%
High Resistance	16%	35%	8%
Moderate Resistance	28%	36%	59%
Total of High & Moderate Resistance	**46%**	**73%**	**67%**
Low Resistance	54%	27%	33%

[a] Area excludes the Bi-State DPS.

The R&R matrix is based upon the likely response of sagebrush to resist invasive annual grasses, which increase fire frequency and the ability of a landscape to recover post-fire. However, sagebrush R&R does not necessarily equate to sage-grouse resiliency and resistance. We found the majority of populations in MZs IV and V, and the entire Great Basin, has either high or moderate resistance and resiliency to fire and invasive species (Tables 5-1 and 5-2). However, for sage-grouse populations to persist in the foreseeable future there needs to be large landscapes of undisturbed sagebrush to allow recolonization of disturbed areas as they recover post-fire. There are several critical assumptions of the applicability of the R&R matrix to sage-grouse populations. First, the ratio between sagebrush stand recovery post-fire versus annual losses to fire in areas without recent burns. Second, the trends in the acres of sagebrush lost to fire per year must stabilize in the future. If current trends of areas burned per year continue to increase, then resiliency may increase the time sage-grouse populations will persist in the Great Basin, but may not ultimately create permanent population reservoirs (Table X). We currently do not have specific quantifiable acreages of how much sagebrush is needed to support populations to allow recolonization of sagebrush stands post-fire. Our simple tabulation of the MTBS data indicates acreages of fires have increased since 2000. Increased certainty in the probability that recent increases in fire acreages will hold true in the future would greatly increase our confidence in assessing the assumptions 1 and 2 from above. We believe the effectiveness of the FIAT and recent Secretarial Order 3336, Rangeland Fire Prevention, Management and Restoration (Order) in reducing the amount of habitat lost in landscapes with high and moderate R&R will be critical (see ***Non-regulatory Conservation Efforts*** section). Finally, we believe our analyses would have greatly benefited if we had a higher resolution fire prediction model similar to both our cropland and oil and gas analyses conducted for the species report. Risk is rarely homogeneous, but we currently have to assume risk for fires are equivalent within each R&R class. Future refinement of our models would greatly benefit from increased information on both future projections of fire rates and a more refined spatially explicit probability of the likelihood fire losses than the current three classes from the FIAT planning process.

[**INSERT FIGURES (2)**]

Figure – FIAT Resistance Classes (3)
Figure – Combined Fires with FIAT

[**INSERT TABLE (1)**]

Table - Acres/Percent of FIAT Classes in Occupied Range by MZ

Timescale for Projecting this Impact

It is not currently possible to predict the exact extent or location of future fire events due to complicated interactions of weather, vegetation, and ignition. However, the best scientific and commercial information available indicates that fire frequency is likely to increase into the future due to increases in cover of invasive annual grasses, human activity, and the projected effects of climate change (see ***Invasive Plants*** and ***Climate Change*** chapters). Given the history of invasive annual grasses on the landscape, the continued challenges to controlling these species, the expansive infestation of invasives across the species' range, and our knowledge of fire return intervals in Wyoming big sagebrush ecosystems, we anticipate invasives and associated wildfires will continue to remove and degrade sagebrush habitats and compromise the sagebrush ecosystems that sage-grouse depend upon indefinitely.

Likelihood of Future Impacts

We anticipate the loss of sagebrush habitat from wildfire to increase due to the intensifying synergistic interactions among fire, human activity, invasive species, and climate change (Miller *et al.* 2011, pp. 179–184). The recent past- and present-day fire regimes across the sage-grouse range have changed with a demonstrated increase in the more xeric Wyoming big sagebrush communities and a decrease across many mountain big sagebrush communities. Both scenarios of altered fire regimes have caused significant losses to sagebrush habitat through facilitating invasive annual grass encroachment at lower elevation Wyoming big sagebrush sites and conifer expansion at higher elevation mountain big sagebrush sites (Miller *et al.* 2011, pp. 181–184). We also anticipate both of these scenarios to worsen in the face of climate change (Baker 2011, p. 200; Miller *et al.* 2011, p. 183). Predicted changes in temperature, precipitation, and carbon dioxide (CO_2) 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). Researchers have suggested that future drought simulations may underestimate decade-scale droughts and larger mega-droughts (Ault *et al.*2014, pp. 7545–7548). Further, in addition to the predicted change in climate toward a warmer and generally wetter Great Basin, variability of interannual and interdecadal wet-dry cycles will increase and likely act in concert with fire, disease, and invasives to further stress the sagebrush ecosystem (Neilson *et al.* 2005, p. 152). Lightning strikes are predicted to increase approximately 50 percent in the 21st century (Romps *et al.* 2014, p. 853). The anticipated increase in suitable conditions for wildfire will likely further interact with people and infrastructure. Human-caused fires have reportedly increased and are correlated with road presence (Miller *et al.* 2011, p. 171). Power lines, vehicles, and equipment, such as welding, cutting torches, and chainsaws, start the most human-caused fires. These were followed by fires caused by railroads, warming/cooking fires, agricultural/debris burning, and fireworks (Havlina *et al.* 2014, pp. 2, 23). Additionally, given the popularity of off-highway vehicles (OHV) and the ready access to lands in the Great Basin, the increasing trend in both fire ignitions by people and loss of habitat will likely continue.

Anticipated Changes from Present

Fire fuel modules have been used to estimate the probability for development of large fires. These fuel models indicate large portions of MZs III, IV and V (collectively, the Great Basin) fall into the high burn probability category for both PHMA and GHMA designations (Manier *et al.* 2013, pp. 85–86). Changes in climate (e.g., increases in temperature, variation in precipitation amount and timing, increased drought risk, increased lightning strikes) will interact and facilitate increased risk of fire, invasions of nonnative annual grasses in Wyoming big sagebrush communities, and conifer encroachment into mountain big sagebrush communities. These changes have already caused the fire return interval in sagebrush ecosystems to deviate from historical fire regimes. Therefore, we expect fire to continue to impact sage-grouse rangewide into the foreseeable future, but fire is expected to have a greater impact within the Great Basin and Columbia Basin regions.

Threat Amelioration

Conservation Efforts Data Base Projects

Through the Conservation Efforts Database (CED), the Service collected information relating to conservation actions that were completed, in progress, or planned. A total of 271 projects addressing fire were entered in the CED as "completed" by data providers. These projects occur in the range of sage-grouse, with the greatest focus in MZs III and IV (Appendix D). Of the projects deemed completed by the project proponents the Service reviewed projects in MZs III, IV, V, and VI as these MZs are the key areas in the sage-grouse range where this threat occurs, or is likely to occur . Most of the acres assessed as effective in our review (Table 5-3) were acres assessed as effective for conifer removal as well. Conservation efforts that are completed and effective for minimizing the threat of fire total 19,138 ha (47,292 ac) (Table 5-3)

Table 5-3. Summary of completed and effective projects entered into the CED that were evaluated and deemed effective by the Service in addressing the fire. Length measurements represent fuel breaks, and area measurements included conifer removal, fuel reduction treatments, and habitat restoration projects following a wildfire.

Management Zone	Conservation Efforts	ha (ac)	km (mi)
III	unique acres (MZ & threat) [1]	448 (1,107)	
	same acres & MZ, > 1 threat [2]	12,587 (31,103)	
	same acres & >MZ, > 1 threats [3]	0	
IV	unique acres (MZ & threat) [1]	1,659 (4,100)	
	same acres & MZ, > 1 threat [2]	2,444 (6,040)	
	same acres & >MZ, > 1 threats [3]	0	
V	unique acres (MZ & threat) [1]	238 (587)	114 (71)
	same acres & MZ, > 1 threat [2]	1,762 (4,355)	
	same acres & >MZ, > 1 threats [3]	0	
VI	unique acres (MZ & threat) [1]	0	
	same acres & MZ, > 1 threat [2]	28 (70)	
	same acres & >MZ, > 1 threats [3]	0	
TOTALS		19,138 (47,292)	114 (71)

[1] projects in one MZ addressing one threat
[2] projects in one MZ addressing more than one threat
[3] projects crossing more than one MZ addressing more than one threat

Candidate Conservation Agreements with Assurances and Candidate Conservation Agreements

In addition to the conservation efforts described above, lands currently enrolled in CCAAs use conservation measures and adaptive management to prevent wildfires and restore sage-grouse habitat following fire events. Approximately 0.17 percent of occupied range in MZ I, 0.78 percent of MZ II, 2.47 percent of MZ IV, and 4.67 percent of MZ V are enrolled in CCAAs in Wyoming and Oregon. Federal lands enrolled in CCAs in Wyoming, Oregon, and Idaho account for 0.04 percent of occupied range in MZ I, 0.21 percent of MZ II, 3.13 percent of MZ IV, and 4.67 percent of MZ V. See the ***Non-Regulatory Conservation Efforts*** section and Table 28-7 for approximate acreages and additional information.

State Plans

The Idaho and Utah state plans have regulatory mechanisms that reduce wildfire in these States on state lands in Idaho and all lands within the Sage-Grouse Management Areas (SGMAs) in Utah.   If enacted, Montana's state plan would reduce wildfire on State lands and on private lands if a project requires a State permit. Although not yet implemented, Idaho's state plan would have regulatory mechanisms that direct fire prevention, suppression, and habitat restoration activities on Idaho State Trust Lands (Idaho Department of State Lands, pp. 17–24). Utah's state plan addresses fire control, suppression, and rehabilitation (State of Utah 2013, p. 13). Additionally, the Utah Governor's Executive Order directs the Utah Division of Forestry, Fire and State Lands to prioritize fuels-mitigation activities and pre-attack planning and coordination with other Federal and local fire suppression partners (State of Utah 2015, p. 4). Utah's state plan prioritizes response to wildfires on State and Federal lands, but actions on private lands are largely voluntary (State of Utah 2013, p. 13). Montana's state plan would prohibit prescribed burns in all sage-grouse habitats on State lands and private lands where state authorization is required unless the burn improves habitats or will not reduce habitats (State of Montana 2014, pp. 16, 20). Montana's state plan would also prioritize fire suppression efforts in core areas and provides coordination and habitat rehabilitation measures in sagebrush habitats on State lands or wherever a state permit may be required (State of Montana 2014, pp. 5, 11, 12). Although not a regulatory mechanism, the Governor of Wyoming's Executive Order prioritizes fire suppression activities in core areas, but recognizes that other local, regional, and national suppression priorities may take precedent (State of Wyoming 2011, p. X). Therefore, Utah's state conservation plan has existing regulatory mechanisms that effectively reduce wildfire on Federal lands. If finalized and implemented, state plans in Montana and Idaho would effectively reduce the threat of wildfire on applicable lands. A summary of state regulations and conservation plans addressing fire, and other threats is in the Regulatory Mechanisms chapter (pp.X).

BLM Resource Management Plans and USFS Land and Resource Management Plans

The BLM and USFS plans include generalized actions to reduce fire risk and improve wildland fire response. The plans include increased interagency coordination, new fire management plans, restrictions on use of prescribed fire, and landscape-level treatment focus, with prioritization of PHMAs and GHMAs. Additionally, restoration conservation measures and monitoring have been included to reduce impacts post-fire, including invasive plants and potential over-grazing.

In addition to the BLM and USFS plans, the BLM commissioned a federally-led team (i.e., FIAT) to identify priority habitat areas within the Great Basin relative to sage-grouse conservation and to develop management strategies to reduce the impacts of invasive annual grasses, wildfires, and conifer encroachment. These assessments incorporated data such as, sage-grouse breeding bird densities, sagebrush cover, and information on soil temperature and moisture regimes associated with resistance and resiliency properties (Chambers *et al.* 2014, entire) along with local knowledge of the landscape (BLM 2014, entire). The five FIAT assessment areas roughly correspond to PACs, which were identified in the COT Report (USFWS 2013, p.X), and includes: Central Oregon (MZ III), Northern Great Basin, Snake/Salmon/Beaverhead, (MZ IV), and Central Oregon, Western Great Basin/Warm Springs Valley (MZ V). The BLM fuels funding for fiscal year 2015 (see *Fuels Management* discussion below) is earmarked for projects near or within the sage-grouse habitat and emphasis areas identified in the FIAT process. Many projects resulting from the FIAT assessments will be fuels treatments designed to improve initial attack effectiveness (Havlina *et al.* 2014, p. 20). Cumulatively, the five FIAT

Assessment Areas identifies >10,000 miles of potential linear fuel treatments, approximately 7.4 million acres of potential conifer treatments, over 5 million acres of potential invasive plant treatments, and over 19 million acres of post-fire rehabilitation. The FIAT also identifies site-appropriate management strategies for fire operations and post-fire decisions.

Further, Secretary of the Interior Sally Jewell issued an Order on January 6, 2015, calling for a comprehensive science-based strategy to address the more frequent and intense wildfires that are damaging vital sagebrush landscapes and productive rangelands, particularly in the Great Basin region. The strategy will begin to be implemented during the 2015 fire season. Goals include reducing the size, severity, and cost of rangeland fires, addressing the spread of cheatgrass and other invasive species, and positioning wildland fire management resources for more effective rangeland fire response. This Order builds on wildland fire prevention, suppression, and restoration efforts to date (DOI 2015, entire). For additional details on the BLM and USFS plans FIAT, and Order these the ***Regulatory Mechanisms*** and ***Non-regulatory Conservation Efforts*** section, respectively.

[**ADD A BRIEF DESCRIPTION OF THE PROPORTION OF PROPOSED FIAT FUELS TREATMENT THAT OCCUR WTTHIN THE 3 CLASSES OF R&R – FROM KEVIN**]

[**INSERT FIGURE**]

Figure - Conservation Actions (Fire Breaks and Fuels Mgmt) overlaid on Fire perimeters by GB Regional scale

Wildland Fire Management

All levels of government collaborate to manage wildfire effectively. Consistent standards, coordination, and agreements enable all agencies to work together to provide effective and efficient response to wildfire regardless of the wildfire location and land ownership (Havlina *et al.* 2014, p. 1). An analysis of 33,782 fires that burned in designated sage-grouse habitat (defined as PHMA and GHMA) from 1992 to 2012, showed that 97 percent (*n* = 32,601) of those fires were less than 1,000 acres and 242 (less than 1 percent) were greater than 10,000 acres (Havlina *et al.* 2014, pp. 1–2).

Fire policies and objectives are integrated into Federal Agency Land and Resource Management Plans. Once a fire starts, predefined objectives including the ecological, social, and legal consequences of the fire determine how the fire will be handled (USFS *et al.* 2009, p. 10; Havlina *et al.* 2014, p. 4). Agency Fire Management Plans and local operational plans further refine unique fire and fuels management guidance within an agency's jurisdiction. Agencies also rely on geospatial data for fire and fuels management guidance. These geospatial layers, including information on land use and fire management plans and range maps for sage-grouse and other priority species, are evaluated through the Wildland Fire Decision Support System (WFDSS) to determine the response to a fire (Havlina *et al.* 2014, pp. 17–18).

The BLM successfully suppresses about 97 percent of all wildfire ignitions in sagebrush ecosystems. The three percent of wildfires that escape usually occur under the most extreme environmental conditions. This, coupled with vegetation changes over time (e.g., conifer encroachment and/or invasive annual plant establishment), has caused these fires to grow larger and become more environmentally destructive than historical fires that occurred under more moderate conditions without suppression.

Current, effective fire suppression has created an environment that is operating at the margin of diminishing returns. Overall conservation effectiveness through increasing suppression capability will be both difficult and expensive. Through better interagency coordination, training and equipment, prepositioning of firefighters and equipment, and improved weather and fire danger forecasting, limited gains in habitat preservation may be realized. Continuing on the path of successful suppression and improving initial attack effectiveness to 99 percent, will continue to present a scenario where some fires will still escape initial attack and will likely do so when conditions are even more extreme. Climate change and invasive annual grasses will compound the issue and provide for a situation where escaped fires under this scenario could impact as much or more of the landscape than when we were suppressing only 97 percent of all fires. This is referred to as the wildfire paradox (Calkin *et al.* 2014, p. 747). Increased fire suppression effectiveness will likely provide some marginal short-term benefits, however, relying entirely on increased fire suppression effectiveness to conserve sage-grouse habitat is unlikely to meet long term objectives for resistant and resilient landscapes.

Fuels Management

The interagency Fuels Management Committee (FMC) is tasked with managing and coordinating the National Interagency Wildland Fuels Management Program. This program is designed to help mitigate risks from wildfires to communities while maintaining and improving ecosystem health (NWCG 2014, p. 1; Havlina *et al.* 2014, p. 20). From 2002 through 2014, the Fuels Management Committee directed between 140 million and 210 million dollars annually to Federal agencies for fuels projects. These funds can be used to complete fuels management work, such as prescribed burning and mechanical treatments, as well as research projects on sagebrush ecosystems and fire effects (Havlina *et al.* 2014, p. 20). Prior to 2012, these treatments were primarily in the Wildland-Urban Interface (WUI). This focus has shifted to emphasize treatments that benefit sage-grouse. Beginning in fiscal year 2015, the BLM is allocating 25 million dollars to projects that benefit sage-grouse. Projects will address stressors to sage-grouse and include conifer removal, seedings, chemical treatments of invasive species, strategically placed fuel breaks, and other measures to change fire behavior, augment suppression effectiveness, or maintain and restore sage-grouse habitat. In 2014, the BLM treated approximately 96,720 ha (239,000 ac) to reduce wildfire related impacts to sage-grouse habitat (Havlina *et al.* 2014, pp. 20–21).

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

- IM-2011-138: Sage-grouse Conservation Related to Wildland Fire and Fuels Management. Replaced IM 2010-149: Sage-grouse Conservation Related to Wildland Fire and Fuels Management.
- IM-2012-017: Use of Revised Sage-Grouse Habitat Maps in Fire Operations and Fuels
- IM-2012-043: Greater sage-grouse Interim Management Policies and ProceduresWO-IM-2010-071: Gunnison and Greater Sage-Grouse Management Considerations for Energy Development

- WO-IM-2011-138: Sage-Grouse Conservation Related to Wildland Fire and Fuels Management
- IM-2013-128: Sage-Grouse Conservation in Fire Operations and Fuels Management
- IM-2014-114: Sage-Grouse Habitat and Wildland Fire Management
- BLM IM 2014-134: Completion of FIAT assessments in sage-grouse habitat

State Fire Management Programs

Federal, State, and local land and wildlife management agencies collaborate and work under national fire guidance strategies to achieve common goals and objectives. State Action Plans have, and are being developed to address the coordinated management of wildfire and sage-grouse habitat. Specific projects are detailed in the State Action Plans to reduce fuels, improve preparedness and initial attack response, identify equipment and training needs, and ensure safe, rapid and aggressive response to wildfire ignitions, and address rehabilitation of wildfire damaged lands to mitigate the spread of invasive plants (Havlina *et al.* 2014, pp. 25–27). State and local fire management agencies view all wildfires as “full suppression” incidents. Every effort is made to suppress fires safely and quickly with a strong initial attack. Many states have agreements with their neighboring states to ensure that a rapid initial attack is possible, even if it is from a neighboring state or jurisdiction. Additionally, they may utilize a “unified command” concept to assist in coordination and cooperation (Havlina *et al.* 2014, p. 26).

Local Fire Management Programs

Many communities have rangeland fire protection associations (RFPAs). In the early 1960s, the Oregon State Legislature passed a stature that enabled the formation of RFPAs under the Board of Forestry (ORS477.315). The Oregon Department of Forestry (ODF) supports the RFPAs with training and access to Federal grants and surplus fire equipment. In Oregon, 18 RFPAs currently field 600+ volunteer fire fighters and more than 200 pieces of water handling fire equipment to protect over 2 million ha (5 million ac) from wildfire. Similar programs are currently in place in Nevada and Idaho.

Post-fire Rehabilitation and Restoration

When wildfires occur on Federal lands, the Burned Area Emergency Stabilization and Rehabilitation (BAER) Program on USFS-managed lands and Emergency Stabilization and Rehabilitation (ESR) on BLM-administered lands initiates an evaluation of habitat impacts and determines the most appropriate rehabilitation treatments. 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 nonnative grass species that establish quickly. Only recently has a modest increase in use of native species for rehabilitation been reported (Richards *et al.* 1998, p. 630; Pyke 2011, p. 542), however, the National Seed Strategy (BLM 2015, entire) is being developed to ensure restoration through the application of locally-adapted seed and plant materials (see ***Non-regulatory Conservation Efforts*** section). Despite efforts to restore and rehabilitate landscapes and sagebrush-steppe communities that have been altered by fire, our understanding of the effectiveness of these treatments is further complicated because most land managers do not systematically collect and track monitoring data (U.S. GAO 2003, p. 5). A recent 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). Even longer time periods may be required for sage-grouse to use recovered or restored landscapes (Knick *et al.* 2011, p. 233).

Restoration of sagebrush habitat is challenging, and restoring habitat function may not be possible in some locations because alteration of vegetation, nutrient cycles, topsoil, and/or biological soil crusts have exceeded recovery thresholds (Shinneman and Baker 2009 cited in Baker 2011, p. 200). Even if possible, restoration can require decades and may be cost-prohibitive. To provide habitat for sage-grouse, restoration must include all seasonal habitats and occur on a large scale (4,047 ha [10,000 ac] or more) to provide all necessary habitat components (Connelly *et al.* 2011, pp. 560–561; Pyke 2011, p. 548). Restoration may never be achieved in some locations with low resistance to invasive plants and low resilience given existing soil, moisture, and temperature regimes (Chambers *et al.* 2014, entire).

Based on a review of existing literature, Baker (2011, pp. 189–196) reported that full recovery to pre-burn conditions in mountain big sagebrush communities ranges between 25 and 100 years and in Wyoming big sagebrush communities between 50 and 120 years. However, data pertaining to the latter community is sparse. By 25 years post-fire, Wyoming big sagebrush typically has less than five percent pre-fire canopy cover (Baker 2011, p. 195). In mountain big sagebrush communities across eight burn sites in eastern Oregon, northwestern Nevada, and northeastern California, full shrub cover was achieved 14 to 27 years post-burn (Ziegenhagen 2003, p. 76). However, Nelle *et al.* (2000, pp. 589–590) found burning resulted in long-term negative impact on sage-grouse nesting habitat because mountain big sagebrush communities required over 20 years for canopy cover to re-establish at levels sufficient for nesting. The findings of Nelle *et al.* (2000, entire) are consistent with other studies, which found that the canopy cover of mountain big sagebrush reached levels similar to adjacent unburned areas within 25 to 35 years, but this can take over 75 years where initial post-fire recruitment is low (Lesica *et al.* 2007, pp. 266–268; Sankey *et al.* 2008, pp. 603–604; Ziegenhagen and Miller 2009, p. 203; Baker 2011, p. 201).

A variety of techniques have been employed to restore sagebrush communities following a fire event (Cadwell *et al.* 1996, p. 143; Quinney *et al.* 1996, p. 157; Livingston 1998, p. 41). The extent and efficacy of restoration efforts is variable and complicated by limitations in capacity (personnel, equipment, funding, seed availability, and limited seeding window), incomplete knowledge, invasive plants, and abiotic factors, such as weather, that are largely outside the control of land managers (Hemstrom *et al.* 2002, pp. 1250–1251; Pyke 2011, pp. 544–545). While post-fire rehabilitation efforts have benefited from additional resources in recent years, resulting in an increase of treated acres from 28,100 ha (69,436 ac) in 1997 to 1.6 million ha (3.9 million ac) in 2002 (Connelly *et al.* 2004, p. 7-35), acreage treated annually remains far outpaced by acreage disturbed.

Assessment of Potential Threat

In 2010, we concluded that fire is one of the primary factors linked to population declines of sage-grouse due to long-term loss of sagebrush and conversion of sagebrush habitats to invasive annual grasses. Loss of sagebrush habitat to wildfire had been increasing in the western portion of the sage-grouse range due to an increase in fire frequency and size. We found this change to be the result of incursion of nonnative annual grasses, primarily cheatgrass. The positive feedback loop between cheatgrass and fires facilitates future fires and precludes the opportunity for sagebrush, which is killed by fire, to become reestablished. Cheatgrass and other invasive plants also alter habitat suitability for sage-grouse by reducing or eliminating native forbs and grasses essential for food and cover.

Our knowledge of wildfire as an ecological process and how it affects sage-grouse has not changed significantly since our 2010 warranted but precluded finding. However, updates to wildfire management strategies and planning tools have occurred. The FIATand Order established local guidance and set forth enhanced policies and strategies for preventing and suppressing wildfire and for restoring sagebrush landscapes impacted by fire across the Great Basin region. Fuel treatments in sage-grouse habitats are prioritized over treatments in other areas (Murphy *et al.* 2013, p. 4). Additionally, protocols have been developed to ensure that plans are current and include guidance for fire management in relation to sage-grouse and sage-grouse habitats. These changes have affected what areas are prioritized for fire-fighting resources during periods of fire activity (Murphy *et al.* 2013, p. 4). While we do not know the extent to which these regulatory and non-regulatory mechanisms will alleviate the wildfire impact to sage-grouse, we believe that this strategic approach to address the impact of fire is appropriate and significant. The use of IMs to increase protection of sage-grouse habitat during wildfire is not adequate to protect the species because IMs are both short-term and have discretionary renewal (decisions made on a case-by-case basis). However, targeting the protection of important sage-grouse habitats during fire suppression and fuels management activities could help reduce loss of key habitat due to fire if directed through a long-term, regulatory mechanism. We describe the impact of wildfire as likely to continue indefinitely; however, this foreseeable future requires a regulatory approach that addresses the impact over the long term.

Between 2006 and 2014, management of wildfires has been successful in extinguishing 97 percent of all fires occurring in sage-grouse habitat in initial attack before they exceeded 404.7 ha (1,000 ac) (Havlina *et al.* 2014, pp. 2–4). Federal, State, and local fire personnel work together to manage wildfire and they continue to work to improve coordination. Wildfire management staff has access to predictive services and is relying more on geospatial layers (including sage-grouse habitat) to predict fire spread and to analyze where to strategically place resources, suppression strategies, and other potential scenarios. However, approximately three percent of wildfires do escape initial attack. These fires affect significant acreages within the range of sage-grouse (e.g., 3,768,918 ha [9,313,199 ac] escaped initial attack between 2000 and 2014)) (USFWS 2015x, p. 1). These escaped fires accounted for 85 percent of burned habitat within the current range of sage-grouse and negatively impact on sage-grouse individuals and populations (USFWS 2015y, p. 1). Thus, barring alterations to the current fire pattern, as well as the difficulties in restoration, the concerns presented by this stressor will continue and likely strongly influence the persistence of sage-grouse, especially in the western half of its range, in the foreseeable future.

CHAPTER 6: INVASIVE PLANTS (ANNUAL GRASSES AND OTHER NOXIOUS WEEDS)

Invasive plants (invasives[1]) alter 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. 5446). Invasive plants reduce and, in cases where monocultures occur, eliminate vegetation that sage-grouse use for food and cover and fragment existing sage-grouse habitat (Miller *et al.* 2011, pp. 160–164). Invasives do not provide quality sage-grouse habitat and where invasive plants are present, sage-grouse are potentially impacted both seasonally (e.g., loss of forbs and associated insects) and long-term (e.g., functional habitat loss)(Manier *et al.* 2013, p. 88). Sage-grouse depend on herbaceous forage for pre-laying and nesting females (Barnett and Crawford 1994, p. 116), a variety of native forbs (e.g., Klebenow and Gray 1968, p. 81; Drut *et al.* 1994, p. 91,) and the insects (Klebenow and Gray 1968, p. 81; Johnson and Boyce, 1990, p. 91; Drut *et al.* 1994, p. 91, Gregg and Crawford, p. 909) associated with them for chick and brood survival, and sagebrush, which is used exclusively throughout the winter for food and cover (Connelly *et al.* 2000a, p. 972). Invasives impact the entire range of sage-grouse, although not all given species are distributed across the entire range (Miller *et al.* 2011, p. 160). Areas at high risk for invasion are distributed throughout the range, but are especially concentrated in eastern Washington (MZ VI), southeastern Oregon (MZs IV and V), southern Idaho (MZ IV), Nevada (MZs III, IV, and V), central Utah (MZ III) and northeast Montana (MZ I) (Leu *et al.* 2008, pp.1119–1139; Miller *et al.* 2011, pp. 160–161). Although nonnative annual grasses occur throughout the sage-grouse's range, they are more pervasive in the western part of the species' range (MZs III, IV, V, and VI) than in the Rocky Mountain States (MZs I and II) (Connelly *et al.* 2004, p. 5–9; Miller *et al.* p. 160). However, in recent years, cheatgrass (and other annual grasses) has increased its spread across the eastern portion of the species' range (Mealor *et al.* 2012, p. 427), particularly in Montana, Wyoming, and Colorado (MZs I and II) (Miller *et al.* 2011, p.160). Although the magnitude of the threat of cheatgrass invasion in the Rocky Mountain states is unknown, without a cost-effective method to eliminate or reduce the distribution and abundance of invasive plants, and with the expansion of invasives due to climate change, the invasion of cheatgrass into the eastern portion of the species range is likely to continue, particularly where disturbance such as wildfire creates suitable conditions (Mealor *et al.* 2012, p. 427). For example, decreases in summer precipitation could cause an expansion of suitable habitat for cheatgrass up to 45 percent, elevating the invasion risk in large portions of Montana, Wyoming, Utah, and Colorado (Bradley 2009, p. 204).

Along with replacing or removing vegetation essential to sage-grouse, invasives fragment existing sage-grouse habitat. They can create long-term changes in ecosystem processes, such as fire-cycles (see ***Fire*** chapter) 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

[1] For the purposes of our analysis in this section, we consider invasive plants (invasives) to be any nonnative plant that negatively impacts sage-grouse habitat, including annual grasses and other noxious weeds. However, the terms 'noxious weeds' and 'invasives' are not consistently defined or applied in the scientific literature. Consequently, both terms are used in our discussion to reflect the original use in the sources we cite. In the source material, it was often unclear whether discussions about noxious weeds included invasive annual grasses, such as cheatgrass, referred solely to invasive forbs and invasive perennial grasses, or only referenced species that are listed on State and Federal noxious weed lists (many of which do not consider cheatgrass a noxious weed). Nonetheless, all of these can be categorized as nonnative plants that have a negative impact on sage-grouse habitat and thus meet our definition of invasive plants.

(Connelly *et al.* 2004, pp. 7-107 and 7-108; Zouhar *et al.* 2008, p. 144; Miller *et al.* 2011, pp. 158–159) but cheatgrass is the most widespread invasive within the Intermountain West and Great Basin (Miller *et al.* 2011, p. 145). This is especially true within basin big sagebrush and xeric Wyoming big sagebrush communities, which are at the most risk to displacement by cheatgrass (Miller and Eddleman 2001, p. 21; Connelly *et al.* 2004, p. 5-9; Chambers *et al.* 2007, p. 141). Medusahead fills a similar niche in more mesic communities with heavier clay soils (Dahl and Tisdale 1975, p. 464). Medusahead can also become abundant on some little sagebrush sites below 1500 m in elevation (Miller and Eddleman 2001, p. 21), as well as some big sagebrush communities (Miller at al. 1999 pp. 271–281). Other invasives include *Euphorbia esula* (leafy spurge), *Centaurea solstitialis* (yellow star-thistle), *C. stoebe* (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 annual grasses (primarily cheatgrass and medusahead) have caused extensive sagebrush habitat loss in the Intermountain West and Great Basin (Connelly *et al.* 2004, pp. 1-2 and 4-16) and have substantially altered regional fire regimes (Balch *et al.* 2013, p. 179). Cheatgrass-dominated rangelands impact sagebrush ecosystems by shortening fire return intervals and perpetuating their own persistence and intensifying the role of fire (Whisenant 1990, p. 4). Fire return intervals are approximately 78 years in cheatgrass-grasslands compared to 169 in native vegetation (Balch *et al.* 2013, p. 178). Sites dominated by cheatgrass may be four times more likely to burn than native sagebrush (Balch *et al.* 2013, p. 178). Between 2000 and 2009, 6.6 million ha (16.2 million ac) burned in the Great Basin. Of the estimated 6.6 million ha, about 0.8 million ha (2 million ac) re-burned due to the positive feedback between cheatgrass and fire (Weltz *et al.* 2014, p. 39A), resulting in ecosystem-level impacts (Billings 1994, pp. 22–30; Mack 2011, pp. 253–265).

The arrival of European settlers in the mid-1800s initiated a series of changes in vegetation composition and structure that resulted in major changes in sagebrush-steppe communities (Chambers *et al.* 2014c, p. 3). Improperly managed grazing by domestic livestock in the mid-1800s, coupled with drought, led to a decrease in native perennial grasses and forbs (Knapp 1996, p. 42; Miller and Eddleman 2001 p. 19; Miller *et al.* 2011, p. 160). Nonnative annual grasses (e.g., cheatgrass and medusahead) were introduced from Eurasia in the late 1800s and spread rapidly into low- to mid-elevation ecosystems with depleted understories (Mack 1981, p. 164; Knapp 1996, pp. 41–43). Domestic livestock and feral free-roaming equids facilitated the dissemination and establishment of cheatgrass (Knapp 1996, p. 42). Once introduced, cheatgrass spread rapidly throughout the Intermountain West (Knapp 1996, p. 42) and likely reached its maximum range expansion in western North America by 1930 (Mack 1981, p. 164; Billings 1990, pp. 301–322), but the recent invasion of cheatgrass southward into the Mojave Desert and eastward has expanded the known distribution of cheatgrass (Miller *et al.* 2011, p. 160). Additionally, cheatgrass appears to be spreading at increasing elevation in the last few decades, occurring at elevations where it was not found in the past (Brown and Rowe 2004, p. 1; Banks and Baker 2011, p. 383). When established, these nonnative annual grasses increase frequency and size of fires to the detriment of native plant species (Miller and Edldleman 2001, p. 20).

Facilitated by repeated anthropogenic and wildfire disturbance, invasive annual grasses (especially cheatgrass and medusahead), have invaded vast portions of sage-grouse range and present a formidable challenge to sagebrush ecosystem conservation (D'Antonio and Vitousek 1992, p. 79; Miller *et al.* 2011, pp. 157–164). Of utmost concern are the synergistic effects of the annual grass-wildfire cycle (see ***Threats Interaction*** section). Although the historical frequency of fire continues to be debated (Baker

2011, pp. 194–196; Miller *et al.* 2011, pp. 164–171), the role of fire in the sagebrush-steppe ecosystem has likely changed significantly since post-European settlement (Crawford *et al.* 2004, p. 7). If sagebrush-steppe ecosystems, particularly Wyoming big sagebrush communities, lack resilience to invasive annual grasses, conversion to a novel annual grassland steady-state is likely (Miller *et al.* 2011, p. 183; Pyke *et al.* 2014, p. 455). Exacerbating the problem is the current ineffectiveness of restoration treatments to restore native sagebrush communities now dominated by annual grasses (Davies *et al.* 2011, p. 2577).

The effects of fire on noxious weeds typically promote the dominance of these plants, establishing an invasive plant-fire regime cycle (Brooks *et al.* 2004; pp. 677–688). Invasive perennial forbs are generally unharmed or may increase following fire due to life history traits, such as prolific seed production, persistent seed banks, and rooting characteristics, including the ability to sprout from rhizomes, root crowns, or adventitious buds (Ielmini *et al.* 2015, p. 6). Conversely, annual invasive forbs with transient seed banks may be vulnerable to, and controlled by, fire during certain life history stages. Deep-rooted, creeping invasive perennials such as *C. repens* (Russian knapweed), *C. virgata ssp. squarrosa* (squarrose knapwed), *Linaria dalmatica* (dalmation toadflax), and *Cirsium arvense* (Canada thistle) do not impact sagebrush-steppe ecosystems on a landscape scale but these invasive perennials can pose a significant threat to native sagebrush habitats on a local scale (Ielmini *et al.* 2015, p. 6).

Current Impacts

Cheatgrass exhibits a high degree of phenotypic plasticity in life history characteristics allowing the nonnative grass to successfully compete against native plants for resources necessary to establish and grow (Harris 1967, pp. 93–94; Mack and Pyke 1983, p. 70; Booth *et al.* 2003, p. 44; Chambers *et al.* 2007, p. 119). For example, the high germination rate (up to 99.5 percent success) of cheatgrass seedlings (Hulbert 1955, pp. 202–209) and rapid development of a deep root system (Stewart and Hull 1949, p. 59; Hulbert 1955, pp. 190–193) provides an advantage over native perennials. Further, cheatgrass root growth is much greater in winter than native perennial grass species, such as *Pseudoroegneria spicata* (bluebunch wheatgrass), which confers an advantage for cheatgrass in the spring because it can use soil moisture earlier and faster than the native grasses (Harris 1967, p. 108; West 1983, pp. 351–374).

The timing of precipitation is also important because cheatgrass and many other invasive annual grasses are well-adapted to climates with cool and wet winters and warm and dry summers (Bradford and Lauenroth 2006, p. 700; Bradley 2009, p. 196). The timing of the western Great Basin precipitation patterns allow cheatgrass to germinate in autumn with the first significant rain. Fall germinated plants can then grow into densely packed stands with root systems elongating during the winter (Stewart and Hull 1949, p. 59). During the following spring when temperatures are sufficiently warm for shoot growth, the more developed cheatgrass root system effectively removes soil moisture to the competitive disadvantage of native perennial grasses (Harris 1967, p. 108; Melgoza *et al.* 1990, p. 12). In contrast, areas that receive regular summer precipitation often are dominated by warm and/or cool season grasses (Sala *et al.* 1997, p. 231) that likely create a more competitive environment and result in greater resistance to annual grass invasion and spread (Bradford and Lauenroth 2006, p. 700; Bradley 2009, p. 204).

Native perennial plant community structure, abundance and composition, along with biological soil crusts, play important roles in controlling cheatgrass dominance (Reisner *et al.* 2013, p. 1039). Evidence suggests abundant bunchgrasses limit invasions by limiting the size and connectivity of gaps between vegetation, and biological soil crusts appear to limit invasions within gaps (Reisner *et al.* 2013, pp. 1047–1048). In addition, native bunchgrasses typically maintain interspaces and provide an open soils surface for biological soil crusts to establish and survive (Ponzetti *et al.* 2007, p. 717). Inappropriate grazing (timing, duration, and/or intensity) may exacerbate the magnitude of nonnative plant invasions by decreasing bunchgrass abundance, shifting bunchgrass composition, and thereby increasing the distance between perennial plants. Grazing and trampling of soils by domestic livestock may further reduce resistance by reducing biological soil crusts and facilitates the establishment and spread of invasives (Reisner *et al.* 2013, p. 1048).

Vegetation treatments, such as targeted grazing and prescribed burning have the potential to reduce cheatgrass dominance by altering seed and aboveground community dynamics (Diamond *et al.* 2012, p. 268). However, in cheatgrass-dominated rangelands, characterized by near-monotypic stands of cheatgrass, traditional grazing systems designed to favor native perennial grasses may not lead to the return of the native bunchgrass community structure (Young and Clements 2007, p. 16). This is especially significant with the application of rest-rotation grazing where cheatgrass can benefit from deferred, no grazing until after seed ripe, and complete rest from grazing, precluding the re-establishment of native perennial species (Young and Clements 2007, p.16).

Changes in vegetation composition and structure associated with invasive annual grasses degrades sagebrush-steppe habitat (Miller *et al.* 2011, p. 163) and may indirectly affect local sage-grouse populations by outcompeting native perennial plants that are important components of sage-grouse habitats. Patterns of nest site selection in northwestern Nevada suggest sage-grouse selected for large expanses of sagebrush-dominated areas (Lockyer 2012, p. 26) and, within those areas, sage-grouse selected microsites with higher shrub canopy cover and lower cheatgrass cover (Lockyer 2012, p. 25). The average cheatgrass cover at selected locations was 7.1 percent compared to 13.3 percent at available locations (Lockyer 2012, p. 26). Nest site selection was also negatively correlated with cheatgrass abundance in south-central Wyoming (Kirol *et al.* 2012, p. 82). Cheatgrass occurred at 6 percent of nest locations compared to 19 percent of the corresponding random locations (Kirol *et al.* 2012, p. 82), indicating that changes in species composition and vegetative structure associated with cheatgrass degraded sage-grouse habitat. Cheatgrass was not widespread, but when present, it was associated with anthropogenic features, suggesting female sage-grouse may not have selected against cheatgrass but instead may possibly have avoided nesting areas dominated by cheatgrass because of human development and infrastructure (Kirol *et al.* 2012, pp. 85–86).

In northern Nevada, recruitment and annual survival were impacted by the presence of invasive annual grasses at larger spatial scales, Leks impacted by invasive annual grasses experienced lower recruitment than non-impacted leks, even following years of high precipitation (Blomberg *et al.* 2012, p. 7). Leks that were not impacted by invasive annual grasses exhibited recruitment rates nearly twice as high as the population average and nearly six times greater than impacted leks during years of high precipitation (Blomberg *et al.* 2012, p. 7). Lek-level survival of adult males was also reduced in areas where leks were impacted by invasive annual grasses (Blomberg *et al.* 2012, p. 8).

At the landscape scale, studies are beginning to quantify the effects of nonnative annual grasses on sage-grouse distribution and abundance. Arkle *et al.* (2013, p. 13) found a strong negative association between sage-grouse occupancy and cheatgrass, even at low cover values (less than 5 percent). In an analysis of 3,184 leks known to be active between 1998 and 2007, Knick *et al.* (2013, p. 1545) found that most active leks had annual grass cover (2.2 percent) within a 5-km radius of the leks compared to 9.8 percent at historic but no longer occupied leks. In a rangewide analysis, Johnson *et al.* (2011, p. 412) found that lek trends (as estimated from lek counts across MZs) had negative associations as the cover of invasives increased at both the 5-km and 18-km scales. Sage-grouse MZs differed little in the average proportional areas dominated by invasive plants (see Table 17.1 pp. 413–416 in Johnson *et al.* 2011) and few leks had greater than 8 percent invasive annual vegetation cover within both buffer distances, suggesting that when the extent of the landscape dominated by invasives becomes relatively high, leks become inactive (Johnson *et al.* 2011, p. 447).

Location and Extent

Quantifying the total amount of sage-grouse habitat impacted by invasives is difficult due to differing sampling methodologies, incomplete sampling, inconsistencies in species sampled, and varying interpretations of what constitutes an infestation (Miller *et al.* 2011, p. 160). In addition, comprehensive landscape-scale maps of the distribution of invasives in the western U.S. do not currently exist, and the total acreage of noxious weed infestations that have been reported at the local, State, and Federal levels is incomplete and widely variable (Ielmini *et al.* 2015, p. 7).

The BLM (1996, p. 6) estimated invasives (which may or may not have included cheatgrass in their estimate) covered at least 3.2 million ha (8 million ac) of BLM-administered lands as of 1994, and predicted 7.7 million ha (19 million ac) would be infested by 2000. However, a qualitative 1991 BLM survey covering 40 million ha (98.8 million ac) of all BLM-administered rangelands in Washington, Oregon, Idaho, Nevada, and Utah (MZs III, IV, V, and VI) reported that nonnative annual grasses were a dominant or significant presence on 7 million ha (17.2 million ac) of public lands within these five states (Pellant and Hall 1994, p. 110). An additional 25.1 million ha (62 million ac) had less than 10 percent cheatgrass in the understory, but were considered to be at risk of cheatgrass invasion (Zouhar 2003, p. 3, in reference to the same survey). As of 2000, the BLM reported that noxious weeds and invasive annual grasses occupied 11.9 million ha (29.4 million ac) of BLM-administered lands in Washington, Oregon, Idaho, Nevada, and Utah (BLM 2007a, p. 3-28). However, when considering all states within the current range of sage-grouse, this number increases to 14.8 million ha (36.5 million ac). More recently, Diamond *et al.* (2012, p. 259) reported cheatgrass currently dominates over 6.9 million ha (17 million ac) in the Great Basin and occupies an additional 25 million ha (62 million ac) as a component of the plant community. Although estimates of the total area infested by cheatgrass vary widely, it is evident that cheatgrass is a significant presence in western rangelands.

The Landscape Fire and Resource Management Planning Tools Project (LANDFIRE) has a rangewide dataset documenting invasive annual grass distribution (Figure 6-1). Based on 1999–2012 imagery (LANDFIRE 1.3.0), approximately 3.4 million ha (8.3 million ac) of nonnative annual grasses occur within the current range of sage-grouse (Table 6-1). Satellite data only maps annual grass monocultures, and not areas where they occur in lower densities or even dominate the sagebrush understory (which is mapped as sagebrush). Therefore, the LANDFIRE dataset is a gross underestimate of the total acres of infestation. However, this dataset provides a rangewide comparison of annual grass monocultures and identifies the large extent of these monocultures in both the western and eastern part of the sage-grouse's range.

Approximately 80 percent of land in the Great Basin Ecoregion (MZs III, IV, and V) is susceptible to displacement by cheatgrass (including over 58 percent of sagebrush that is moderately or highly susceptible) within 30 years (Connelly *et al.* 2004, p. 7-17, Suring *et al.* 2005, p. 138; Miller *et al.* 2011, p. 182). Due to the disproportionate abundance of cheatgrass in the Great Basin, suggesting an increased susceptibility to cheatgrass invasion than other parts of the sage-grouse's range, a formal analysis of the risk of cheatgrass invasion in other areas is needed to make inferences (Connelly *et al.* (2004, p. 7-8). Also, while nonnative annual grasses are usually associated with lower elevations (e.g., between 600–1820 m (2000–6000 ft.) in eastern Idaho)(Stewart and Hull 1949, p. 72) and drier climates (Connelly *et al.* 2004, p. 5-5), the ecological range of cheatgrass continues to expand at low and high elevations (Ramakrishnan *et al.* 2006, pp. 61–62), both southward and eastward (Miller *et al.* 2014, p. 160). Local infestations of cheatgrass and other annual grasses occur in Montana, Wyoming, and Colorado (MZs I and II) (Miller *et al.* 2011, p.160), and there is evidence that cheatgrass is impacting fire intervals in Wyoming. For example, 40,469 ha (100,000 ac) of sagebrush that burned in a wildfire southeast of Worland, Wyoming (MZ II), became infested with cheatgrass, accelerating the fire return interval in this area (Wyoming Big Horn Basin Sage-grouse Local Working Group 2007, pp. 39–40).

Cheatgrass is just one of a number of other invasive plant species increasing in extent within the range of sage-grouse (Miller *et al.* 2011, pp. 158–159). An analysis by Ielmini *et al.* (2015, p. 18) ranked the relative invasion risk and estimated the abundance of invasives within the range of sage-grouse (Table 6-4), concluding that the five highest ranked invasives plants for risk to sage-grouse were cheatgrass, spotted knapweed, *Cardaria* spp. (whitetop), leafy spurge, and Russian knapweed. The five most abundant invasive plant species were cheatgrass, Canada thistle, whitetop, spotted knapweed, and Russian knapweed (Ielmini *et al.* 2015, p. 18). Additionally, other invasive species (e.g., *Chondrilla juncea* [rush skeletonweed], yellow star-thistle) were likely to have small infestations or be absent across much of the range of sage-grouse but remain a high concern to land managers (Ielmini *et al.* 2015, p. 18).

Invasives that are not annual grasses impact the entire range of sage-grouse, although not all given species are distributed across the entire range (Figure 6-1). LANDFIRE also has a rangewide dataset documenting other nonnative grasses and forbs, including perennial grasses and annual, perennial, and biennial forbs. Like annual grasses, other invasive plants are grossly underestimated in the LANDFIRE dataset because the dataset only includes monocultures of these species. Based on 1999–2012 imagery (LANDFIRE 1.3.0), over 1 million ha (2.6 million ac) of other invasive plants occur within the current range of sage-grouse (Table 6-1). Collectively, invasives account 5.4 percent of the breeding habitat distribution (Table 6-2) and comprise # percent of the modeled sage-grouse distribution (Table 6-3). Aside from LANDFIRE, the only other information documenting the specific distribution of invasives within the range of the species is at a presence–absence scale at the county level. DiTomaso (2000, p. 257) estimated that western rangelands are infested with 2,900,000 ha (7,166,027 ac) of spotted knapweed, 1,300,000 ha (3,212,357 ac) of diffuse knapweed, 8,000,000 ha (19,768,352 ac) of yellow star-thistle, and 1,100,000 ha (2,718,148 ac) of leafy spurge, but this estimate did not describe the distribution of invasives across the landscape. These estimates, combined with estimates of acres infested by cheatgrass, illustrate the severity of the invasives problem.

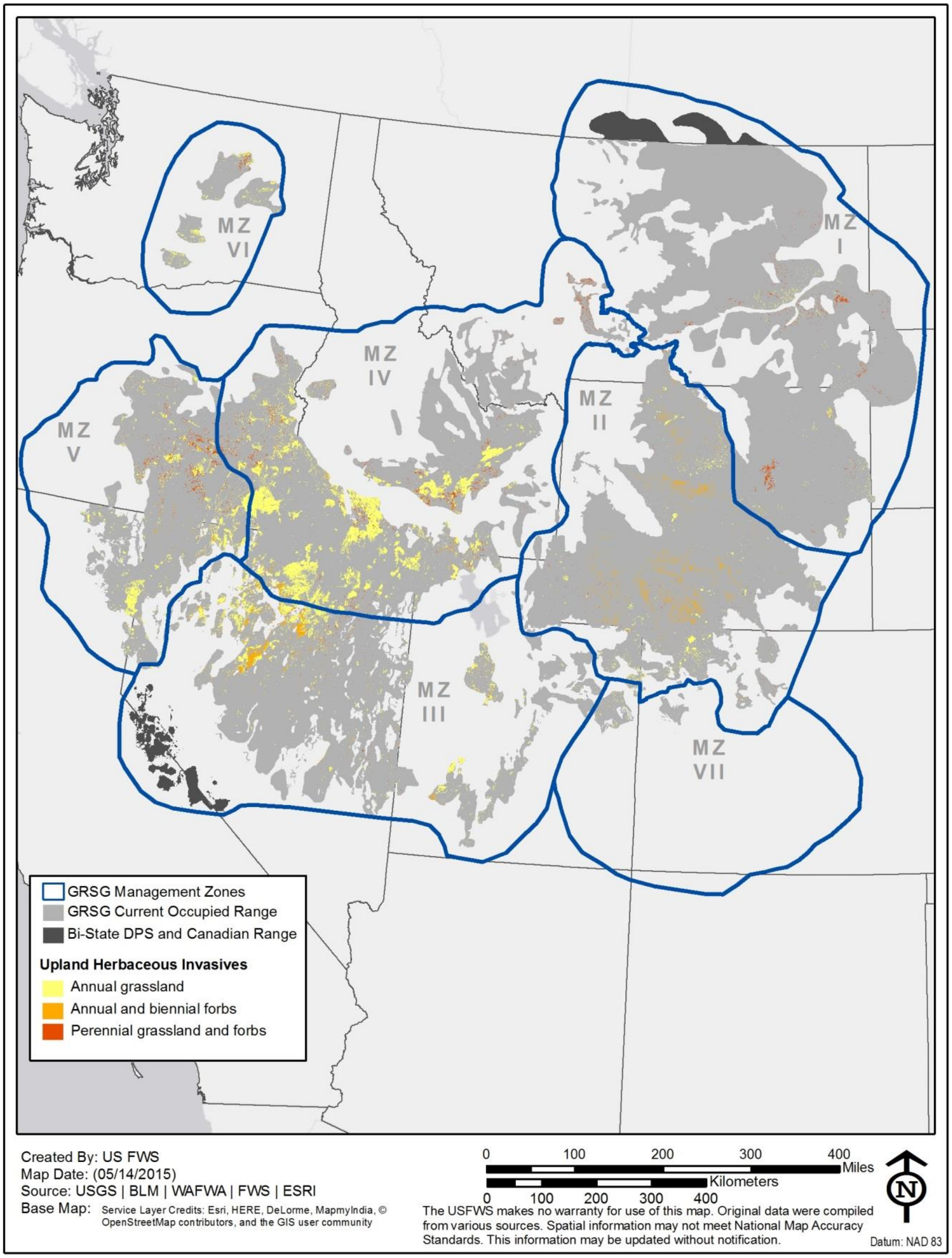

Figure 6-1. Distribution of upland, herbaceous invasive plants across the occupied range of greater sage-grouse.

Table 6-1. Acreage statistics for upland herbaceous invasive vegetation within greater sage-grouse occupied range by Management Zone.

Management Zone	Annual Grassland		Annual and Biennial Forbs		Perennial Grassland and Forbs		All Invasives	
	Acres	% of Occupied Range	Acres	% of Occupied Range	Acres	% of Occupied Range	Acres	% of Occupied Range
I[1]	182,576	0.4	2,183	0.0	220,292	0.5	405,051	0.9
II	462,392	1.2	747,046	2.0	43,451	0.1	1,252,889	3.4
III[1]	1,475,918	5.1	552,356	1.9	42,151	0.1	2,070,425	7.2
IV	4,690,973	12.1	156,580	0.4	469,290	1.2	5,316,843	13.8
V	1,267,256	6.6	64,785	0.3	289,386	1.5	1,621,426	8.4
VI	195,762	7.1	0	0.0	28,027	1.0	223,789	8.1
VII	44,371	3.8	0	0.0	3	0.0	44,374	3.8
Rangewide[1]	8,319,249	4.8	1,522,951	0.9	1,092,599	0.6	10,934,799	6.3

[1]Does not include the Bi-State DPS and Canadian portion of the range.

Table 6-2. Acreage statistics for upland herbaceous invasive vegetation within the modeled breeding habitat distribution for greater sage-grouse.

Management Zone	Annual Grassland		Annual and Biennial Forbs		Perennial Grassland and Forbs		All Invasives	
	Acres	% of Occupied Range	Acres	% of Occupied Range	Acres	% of Occupied Range	Acres	% of Occupied Range
I [1]	21,531	0.2	335	0.0	31,450	0.3	53,315	0.5
II	195,444	1.6	99,961	0.8	10,995	0.1	306,400	2.6
III [1]	205,930	2.4	37,499	0.4	20,513	0.2	263,942	3.1
IV	1,523,058	13.2	9,549	0.1	87,810	0.8	1,620,418	14.0
V	225,653	6.5	4,060	0.1	4,264	0.1	233,977	6.8
VI	48,231	4.4	0	0.0	20,747	1.9	68,978	6.3
VII	632	0.4	0	0.0	0	0.0	632	0.4
Rangewide [1]	2,220,478	4.7	151,405	0.3	175,779	0.4	2,547,662	5.4

[1] Does not include the Bi-State DPS and Canadian portion of the range.

Table 6-3. Percentage of the relative population index located within upland herbaceous invasive vegetation across the occupied range of the greater sage-grouse.

Management Zone	**Annual Grassland**	**Annual and Biennial Forbs**	**Perennial Grassland and Forbs**	**All Invasives**
	% of Population Index	**% of Population Index**	**% of Population Index**	**% of Population Index**
I[1]	tbd	tbd	tbd	
II	tbd	tbd	tbd	
III[1]	tbd	tbd	tbd	
IV	tbd	tbd	tbd	
V	tbd	tbd	tbd	tbd
VI	tbd	tbd	tbd	
VII	tbd	tbd	tbd	tbd
Rangewide[1]	tbd	tbd	tbd	

[1]Does not include the Bi-State DPS and Canadian portion of the range.

Table 6-4. Highest average (± standard error, or SE) ranks for relative invasion risk of priority plants and average abundance estimates grouped by management zone (MZ). Invasion risk values indicate these plants may continue to spread. Risk and abundance values were estimated by survey respondents based on the scale and site conditions of their management or administrative unit (from Ielmini *et al.* 2015, p. 34).

Management Zone	Plant Species	Relative Invasion Risk		Abundance Estimate	
		Rank[a] Mean (SE)	Risk Category	Rank[b] Mean (SE)	Abundance Category
I	Leafy spurge	4.6 (0.12)	Mod high to high	6.3 (0.19)	Many small infestations
	Canada thistle	4.2 (0.17)	Moderately high	6.5 (0.09)	Large infestations
	Spotted knapweed	4.1 (0.20)	Moderately high	5.2 (0.26)	Few small infestations
	Cheatgrass	3.9 (0.21)	Moderately high	6.1 (0.24)	Many small infestations
	Russian knapweed	3.6 (0.19)	Mod to moderately high	4.9 (0.22)	Few small infestations
II	Cheatgrass	4.4 (0.12)	Moderately high	6.4 (0.11)	Large infestations
	Whitetop	3.8 (0.15)	Mod to moderately high	5.8 (0.16)	Many small infestations
	Perennial pepperweed	3.8 (0.18)	Mod to moderately high	5.3 (0.24)	Few small infestations
	Leafy spurge	3.8 (0.18)	Mod to moderately high	4.9 (0.24)	Few small infestations
	Russian knapweed	3.7 (0.17)	Mod to moderately high	5.2 (0.23)	Few small infestations
III	Cheatgrass	4.4 (0.17)	Moderately high	6.8 (0.07)	Large infestations
	Whitetop	4.2 (0.15)	Moderately high	6.1 (0.17)	Many small infestations
	Perennial pepperweed	4.0 (0.17)	Moderately high	5.5 (0.26)	Few to many small
	Russian knapweed	4.0 (0.16)	Moderately high	5.6 (0.20)	Few to many small
	Spotted knapweed	3.8 (0.18)	Mod to moderately high	5.0 (0.22)	Few small infestations
IV	Cheatgrass	4.2 (0.13)	Moderately high	6.3 (0.13)	Many small infestations
	Spotted knapweed	4.1 (0.15)	Moderately high	5.6 (0.20)	Many small infestations
	Rush skeletonweed	4.0 (0.19)	Moderately high	4.7 (0.29)	Few small infestations
	Leafy spurge	3.8 (0.16)	Mod to moderately high	5.2 (0.21)	Few small infestations
	Medusahead	3.6 (0.18)	Mod to moderately high	4.1 (0.30)	Rare and high concern
V	Medusahead	4.5 (0.24)	Moderately high	6.1 (0.39)	Many small infestations
	Cheatgrass	4.3 (0.29)	Moderately high	6.5 (0.34)	Few large infestations
	Spotted knapweed	3.7 (0.36)	Mod to moderately high	4.6 (0.54)	Few small infestations
	Perennial pepperweed	3.6 (0.34)	Mod to moderately high	5.4 (0.44)	Few small infestations
	Whitetop	3.4 (0.30)	Moderate	5.3 (0.42)	Few small infestations
VI	Cheatgrass	4.2 (0.24)	Moderately high	6.3 (0.22)	Many small infestations
	Whitetop	3.8 (0.26)	Mod to moderately high	5.3 (0.28)	Few small infestations
	Rush skeletonweed	3.4 (0.47)	Moderate	4.0 (0.53)	Rare and high concern
	Diffuse knapweed	3.3 (0.28)	Moderate	5.9 (0.14)	Many small infestations
	Perennial pepperweed	3.2 (0.37)	Moderate	4.2 (0.37)	Rare and high concern
VII	Cheatgrass	4.2 (0.19)	Moderately high	6.5 (0.12)	Few to many large
	Yellow toadflax	4.0 (0.20)	Moderately high	5.9 (0.24)	Many small infestations
	Russian knapweed	4.0 (0.16)	Moderately high	5.6 (0.28)	Many small infestations
	Spotted knapweed	4.0 (0.19)	Moderately high	4.9 (0.26)	Few small infestations
	Canada thistle	3.9 (0.17)	Moderately high	6.3 (0.11)	Many small infestations

[a] Relative invasion risk ranks: 1, low risk; 2, moderately low risk; 3, moderate; 4, moderately high risk; 5, high risk.
[b] Abundance estimate ranks: 1, absent; 2, rare and low concern; 3, absent and high concern; 4, rare and high concern; 5, a few small infestations; 6, many small or few large infestations; 7, many large infestations.

Projected Future Impacts (Timescale, Likelihood of Future Impacts and Anticipated Changes from Present)

The changes in sagebrush ecosystem dynamics due to invasive annual species and longer, hotter, and drier fire seasons due to a warming climate make it unlikely that these threats can be ameliorated completely (Abatzoglou and Kolden 2011, p. 476). We anticipate invasive plants and associated fires will be on the landscape for the next 100 years or longer.
Increased fire frequency, facilitated by the spread of invasives (particularly nonnative annual grasses) will continue indefinitely unless an effective means for controlling invasives are found. To date, no broad scale cheatgrass eradication method has been developed. Rehabilitation and restoration techniques are largely unproven or experimental (Pyke 2011, p. 543). Effective restoration of sagebrush-steppe ecosystems will require many years to have a substantial impact in slowing or stabilizing this loss (Miller *et al.* 2011, p. 184). Therefore, given the history of invasive plants on the landscape, our continued inability to control such species, and the expansive infestation of invasive plants across the species' range currently, we anticipate invasives and associated fires will be on the landscape for the next 100 years or longer.
collected in the western half of the range, predictsed favorable conditions for cheatgrass across much of the sage-grouse's range under current and future (2100) climate conditions (Bradley *et al.* (2009, pp. 1511–1521; Bradley 2009, pp. 196–208). A strong indicator for future cheatgrass locations is the proximity to current locations (Bradley and Mustard 2006, p.1146) as well as summer, annual, and spring precipitation, and winter temperature (Bradley 2009, p. 196). In the future some areas may become unfavorable for cheatgrass while others may become favorable (Bradley *et al.* (2009, p. 1517) predicted. Specifically, climatically suitable cheatgrass habitat may shift northwards, leading to expanded risk in Idaho, Montana, and Wyoming, but reduced risk in southern Nevada and Utah (Bradley *et al.* (2009, p. 1515). Despite the potential for future retreat in Nevada and Utah, there will still be climatically suitable habitats for cheatgrass in these states, well within the range of sage-grouse (see Figure 4b in Bradley *et al.* 2009, p. 1517). Subsequent modelling documenting the probability of cheatgrass occurrence in the Great Basin (MZs III, IV, and V) suggests that the most serious risk of cheatgrass invasion lies in the Snake River Plains (Manier *et al.* 2013, p. 88). Observed and predicted warming trends may also lead to an increased susceptibility of cheatgrass invasion at higher elevation rangelands in the eastern portion of the species' range (e.g., Wyoming), particularly after a fire event (Mealor *et al.* 2012, p. 433).

Changes in climatic suitability may create restoration opportunities in areas that are currently dominated by invasives (Bradley *et al.* 2009, p. 1511). We anticipate that cheatgrass will eventually disappear from areas that become climatically unsuitable for this species, but this transition is unlikely to occur suddenly. Also, areas that become unfavorable to cheatgrass may become favorable to other invasives, such as *B. rubens* (red brome) in the southern Great Basin, which is more tolerant of higher temperatures (Bradley *et al.* (2009, p. 1519). Invasions into native plant communities may also be sequential, as the initial invaders are replaced by a series of new invasives or by species adapting to new habitats within their range (Young and Longland 1996, p. 390). For example, areas along the Snake River Plain and the Boise Front Range in Idaho, which were once dominated by cheatgrass, have been replaced by medusahead. Rush skeletonweed, which is typically localized to disturbed areas in xeric sagebrush-grassland communities, is now invading areas dominated by medusahead (Sheley *et al.* 1999, pp. 308–314) and following wildfire (Kinter *et al.* 2007, p. 393). Therefore, one cannot assume that areas that become unsuitable for cheatgrass will return to pre-invaded habitat conditions without significant effort.

Bradley *et al.* (2009, p. 1519) suggested that modeling and experimental work is needed to assess whether native species could occupy these sites if invasives are reduced or eliminated by climate change.

Like cheatgrass, the distribution of other invasives will likely shift with climate change. The range of spotted knapweed may expand in some areas, mainly in parts of Oregon, Idaho, western Wyoming, and Colorado, and may contract in other areas (e.g., eastern Montana) (Bradley *et al.* 2009, p. 1518). The range of yellow star-thistle is also predicted to expand eastward (Bradley *et al.* 2009, p. 1514) and that the invasion risk of leafy spurge will likely decrease in several states, including parts of Colorado and Idaho (Bradley *et al.* 2009, pp. 1516–1518).

Threat Amelioration

Conservation Efforts Database Projects

Through the CED, the Service collected information relating to conservation actions that were completed, in progress, or planned. A total of 1,181 projects addressing the threat of invasive plants were entered in the CED as "completed" by data providers. These projects totaled more than 500,000 ha (1.3 million ac) rangewide, with the greatest total effort in MZ V (Appendix D). Conservation efforts that were deemed effective through Service review totaled 108,026 ha (266,939 ac; Table 6-5)

Table 6-5. Summary of completed and effective projects evaluated by the Service and deemed effective in addressing invasive plants. Acres for one project were reported for multiple MZs; this number of acres is reflected only once in the table total.

Management Zone	Conservation Effort	ha (ac)	km (mi i)
I	unique acres (MZ & threat)[1]	0	0
	same acres & MZ, > 1 threat[2]	0	0
	same acres, > 1 MZ, >1 threat[3]	68,797 (170,000)	0
II	unique acres (MZ & threat)[1]	839 (2,072)	0
	same acres & MZ, > 1 threat[2]	0	0
	same acres, > 1 MZ, >1 threat[3]	68,797 (170,000)	0
III	unique acres (MZ & threat)[1]	2,256 (5,576)	0
	same acres & MZ, > 1 threat[2]	669 (1,654)	0
	same acres, > 1 MZ, >1 threat[3]	0	0
IV	unique acres (MZ & threat)[1]	14,157 (34,984)	0
	same acres & MZ, > 1 threat[2]	21,308 (52,653)	0
	same acres, > 1 MZ, >1 threat[3]	68,797 (170,000)	0
V	unique acres (MZ & threat)[1]	0	2 (1.30)
	same acres & MZ, > 1 threat[2]	0	0
	same acres, > 1 MZ, >1 threat[3]	0	0
VI	unique acres (MZ & threat)[1]	0	0
	same acres & MZ, > 1 threat[2]	163 (403)	0
	same acres, > 1 MZ, >1 threat[3]	0	0
VII	unique acres (MZ & threat)[1]	0	0
	same acres & MZ, > 1 threat[2]	69 (171)	0
	same acres, > 1 MZ, >1 threat[3]	0	0

TOTALS	108,026 (266,939)	2 (1.30)

[1]projects in one MZ addressing one threat
[2] projects in one MZ addressing more than one threat
[3] projects crossing more than one MZ addressing more than one threat

Candidate Conservation Agreements with Assurances and Candidate Conservation Agreements

In addition to the conservation efforts discussed above, lands currently enrolled in CCAAs include restrictions on planting and introduction of invasives and require control and treatment of existing and newly documented invasive plants. Approximately 0.17 percent of occupied range in MZ I, 0.78 percent of MZ II, 2.47 percent of MZ IV, and 4.67 percent of MZ V are enrolled in CCAAs in Wyoming and Oregon. Federal lands enrolled in CCAs in Wyoming, Oregon, and Idaho account for 0.04 percent of occupied range in MZ I, 0.21 percent of MZ II, 3.13 percent of MZ IV, and 4.67 percent of MZ V. See the ***Non-regulatory Conservation Efforts*** section and Table 28-7 for approximate acreages and additional information.

State Plans

On state lands in Idaho and on Federal lands in Utah, existing regulations reduce habitat loss due to noxious weeds and invasive annual grasses in these states. If implemented, Idaho's state plan would enforce a commitment to cooperate with partners to treat invasives and implement other conservation actions to reduce noxious weeds on adjoining Federal lands (Idaho Department of Lands 2015, p. 24). In conjunction with fire suppression resources and Utah's rehabilitation and reseeding program, Utah's state plan uses fire plans, prioritization measures, and conservation efforts to reduce habitat loss associated with noxious weeds (State of Utah 2013, pp. 12–14). Therefore, regulations in Idaho and Utah reduce the threat of noxious weeds and invasive annual grasses in those States on applicable lands.

If enacted, regulations in Montana's state plan would effectively reduce habitat loss from invasive plants on Montana State lands. Montana's state plan would require monitoring after wildfire to ensure that sagebrush communities reestablish, would prioritize noxious weed treatments in core areas, require weed-free seed mixtures in core areas, and would require weed control along pipelines (State of Montana 2014, pp. 7, 12, 15). In conjunction with other State invasive and noxious weed management laws, Montana's state plan would effectively reduce habitat loss due to noxious weeds and invasive annual grasses on State lands.

Although not a regulatory mechanism, Colorado's state plan identifies responsible partners, conservation measures, and objectives for communication and coordination to address the threat of noxious weeds and invasive annual grasses on all lands in Colorado (Colorado Division of Wildlife 2008, pp. 425–427). Three projects in Colorado effectively reduced noxious weeds and improved native habitats (Colorado Department of Natural Resources 2013, pp. 1–3), and similar projects across larger areas could also potentially reduce the threat of noxious weeds. Although these efforts are in place and helped reduce habitat loss due to noxious weeds and invasive annual grasses in Colorado, they are entirely voluntary and are not regulatory mechanisms. A summary of state regulations and conservation plans addressing invasives, and other threats is in the Regulatory Mechanisms chapter (pp.X).

BLM Resource Management Plans and USFS Land and Resource Management Plans

The BLM and USFS plans incorporate the FIAT process in addition to assessing invasive annual grass infestation prior to any treatments, resting of treatment areas prior to the reintroduction of cattle, investigating use of biological controls, using genetically-appropriate native seeds during restoration, and monitoring and adjustment of treatment sites and methods as needed to prevent the spread of invasives. For additional details, see additional discussion on FIAT in the ***Non-regulatory Conservation Efforts*** section and BLM/USFS plans in the ***Regulatory Mechanisms*** section.

Threat Amelioration Summary

Many efforts are ongoing to restore or rehabilitate sage-grouse habitat affected by invasive species. Common rehabilitation techniques include first reducing the density of invasives using herbicides, targeted grazing, pathogenic bacteria and other forms of biocontrol, or prescribed fire (Tu *et al.* 2001, entire; Larson *et al.* 2008, p. 250; Pyke 2011, pp. 543–544). Sites are then typically reseeded with grass and forb mixes, and sometimes planted with sagebrush plugs. Despite ongoing efforts to transform lands dominated by invasive annual grasses into quality sage-grouse habitat, restoration and rehabilitation techniques are considered to be mostly unproven and experimental (Pyke, 2011, p. 543). Several components of the restoration process are being investigated with varying success (Pyke 2011, p. 543). Of particular importance is the development of methods that eliminate or reduce the distribution and abundance of invasive plants and also promote the re-establishment and productivity of native, herbaceous species (Hanser and Manier 2013, p. 31). Some techniques show promise, such as use of the herbicide Imazapic to control cheatgrass and other nonnative annual grasses (Kyser *et al.* 2007, p. 66). However, further analyses of the benefit of this method still need to be conducted (Pyke 2011, p. 543). Also, it will take time for sagebrush to establish and mature in areas currently dominated by invasive annual grasses. The use of biological control agents (e.g., *Psudomonas flurescens* strains; Kennedy *et al.* 2001, pp. 792–797 and *Pyrenophora seminiperda*; Meyer *et al.* 2001, p. 54) is also promising but test applications are not ready for management and implementation. Rehabilitation and restoration efforts also are hindered by cost and the ability to procure the equipment and seed needed for projects (Pyke 2011, p. 544). Furthermore, while restoration projects for other species may depend on a single site or landowner, restoration of sage-grouse habitat requires partnerships across multiple ownerships and jurisdictions in order to restore and maintain a connective network of intact vegetation (Pyke 2011, p. 548). Regardless, the limitations of ongoing efforts to transform sagebrush-steppe communities dominated by invasives into quality sage-grouse habitat, restoration is occurring and localized weed treatments have been applied across all sage-grouse MZs within the range of the species.

A variety of regulatory mechanisms and nonregulatory measures to control invasive plants exist. However, no single Federal law or combination of policies provides clear authority or coordination among Federal agencies to address invasive species (Corn and Johnson 2013, p. 1) and the extent to which these mechanisms effectively ameliorate the current rate of invasive expansion is unclear. From a regulatory standpoint, only invasive plant species listed on Federal or State "noxious weed" lists are required to be managed. For example, only Oregon, California, Colorado, Utah, and Nevada list medusahead as a noxious regulated weed (Center for Invasive Species Management 2015), but other states with the range of sage-grouse are at risk of invasion by medusahead (e.g., Washington, Idaho). Cheatgrass is not listed as a Federal noxious weed and is largely unregulated by the States (Ielmini *et al.*

2015, p. 15). Colorado is the only western state that lists cheatgrass as a noxious weed (Center for Invasive Species Management 2015). These laws may provide some protection for sage-grouse habitats, although large-scale control of invasive plants is not occurring, and rehabilitation and restoration techniques are mostly unproved and experimental (Pyke 2011, p. 543).

The average rates of spread of invasive plants are difficult to determine because very little information is available describing the accurate abundance of invasive plant distributions in the western U.S. However, it is widely accepted that the spread of invasive plants is exceeding treatment rates conducted by most county, State, and Federal weed management programs (Ielmini *et al.* 2015, p. X). If noxious weeds are spreading at a rate of 931 ha (2,300 ac) per day on BLM-administered lands (BLM 1996, p. 1), this amounts to 339,815 ha (839,500 ac) per year, representing an increase of about 8 to 20 percent annually (Federal Interagency Committee for the Management of Noxious and Exotic Weeds 1997, p. v). However, this estimate includes both suitable and nonsuitable habitat for sage-grouse and it is unclear whether this estimate is limited to noxious weeds or if it includes other invasives (e.g., cheatgrass). Regardless, we can compare this estimate to the area of all invasives (excluding conifers) treated by the BLM between October 2005 and September 2007, which totaled 259,897 ha (642,216 ac), i.e., approximately 86,632 ha (214,072 ac) treated annually.

The number of acres treated annually (86,632 ha; 214,072 ac) is not keeping pace with the rate of spread (339,815 ha; 839,500 ac), especially when considering the inability to treat the threat.

The National Invasive Species Council (2008, p. 8) acknowledges that there has been a significant increase in activity and awareness, but much remains to be done to prevent and mitigate the problems caused by invasive species. As an example, the State of Montana has made much progress through partnerships in reducing noxious weeds in the State from 3.2 million ha (8 million ac) in 2000 to 3.1 million ha (7.6 million ac) in 2008 (Montana Weed Control Association 2008). However, the Montana Noxious Weed Summit Advisory Council Weed Management Task Force (2008, p. III) estimates that to slow weed spread and reduce current infestations by 5 percent annually, they require 2.6 times the current level of funding from a variety of private, local, State, and Federal sources (or 55.8 million dollars versus 21.2 million dollars). In addition to funding, other factors that potentially limit ability to control invasives include the amount of available native seed sources, the time it takes to restore sagebrush to an area once it is removed from a site, and the existence of treatments that are known to be effective in the long-term. Monitoring is limited in many cases and, where it occurs, monitoring typically does not document the population response of sage-grouse to these treatments.

Federal agencies duties and responsibilities for addressing invasive species are currently directed under Executive Order 13112. This Executive Order, when coupled with other Federal authorities, laws, regulations, and policies, requires Federal agencies to establish, coordinate, and implement better invasive species management programs across the U.S. However, individual Federal agency policies on invasive species management vary widely. In addition to broadly defining the duties of Federal agencies, the Executive Order established a National Invasive Species Council (NISC) to coordinate the Federal response, a non-Federal Invasive Species Advisory Committee operating under the Federal Advisory Committee Act, and the development of a National Invasive Species Management Plan (initially released in 2001 and updated in 2008) to guide Federal agency activities. However, the management plans have not driven Federal agency priorities nor have they provided a mechanism for increasing Federal funding for invasive species research or management. As a result, Federal invasive species research and management programs remain largely uncoordinated, and highly variable in structure, capacity, and functionality (Ielmini *et al.* 2015, p. 10). To date, NISC has not met since 2008, and an update to the national plan (which expired in 2012) has not yet been completed. Federal funding for the management activities necessary to implement policy and effectively counter the establishment and spread of invasives is lacking, particularly the western U.S., causing many Federal research and management programs to be curtailed or significantly reduced in both scale and scope. In some cases, the budgetary discretion given to agencies allows the diversion of dedicated invasive species funds for other uses, often creating additional pressures on invasive plant management program capacity (Ielmini *et al.* 2015, p. 13).

The BLM uses regulatory mechanisms to address invasive species concerns, particularly through the NEPA process. For projects proposed on BLM-administered rangelands, BLM has the authority to identify and prescribe best management practices for weed management; where prescribed, these measures must be incorporated into project design and implementation. Some common best management practices for weed management may 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.

The BLM conducts treatments for noxious and invasive weeds on BLM-administered lands, the most common being reseeding through the Emergency Stabilization and Burned Area Rehabilitation Programs. As with other agencies and organizations, the extent to which these measures are implemented depends in large part on funding, staff time, and other regulatory and non-regulatory factors. Therefore, we cannot assess their value as regulatory mechanisms for the conservation of sage-grouse. Herbicides also are commonly used on BLM-administered lands to control invasives, but the BLM abides by State pesticide law requirements (e.g., some states may have label restrictions for the active ingredient and/or the active ingredient is not authorized for use). In 2007, the BLM completed a programmatic EIS (72 FR 35718) and record of decision (72 FR 57065) for vegetation treatments on BLM-administered lands in the western U.S. This program guides the use of herbicides for field-level planning, but does not authorize any specific on-the-ground actions; site-specific NEPA analysis is still required at the project level.

In the absence of Federally-led coordination, important regional efforts have emerged. In 2014, the WAFWA Initiative began developing a status report (Ielmini *et al.* 2015, entire) on invasive species management practices and recommendations to restore sage-grouse and its habitats. The Initiative, through the Great Basin Landscape Conservation Cooperative, contracted with Center for Invasive Species Management (CISM; Montana State University, Bozeman, MT) to develop and administer an on-line assessment, and to gather and analyze data on the specific characteristics and functions of invasive plant management programs within the current and historic range of sage-grouse. The on-line assessment provided information used to document the status and function of local, State and Federal invasive plant management programs, encompassing 11 western states, with additional information and data provided by western weed management experts. Using this information, the WAFWA report (Ielmini *et al.* 2015, entire) described the infrastructure, activities, and challenges of the western weed management community and offered recommendations to improve sage-grouse conservation.

The FIAT, restoration and resilience matrix (Chambers *et al.* 2014c, p. 20), and Secretarial Order 3336, offer other examples of coordinated efforts to develop a regional invasive plant management strategy linked to sagebrush restoration and sage-grouse conservation. The purpose of the FIAT assessment (BLM 2014, entire) is to identify priority habitat areas and management strategies to reduce the threats to sage-grouse resulting from impacts of invasive annual grasses, wildfires, and conifer expansion. The basis of the FIAT protocol is recent scientific research on resistance and resilience of Great Basin ecosystems (Chambers *et al.* 2014c, entire). Chambers *et al.* (2014c, entire) developed a strategic approach that integrates both landscape prioritization and site-scale decisions tools for the conservation of sagebrush habitats across the range of sage-grouse, with an emphasis on the western portion of the range. The use of landscape cover of sagebrush as an indicator of sage-grouse habitat, and the use of soil temperature and moisture regimes as an indicator of landscapes resilient to disturbance and resistant to invasive annual grasses can be used together to determine potential management strategies at the landscape scales at which sage-grouse depends (Wisdom and Chambers 2009, p. 740; Chambers *et al.* 2014c, p. 12).

On January 6, 2015 the Secretary of Interior issued Secretarial Order 3336 calling for a comprehensive science-based strategy to address the more frequent and intense wildfires in the Great Basin region. The Order establishes enhanced policies and strategies for preventing and suppressing rangeland fires and for restoring sagebrush landscapes impacted by fire. This Secretarial Order also identifies invasive plants as an important issue that needs to be addressed.

The Western Weed Coordinating Committee (WWCC) serves in a leadership role to help coordinate local, State, and Federal invasive plant management activities, and facilitate communication and collaboration strategically across the West. State, Federal, and provincial invasive plat management agencies are the principle members of the WWCC. Other public and private invasive plant management organizations can be valuable partners for sage-grouse conservation and sagebrush-steppe restoration, particularly in regard to on-the-ground management activities within Cooperative Weed Management Areas (CWMAs). CWMAs provide a voluntary approach to control invasive species across the range of sage-grouse. CWMAs are partnerships between Federal, State, and local agencies, tribes, individuals, and interested groups to manage both species designated by State agencies as noxious weeds, and invasive plants in a county or multi-county geographical area.

For additional details see additional discussion in the ***Non-regulatory Conservation Efforts*** section.

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Assessment of Potential Threat

In our 2010 warranted but precluded finding we found that invasives were a serious rangewide threat, and one of the highest risk factors for sage-grouse. Based on the ability of invasive annual grasses to out-compete sagebrush and native perennial bunchgrasses, the inability to effectively control invasives once they become established, and the synergistic interaction between invasive plants and other risk factors on the landscape (e.g., wildfire, anthropogenic land use) the concerns presented by this stressor will continue and likely influence persistence of sage-grouse, particularly in the western part of the species' range. Invasives reduce and eliminate vegetation that is essential for sage-grouse to use as food and cover. Their presence on the landscape has removed and fragmented sage-grouse habitat. Because invasives are widespread, have the ability to spread rapidly, occur near areas susceptible to invasion, and are difficult to control, we anticipate that invasives will continue to replace and reduce the quality of sage-grouse habitat across the range in the foreseeable future. There have been many studies addressing effective invasive control methods, as well as conservation actions to control invasives, with varied success. While some efforts appear successful at smaller scales, prevention (e.g., early detection and fire prevention) appears to be the only known effective tool to preclude or minimize large-scale habitat loss from invasive species in the future.

CHAPTER 7: CONIFER ENCROACHMENT

Pinyon-juniper woodlands are a native habitat type dominated by pinyon pine and various juniper species that can encroach upon, infill, and eventually replace sagebrush habitat. These two woodland types are often referred to collectively as pinyon-juniper; however, some portions of the sage-grouse's range are only impacted by juniper encroachment.

Pinyon-juniper expansion into sagebrush habitats, with subsequent replacement of sagebrush communities, has been well documented (Miller *et al.* 2000, p. 575; Connelly *et al.* 2004, p. 7-5; Crawford *et al.* 2004, p. 2; Miller *et al.*. 2008, p. 1). Prior to 1860, two-thirds of the Great Basin was treeless and occupied by sagebrush-steppe communities (Miller *et al.* 2008, p. 13). Increases in post-European settlement conifer expansion began in the mid-to late 1800s, influencing high elevation sagebrush-steppe communities across the range of sage-grouse (Miller *et al.* 2011, p. 167). The initial increase in conifer establishment in the 1800s did not have an immediate effect on sagebrush habitats until the density and size of trees resulted in declines in shrub cover (Miller *et al.* 2011). Based on past trends and the current distribution of pinyon-juniper relative to sagebrush habitat, we anticipate that expansion will continue at varying rates across the landscape and cause further loss of sagebrush habitat within the western part of the sage-grouse's range, especially in parts of MZs III, IV, and V.

While pinyon-juniper expansion appears less problematic in the eastern portion of the range (MZs I, II and VII) and silver sagebrush communities (primarily MZ I), conifer encroachment is an impact mentioned in Wyoming, Montana, and Colorado state sage-grouse conservation plans, indicating that this is of some concern in these states as well (Stiver *et al.* 2006, p. 2-23). Colorado's State plan mapped areas threatened by pinyon-juniper encroachment in northwestern Colorado, and specifically attributed some sage-grouse habitat loss in Colorado to pinyon-juniper expansion (Colorado Greater Sage-grouse Steering Committee 2008, pp. 179, 182). Furthermore, LANDFIRE data (LANDFIRE 1.3.0) illustrates extensive coverage of pinyon-juniper woodlands in parts of northwestern Colorado within the range of sage-grouse (Figure 7-1). These data also show limited pinyon-juniper coverage in Montana and Wyoming; however, LANDFIRE data could be a major underestimate of juniper because it is difficult to classify pinyon-juniper woodlands with satellite imagery when the trees occur at low densities (Hagen 2005, p. 142).

Current Impacts

Pinyon-juniper extent has increased 10-fold in the Intermountain West since European settlement causing the loss of many native perennial bunchgrass and sagebrush-bunchgrass communities (Miller and Tausch 2001, pp. 15–16). This expansion has been attributed to the reduced role of fire and the introduction of domestic livestock grazing, particularly during the late 1800s and early 1900s; however, these factors may not entirely explain the expansion of western juniper (Soule and Knapp 1999, entire). Conifer encroachment may be facilitated by increases in global CO_2 concentrations, climate change, and natural recovery from past disturbance (Miller and Rose 1999, pp. 555–556; Miller and Tausch 2001, p. 15; see ***Fire*** chapter) but the influence of CO_2 has not been supported by some research (Archer *et al.* 1995, entire).

Miller *et al.* (2005, p. 24) characterized three stages of woodland succession: Phase I, where conifer are present but shrubs and herbaceous species remain the dominant vegetation that influence ecological processes (e.g., hydrologic, nutrient and energy cycles); Phase II where conifer are codominant with shrubs and herbaceous species, resulting in modifications of ecological processes; and Phase III where conifer becomes the dominant species, with significantly reduced shrub canopy cover and herbaceous species diversity.

Today, conifer encroachment is largely an infill issue, where Phase I sites are becoming Phase II sites, and Phase II sites are maturing into Phase III sites. Approximately 80 percent of sites invaded by conifers are still in Phase I and Phase II, where some native shrubs and bunchgrasses are present (Miller *et al.* 2008, p. 9). Miller *et al.* (2005, p. 25) estimated the minimum time for the juniper overstory to begin suppressing the understory is 45 to 50 years and approach stand closure 70 to 90 years on cool, mesic sites compared to 120 to 170 years on warm, xeric sites. Crossing the ecological threshold through the successional transition of sagebrush habitats from Phase II to Phase III is especially concerning because treatment options become more limited in Phase III (Johnson and Miller 2006, p. 8).

Conifer expansion presents a stressor to sage-grouse because sites invaded by conifers do not provide suitable sage-grouse habitat. For example, when juniper increases in mountain big sagebrush communities, shrub cover declines and the season of available succulent forbs is shortened due to soil moisture depletion (Crawford *et al.* 2004, p. 8). Trees may also offer perch sites for avian predators, potentially increasing the predation risk (see ***Predation*** chapter).

Commons *et al.* (1999, p. 238) found that the number of male Gunnison sage-grouse on leks in southwestern Colorado doubled after pinyon-juniper removal and mechanical treatment of mountain sagebrush and deciduous brush. Because the behavioral response of Gunnison sage-grouse is likely similar to that of greater sage-grouse , we infer that some greater sage-grouse populations have been negatively affected by pinyon-juniper encroachment and that some populations will decline in the future due to projected increases in the pinyon-juniper type, especially in areas where pinyon-juniper encroachment is a landscape-scale threat (parts of MZs III, IV, and V). Doherty *et al.* (2008, p. 187) reported a strong avoidance of conifers by female sage-grouse in the winter, further supporting our previous inference. Freese's (2009, pp. 84–85, 89–90) found that sage-grouse in central Oregon used areas with less than 5 percent juniper cover more often in the breeding and brood-rearing seasons than similar habitat that had greater than 5 percent juniper cover. Therefore, pinyon-juniper encroachment into occupied sage-grouse habitat reduces, and likely eventually eliminates, sage-grouse occupancy in these areas.

Baruch-Mordo *et al.* (2013, p. 239) suggest that sage-grouse incur population-level impacts at very low levels of encroachment and found no leks remained active when conifer canopy cover exceeded 4 percent. This pattern corresponds with other findings of a negative relationship, or avoidance, of conifer habitat affecting all sage-grouse life stages (i.e., nesting, brood-rearing, and wintering; e.g., Doherty *et al.* 2008, p. 187; Atamian *et al.* 2010, pp. 1537–1538; Doherty *et al.* 2010 p. 1547; Casazza *et al.* 2011, p. 163). Knick *et al.* (2013, p. 1544) found that almost all leks were in areas containing little conifer cover in the surrounding landscape. Active leks were absent from areas with greater than or equal to 40 percent conifer and averaged less than 1 percent conifer woodland within 5 km (3 mi), compared to an average of 13 percent for the study area and 3.4 percent for historic sage-grouse locations that are currently unoccupied (Knick *et al.* 2013, pp. 1544–1545).

Location and extent

Pinyon-juniper woodlands are often associated with sagebrush communities (Miller *et al.* 2008, p. 1) and currently occupy at least 18 million ha (44.6 million ac) of the Intermountain West within the sage-grouse's range (Crawford *et al.* 2004, p. 8; Miller *et al.* 2008, p. 1). Based on 1999–2012 imagery (LANDFIRE 1.3.0), approximately 4.7 million ha (over 11.5 million ac) of conifer woodlands occur within the current range of sage-grouse (Table 7-1), comprising over 6 percient of the current occupied range. Conifer encroachment is a landscape scale threat in parts of MZ III, IV, and V, affecting millions of acres of habitat, but is present at least locally in all MZs (USFWS 2013, pp. 23–36).

Few studies have documented conifer woodland dynamics at the landscape scale across different ecological provinces, creating some uncertainty regarding the total amount of expansion that has occurred in sagebrush communities (Miller *et al.* 2008, p. 1). Regardless, we know that up to 90 percent of existing woodland in the sagebrush-steppe and Great Basin sagebrush vegetation types were previously dominated by sagebrush vegetation prior to the late 1800s (Miller *et al.* 2011, pp. 155–157). Based on past trends and the current distribution of pinyon-juniper relative to sagebrush habitat, we anticipate that expansion will continue at varying rates across the landscape and cause further loss of sagebrush habitat within the western part of the sage-grouse's range, especially in parts of MZs III, IV, and V.

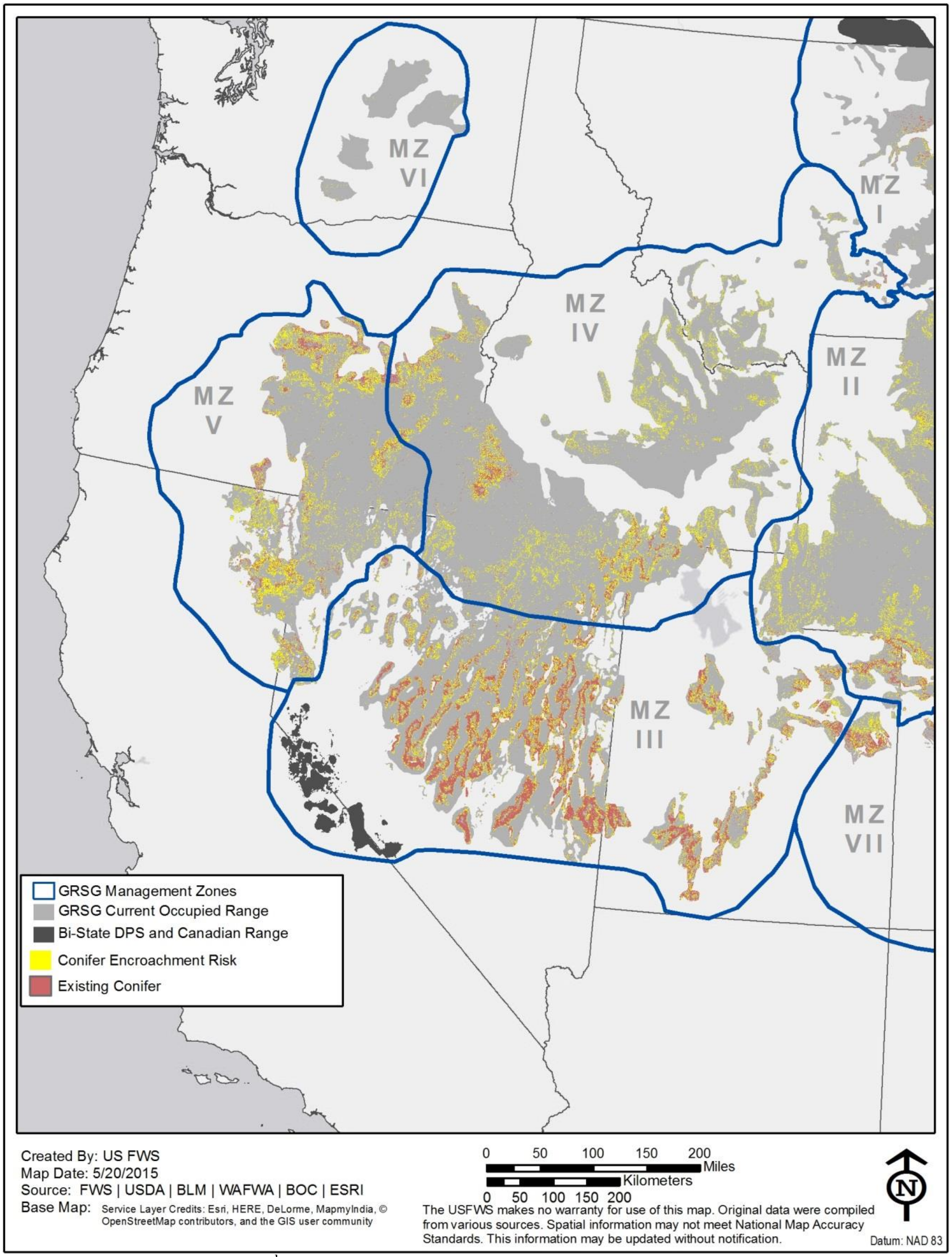

Figure 7-1. Conifer[a] occurrence[b] and potential encroachment[c] within the Great Basin region of greater sage-grouse occupied range.

[a] Include pinyon pine, juniper, and other conifers.

[b] Using LANDFIRE data.

[c] Using GAP data to identify sagebrush within 120-meters of existing conifer.

[INSERT TABLE]

Table X-1. Acres of conifer woodland and percent of current range, by management zone

Projected Future Impacts (Timescale, Likelihood of Future Impacts, and Anticipated Changes from Present)

Native conifers are expanding and infilling their current range mainly due to decreased fire return intervals, livestock grazing, and increases in global CO_2 concentrations associated with climate change, among other factors. Climate change will likely alter the range of individual invasive species, including pinyon and juniper, increasing fragmentation and habitat loss of sagebrush communities. Despite the potential shifting of individual species, native conifers will persist and continue to spread rangewide in the foreseeable future and we anticipate pinyon-juniper expansion into sage-grouse habitat will continue for the next 100 years or longer.

The pattern and rate of woodland expansion into sagebrush habitat is difficult to measure and varies according to landscape gradients such as topography and productivity as well as climate patterns that favor tree establishment (Weisberg *et al.* 2007, p. 123). The probability of conifer displacing sagebrush communities increases where seed sources are nearby (Miller *et al.* 2011, p. 167). Modeling suggest that sites within 1,000 m (3,280 ft.) of pinyon-juniper have the greatest (20 percent) risk of expansion and locations beyond 1,000 m (1,000 to 2,000 m; 3,280 to 6550 ft.), experience one-half of this potential (Bradley 2010, p. 202). Thus, sagebrush habitats in close proximity (250 m; 820 ft.) to existing pinyon-juniper may have increased invasion risk due to the proximity of the seed source (Manier *et al.* 2013, p. 92). Manier *et al.* (2013, p. 92) estimated 6 to 13 percent of sage-grouse habitat across all MZs may be at risk of conifer encroachment. The most pronounced risks are across the Great Basin (approximately 13 percent and 10 to 12 percent for southern and northern Great Basin region, respectively; MZs III and V) (Manier *et al.* 2013, p. 92). The estimated area of conifer expansion is predicted to be smaller in the Snake River Plain (MZ IV; 7 to 8 percent for PHMA and GHMA, respectively) and Wyoming Basin (MZ II; 6 to 7 percent, for PHMA and GHMA habitats, respectively) (Manier *et al.* 2013, p. 92). Although not all areas will be invaded uniformly or completely in the MZs identified above, Manier *et al.*'s (2013, p. 93) risk assessment identified large portions of sage-grouse habitat in MZs III, IV, and V at risk of conifer invasion based on proximity to seed sources.

Connelly *et al.* (2004, pp. 7-8 to 7-14) estimated that approximately 60 percent of sagebrush in the Great Basin was at low risk of displacement by pinyon-juniper in 30 years, 6 percent at moderate risk, and 35 percent at high risk. Mountain big sagebrush appears to be most at risk of pinyon-juniper displacement (Connelly *et al.* 2004, p. 7-13). As with cheatgrass (see ***Invasive Plants*** chapter,), the Great Basin appears more susceptible to conifer encroachment than other portions of the sage-grouse's range; however, Connelly *et al.* (2004, p. 7-8) cautioned that a formal analysis of the risks posed in other locations was needed before such inferences could be made. Miller *et al.* (2008, p. 12) reported that without intervention, 75 percent of conifer encroachment in the western portion of the sage-grouse range may transition into Phase III within the next 30–50 years.

Annual encroachment rates that were reported in five studies ranged from 0.3 to 31 trees per ha (0.7 to 77 trees per ac) (Sankey and Germino 2008, p. 413). For the three studies that measured the percent increase in juniper cover per year, cover increased between 0.4 and 4.5 percent annually (Sankey and Germino 2008, p. 413). Sankey and Germino (2008, p. 413) compared juniper encroachment rates from previous research to their study. Their estimate that juniper cover increased 0.7 to 1.5 percent annually was based on a 22 to 30 percent increase in cover between 1985 and 2005 at their southeastern Idaho study site (Sankey and Germino 2008, pp. 412-413).

Long-term changes in climate that facilitate conifer encroachment may accelerate the loss of sagebrush habitats. Approximately 12 percent of the current distribution of sagebrush is predicted to be replaced by woody vegetation for each 1 degree increase in temperature (Nielson *et al.* 2005 cited in Miller *et al.* 2011, p. 145). Based on past trends and the current distribution of pinyon-juniper relative to sagebrush habitat, we anticipate that expansion will continue at varying rates across the landscape and cause further loss of sagebrush habitat within the western part of the sage-grouse's range, especially in parts of MZs III, IV, and V (Figure 7-1).

Threat Amelioration

Conservation Efforts Database Projects

Through the CED, the Service collected information relating to conservation actions that were completed, in progress, or planned. A total of 556 projects addressing conifer encroachment were entered in the CED as "completed" by data providers. These projects occur across most of the range of sage-grouse and total more than 141,640 ha (350,000 ac), with most of the efforts occurring in MZs III, IV, and V (Appendix D). Of the projects deemed completed by the project proponents, the Service reviewed projects in MZs III, IV, V, and VII for effectiveness as these MZs are the key areas in the sage-grouse range where this threat occurs, or is likely to occur (Table 7-2)

Table 7-2. Summary of projects determined to be effective in the Service evaluation of completed CED projects addressing conifer encroachment. Some of the projects addressed more than one threat, or spanned more than one MZ. These are indicated separately with footnotes. Most projects involved the removal of conifers.

Management Zone	Conservation Efforts	ha (ac)
III	unique acres (MZ & threat) [1]	16,533 (40,904)
	same acres & MZ, > 1 threat [2]	11,917 (29,448)
	same acres & >MZ, > 1 threats [3]	0
IV	unique acres (MZ & threat) [1]	26,506 (65,497)
	same acres & MZ, > 1 threat [2]	2,444 (6,040)
	same acres & >MZ, > 1 threats [3]	450 (1,111)
V	unique acres (MZ & threat) [1]	20,689 (51,123)
	same acres & MZ, > 1 threat [2]	1,380 (3,411)
	same acres & >MZ, > 1 threats [3]	450 (1,111)
VII	unique acres (MZ & threat) [1]	1356 (3,350)
	same acres & MZ, > 1 threat [2]	0
	same acres & >MZ, > 1 threats [3]	0

TOTAL	**81,745 (**201,996)

[1] projects in one MZ addressing one threat
[2] projects in one MZ addressing more than one threat
[3] projects crossing more than one MZ addressing more than one threat

Candidate Conservation Agreement with Assurances and Candidate Conservation Agreements

In addition to these conservation efforts, lands currently enrolled in CCAAs require removing undesirable conifers encroaching into sage-grouse habitats. Approximately 0.17 percent of occupied range in MZ I, 0.78 percent of MZ II, 2.47 percent of MZ IV, and 4.67 percent of MZ V are enrolled in CCAAs in Wyoming and Oregon. Federal lands enrolled in CCAs in Wyoming, Oregon, and Idaho account for 0.04 percent of occupied range in MZ I, 0.21 percent of MZ II, 3.13 percent of MZ IV, and 4.67 percent of MZ V. See the ***Non-regulatory Conservation Efforts*** section and Table 28-7 for approximate acreages and additional information.

State Plans

State plans in Idaho and Utah include regulatory mechanisms that reduce conifer encroachment on applicable lands within each state. Montana's state plan would include similar regulatory mechanisms if enacted. If implemented, Idaho's state plan contains conservation measures and restoration guidelines to reduce conifer encroachment on State trust lands (Idaho Department of Lands 2015, p. 23). Utah's state plan calls for the aggressive removal of encroaching conifers and other plant species to expand sage-grouse habitats and provides annual targets to increase habitats (State of Utah 2013, p. 4). However, these Utah regulations apply only to State and Federal lands and are entirely voluntary on private, School and Institutional Trust Lands Administration (SITLA) and local government lands. With the Governor's mandate, Montana's state plan would direct agencies that manage sagebrush to adopt management plans and authorization stipulations so there is no net expansion of conifers in core areas and to remove conifers within at least 0.6 mile of leks and without significantly impacting sagebrush (State of Montana 2014, p. 17). Utah's plan reduces, and plans in Montana and Idaho would effectively reduce the threat of conifer encroachment on applicable lands in these states.

Colorado's state plan contains objectives to reduce conifer encroachment near three sage-grouse populations and to refine and regularly update the mapping of encroaching conifer on all sage-grouse habitats in the state. From 2004 to 2012, the State of Colorado and its partners removed approximately 6,000 acres (2,481 hectares) of conifer in the state (Colorado Package 2013, Appendix A pp. 5–10). Although Colorado's state plan effectively reduces conifer encroachment on all lands and conifer has been removed, the plan's provides voluntary conservation measures only and its objectives are not regulatory.

Conservation measures in Nevada's state plan inventory and prioritize the treatment of conifer encroachment areas based on an area's potential to return to suitable habitat for sage-grouse, its importance to connectivity, and other fuels management considerations (State of Nevada 2014, p. 63). The plan recommends that Federal, State, and other partners treat 100,000 ac of encroaching conifer annually to benefit sage-grouse (State of Nevada 2014, p. 64). The plan incentivizes and assists the development of the bio-fuels and biomass removal industries and encourages the development of sufficient resources to address habitat loss and degradation in the next 10 years (State of Nevada 2014, p. 64). However, these components of Nevada's plan are not regulatory mechanisms and it is unclear how the management actions will be achieved or what plans will be implemented. A summary of state regulations and conservation plans addressing conifer encroachment, and other threats is in the ***Regulatory Mechanisms*** section.

BLM Resource Management Plans and USFS Land and Resource Management Plans

Conifer encroachment is addressed in the BLM and USFS plans through annual conifer removal in accordance to the Vegetation Development Dynamics Tool (VDDT) and FIAT assessments, which includes treatment schedules for mechanical and prescribed fire removal. Conifer removal will be prioritized in areas closest to occupied sage-grouse habitat and where juniper encroachment is phase I or phase II. For additional details see the ***Regulatory Mechanisms*** section.

Other Conservation Efforts (e.g., Data Call, SGI)

In Oregon, projects initiated since 2009 that were sponsored by the Oregon Department of Fish and Wildlife's (ODFW) Mule Deer Initiative and Bird Stamp program removed 3,320 acres of Phase I and II juniper in sage-grouse habitats (ODFW 2014). Although the COT Report identified conifer encroachment in both the Wyoming and Powder River Basin as a low threat (pp. 16–18), Local Working Groups have been active to address the encroachment issues, treating 2,812 acres of conifer in Wyoming (WGFD 2014, p. 214). Since 2009, Colorado Parks and Wildlife has conducted several pinyon-juniper removal projects, removing 6,430 acres of conifer to restore functional sage-grouse habitat (CPW 2014, pp. 34–42).

In 2010, NRCS launched the SGI. The Sage Grouse Initiative is a collaborative effort between federal and state agencies, non-governmental conservation organizations, and private landowners, effort to implement conservation practices which alleviate threats to sage-grouse while improving the sustainability of working ranches. Since 2010, SGI has cut invasive conifer from 163,995 ha (405,241 ac) of primarily Phase I and II conifer, of which 84 percent of the removal was focused in the Great Basin (USDA 2015, p. 7). Nearly half of these acres (80,614 ha; 199,203 ac) are in Oregon where conifer removal during SGI has increased by 1,411 percent and reduced conifer encroachment by 68 percent on private lands (USDA 2015, p. 2). The SGI in Oregon targeted conifer removal in PACs near active leks and other occupied seasonal habitats (USDA 2015, p. 18), although efficacy of these actions in restoring sage-grouse occupation is unknown. Despite this, we infer some level of positive response based on Commons *et al.*'s (1999, entire) Gunnison sage-grouse study and the documented avoidance, or reduced use, by sage-grouse of areas where pinyon-juniper has encroached upon sagebrush communities (Doherty *et al.* 2008, p. 187; Freese 2009, pp. 84–85, 89–90; Atamian *et al*. 2010, pp. 1537–1538; Doherty *et al*. 2010 p. 1547; Casazza *et al*. 2011, p. 163). New,

In addition to SGI, the FIAT process (BLM 2014, entire) was used to develop collaborative step-down assessments that address threats to sage-grouse resulting from invasive annual grasses, wildfires, and conifer expansion (see ***Non-regulatory Conservation Efforts*** section). Cumulatively, the FIAT step-down assessments identify approximately 7.4 million acres of potential conifer treatments for five priority landscapes (i.e., Central Oregon, Northern Great Basin, Snake/Salmon/Beaverhead, Southern Great Basin, Western Great Basin/Warm Springs Valley) in the Great Basin region (III, IV, and V).

Threat Amelioration Summary

Since 2010, many conservation actions have addressed conifer expansion using a variety of techniques (e.g., mechanical, herbicide, cutting, burning) to remove conifers in sage-grouse habitat. The effectiveness of these treatments varies with the technique used and proximity of the site to invasive plant infestations, among other factors. Although our ability to predict the pathway of plant succession following the removal of conifer is relatively high in communities with abundant native grasses and forbs in Phase I and II conifer woodlands (Miller *et al.* 2005, p. 28), the plant-community response to these treatments is not always consistent or predictable, and succession may not move in a desirable direction following treatment (Miller *et al.* 2014, entire).

Numerous studies have evaluated plant response to conifer removal, but we are not aware of any study documenting a direct correlation between these treatments and increased sage-grouse productivity. Despite this, we infer some level of positive response based on Commons *et al.*'s (1999, entire) Gunnison sage-grouse study and the documented avoidance, or reduced use, by sage-grouse of areas where pinyon-juniper has encroached upon sagebrush communities (Doherty *et al.* 2008, p. 187; Freese 2009, pp. 84–85, 89–90; Atamian *et al.* 2010, pp. 1537–1538; Doherty *et al.* 2010 p. 1547; Casazza *et al.* 2011, p. 163). However, since the effectiveness of treatments for sage-grouse is typically based on a short-term, anecdotal evaluation of whether pinyon-juniper was successfully removed from a site, it is unclear whether pinyon-juniper removal has a positive long-term population-level impact for sage-grouse. In most cases it is still too early to measure a population response to these treatments (ODFW 2008, p. 3). Although we do not know if these efforts are effectively ameliorating the threat of conifer expansion, anecdotal observations indicate that these actions are resulting in the addition of suitable habitat in some instances.

Furthermore, while many acres have been treated since 2010, treatments are not likely keeping pace with the current rate of conifer encroachment, at least in parts of the species range. For example, while Oregon has treated approximately 8,094 ha (20,000 ac) of juniper to restore native sagebrush habitat between 2003 and early 2008 (about 1,619 ha or 4,000 ac per year; ODFW 2008, p. 3), LANDFIRE data showed at least 106,882 ha (264,110 ac) of juniper occur within 4.8 km (3 mi) of Oregon leks. This distance (4.8 km; 3 mi) reflects the upper estimate of a typical pinyon seed dispersal event, although seeds may be dispersed shorter distances and up to at least 10 km (6.2 mi) (Chambers *et al.* 1999, p. 12). At this rate, it would take approximately 60 years to remove the threat of juniper encroachment within 4.8 km (3 mi) of sage-grouse leks in Oregon, assuming expansion does not continue.

Again, LANDFIRE data provides a gross underestimate of pinyon-juniper since it misses single, large trees. This underestimate suggests that it will take longer than 60 years to fully address the threat of conifer encroachment in Oregon, if conservation actions continue to occur at the current rate. Furthermore, not all treatments are effective. Again, the measure of effectiveness typically refers to whether vegetation was treated successfully, and not whether sage-grouse use an area that has been treated.

Assessment of Potential Threat

Functional habitat loss is occurring from the expansion of native conifers, mainly due to decreased fire return intervals, livestock grazing, increases in global CO_2 concentrations, and climate change. In our 2010 warranted but precluded finding, we found that even though conifer is present throughout the range, conifer encroachment is not at a level that is causing a threat to sage-grouse everywhere within the species range. The impact of conifer encroachment generally is higher in western portions of the range (MZs III, IV, and V), but is of less concern in the Rocky Mountain States (MZs I, II and VII), such as Wyoming and Montana.

Pinyon-juniper treatments, particularly when done in the early stages of encroachment when the sagebrush and forb understory is still intact, have the potential to provide an immediate benefit to sage-grouse. However, studies have not yet documented a correlation between pinyon-juniper treatments and increased sage-grouse productivity.

CHAPTER 8: AGRICULTURAL CONVERSION

Agricultural conversion changes sagebrush rangelands to tilled agricultural crops or re-seeded exotic grass pastures, and is an important source of habitat loss and fragmentation for sage-grouse (Baker *et al.* 1976, p. 165; Braun 1998, p. 143; Schroeder *et al.* 2004, p. 363; Aldridge *et al.* 2008, p. 983; Schroeder and Vander Haegen 2011, p. 519; Wisdom *et al.* 2011, p. 462; USFWS 2013, p. 48). Agricultural conversion was identified as one of the primary causes of habitat fragmentation leading to the specie's decline in 2010 (75 FR 13931). A total of more than 23,000,000 ha (88,780 mi²)—approximately 11 percent of the sage-grouse's historical range—was converted to agricultural lands (Knick *et al.* 2011, p. 208). Agricultural conversion is particularly notable in the Columbia Basin (MZ VI), Great Plains (MZ I), and Snake River Plain (MZ IV) (Connelly *et al.* 2004, p. 5-55; Knick *et al.* 2011, p. 209). Topography, soils, and climate historically limited agricultural development on the remaining sagebrush rangelands; however, recent economic advantages (e.g., crops for biofuels) and technological improvements (e.g., extended irrigation coverage and cultivation) now permit development on steeper terrain and areas further from floodplains (Knick *et al.* 2011, p. 208).

Agricultural conversion eliminates sagebrush habitat and the percentage of land in agriculture is almost three-fold higher in extirpated sage-grouse range than in occupied habitat (Wisdom *et al.* 2011, p. 462). Sage-grouse are more likely to be extirpated from areas containing greater than 25 percent cropland and less than 25 percent sagebrush (Aldridge *et al.* 2008, p. 983). In the western portion of the species' historical range (California, Idaho, Nevada, Oregon, Utah, and Washington), leks are more common in areas with less than 10 percent agricultural land cover within a 5 km (3 mi) radius (Knick *et al.* 2013, p 1544). While sage-grouse will forage on some agricultural crops (e.g., alfalfa; Schroeder *et al.* 1999, p. 4) they avoid cultivated cropland when selecting nesting and brood-rearing habitat (Aldridge and Boyce 2007, pp. 508 and 523).

Several studies have documented population level impacts to sage-grouse as a result of the loss of habitat and fragmentation due to agricultural conversion. In Idaho, decline in the number of males per lek from 1975 to 1992 was strongly correlated with a 74 percent increase in the amount of land converted to agriculture (Leonard *et al.* 2000, p. 268), and lek persistence in Wyoming was negatively associated with the proportion of nearby lands in tilled agriculture (6.4 km [4 mi]; Walker *et al.* 2007, p. 2650). In Wyoming, Montana, and Colorado, a conversion of 16 percent or more of lands dominated by sagebrush through plowing or spraying herbicide correlated with a 50 to 100 percent reduction in the number of male sage-grouse occupying leks (Swenson *et al.* 1987, p. 129). Conversion of 30 percent of winter habitat to agriculture in Montana resulted in a 73 percent decline in the number of male sage-grouse occupying leks (Swenson *et al.* 1987, p. 130). In Montana, North and South Dakota and Canada (MZ I) lek activity and size were negatively correlated with increasing proportions of agricultural tillage (Smith *et al.* 2005, p. 314; Tack 2009, p. iii). Similar results were documented in a rangewide study (Johnson *et al.* 2011, p. 407). Lek count declines begin when the proportion of sagebrush converted to agriculture is 1.5 to 2.5 percent of the landscape; substantial declines in lek counts may occur when this proportion exceeds 16 percent; and sage-grouse populations may be extirpated when the proportion exceeds 25 to 27 percent (Manier *et al.* 2013, p. 30).

Conversion of sagebrush into agricultural production also fragments sage-grouse habitat (Connelly *et al.* 2004, p. 7-23; Davies *et al.* 2011, p. 2575; RISCT 2012, p. 7; Knick *et al.* 2013, p. 1547; USFWS 2013, p. 48). Fragmentation from agricultural activities influences approximately 49 percent of remaining sagebrush habitat and 84 percent of priority habitats throughout the species' range (Connelly *et al.* 2004, pp. 1-1 and 7-23; Manier *et al.* 2013, p. 30). Agricultural fragmentation precludes sage-grouse movements to traditional seasonal habitats and other landscape movements. Agriculture was the largest barrier to sage-grouse migration in the Northern Montana population (MZ 1) over the past 30 to 100 years along the Milk River and a significant contributor to population decline (Bush *et al.* 2011, p. 537). In Washington (MZ VI), sage-grouse are now restricted to two isolated populations, primarily due to the conversion of sagebrush rangeland to cropland (Schroeder and Vander Haegen 2006, pp. 7–8). In southern Idaho, habitat conversion to croplands and other agricultural practices along the Snake River now precludes sage-grouse movement between populations north and south of the Snake River (Knick and Connelly 2011, p. 211), potentially affecting genetic exchange and adaptions that allow the species to persist in both of the associated ecological conditions. The extent of agricultural disturbance necessary to result in complete loss of movement (such as in the Snake River plain) is not known. Sufficient sagebrush habitats have been retained in the agricultural areas of the Great Plains (MZ I) to support sage-grouse (Knick and Connelly 2011, p. 211).

Sage-grouse may use irrigated croplands, pasture, and CRP lands, particularly during the late brood-rearing period when native plants have matured and dried, but irrigated agricultural lands remain green (Schroder *et al.* 1999, p. 4; Connelly *et al.* 2004, pp. 4-1 and 4-10; Knick *et al.* 2011, p. 211). Dryland cereal grains are generally not beneficial habitat as they are not irrigated and therefore do not provide succulent forb or insect food resources. However, the value of irrigated croplands to late-summer broods depends on the type of vegetation and the juxtaposition of the modified habitat in relation to adjacent sagebrush habitat (Swensen *et al.* 1987, p. 128; Blus *et al.* 1989, p. 1114; Connelly *et al.* 2004, p. 4-18). The use of irrigated cropland and pasture may not be beneficial to sage-grouse if it increases exposure to pesticides (Blus *et al.* 1989, pp. 1141–1142), West Nile virus (Walker 2008, p. 184), predation (Connelly *et al.* 2004, p. 7-23), or increases mortality caused by collision with fences (Braun 1998, p. 145; Braun 2006, p. 11). Additionally, disturbance from tillage likely reduces the availability of nesting sites (Holloran *et al.* 2005, p. 648), and in at least one study nesting sage-grouse and broods avoided areas close to cultivated cropland (Aldridge and Boyce 2007, p. 508).

Irrigation canals necessary for agricultural activities cover 99,100 ha (383 mi²); approximately 0.1 percent of the land area within the current range of the species (Knick *et al.* 2011, p. 209). Although the footprint is small, irrigation may have significant negative impacts on broods through canal diversion of water from riparian areas. Additionally, reservoirs may potentially inundate some riparian habitat (Braun 1998, p. 144), increase attraction of predators (Donnelly 2014, in litt), as well as creating a potential for impacts from WNv (see ***Disease*** chapter).

Location and Extent

Agricultural conversion has occurred across the species' range, but the intensity varies between populations (Figure 8-1). The primary agricultural regions within historical sagebrush habitat occur in the Columbia Basin (MZ VI; 32 percent of total area) and the Great Plains (MZ I; 19 percent of total area) (Knick *et al.* 2011, p. 209). Portions of the Snake River Plain (MZ IV; 25 percent of Idaho; 10 percent throughout the MZ) are also heavily affected by agricultural conversion (Connelly *et al.* 2004, p. 5-55; Knick *et al.* 2011, p. 209). The remaining MZs (Wyoming Basin, Southern Great Basin, Northern Great Basin, and Colorado Plateau; MZs II, III, V, and VII respectively) have less than 5 percent of the land in agriculture (Knick *et al.* 2011, p. 209; Table 8-1).

Table 8-1: Summary of impacts to greater sage-grouse from agricultural conversion by Management Zone (Knick *et al.* 2011; USFWS 2013, pp. 16–26).

Management Zone	Current Extent of MZ Affected (Direct / Indirect)	Notes
I	19% 91%	Local impacts in 2/4 populations; widespread impacts in 1/4
II	4% 70%	Widespread impacts in 4/9 populations
III	2% 62%	Local impacts in 1/12 populations; widespread impacts in 2/12
IV	10% 84%	Local impacts in 3/9 populations; widespread impacts in 4/9
V	4% 65%	Local impacts in 2/4 populations; widespread impacts in 1/4
VI	32% 90%	Local impacts in 1/4 populations; widespread impacts in 2/4
VII	5% 81%	Widespread impacts in 1/2 populations

Agricultural conversion of sagebrush is especially notable in habitat with deep, fertile soils and higher precipitation rates (Connelly *et al.* 2004, p. 1-1; Davies *et al.* 2011, p. 2575). This loss has eliminated the most productive sagebrush rangelands as habitat for the sage-grouse and has marginalized the species onto less productive sagebrush habitat (Manier *et al.* 2013, p. 1). For example, in the Columbia Basin (MZ VI), approximately 75 percent of sagebrush rangelands that occurred on deep, loamy soils have been converted to agriculture, but only 15 percent have been converted on shallow soils (Connelly *et al.* 2004, p. 7-23). The rate of conversion of sagebrush to agriculture will likely slow as the most productive lands have already been converted (Baker *et al.* 1976, p. 167). New cropland totals within occupied sage-grouse range have decreased for every state except South Dakota since 1982 (USDA 2013, p. 4), likely reflecting, in part, decreasing land suitability for crop production.

Future Impacts

Our summary of previous research clearly indicates when sagebrush is converted to tillage agriculture at landscape scales, sage-grouse populations negatively respond (Leonard *et al.* 2000, p. 268; Walker *et al.* 2007, p. 2650; Swenson *et al.* 1987, p. 129 & p.130; Smith *et al.* 2005, p. 314; Tack 2009, p. iii; Johnson *et al.* 2011, p. 407; Manier *et al.* 2013, p. 30). Further, breeding habitat models developed by the Service for this species report corroborate negative responses of sage-grouse documented in the past (Figure 8-1). However, strong negative effects within impacted regions, do not necessarily translate to large scale population impacts across vast areas such as a MZ. This is because the risk of cropland conversion is heterogeneous. We would expect high levels of future impacts if current sage-grouse population centers overlap areas with high probabilities of being cropland in the future. Conversely, we would expect future impacts to be low, if current sage-grouse population centers do not overlap areas with high probabilities of being cropland in the future.

To identify regions and populations at risk from agriculture conversion in MZ I, we utilized a recently developed cropland suitability model described in Smith *et al.* (in review). This cropland risk model provides a probability surface with values ranging from 0–1, representing the relative suitability of each grid cell to cropland conversion. Values of 1 are the most similar to current cropland and the most suitable for future conversion (Figure 8-2). We recognize rate and location of future cropland conversions can be difficult to predict because of changing technologies and because agriculture demand and commodity prices are driven on a global scale. We therefore presented a simple cumulative range of potential future impacts by quantifying sage-grouse population exposure within each 5 percent cropland probability class (Figure 8-3).

These results suggest that future impacts from agricultural conversion are unlikely to have significant impacts on the remaining occupied range of sage-grouse. This is because most of the remaining populations exist in areas with low probabilities of being cropland (Figure 8-3). For example, 87 percent of the current population is located on areas with cropland probabilities of 0.35 or less (Figure 8-3). Due to the low overall exposure of sage-grouse populations to cropland risk we did not conduct any further simulations or more complicated analyses for the status assessment. There is a potential that economic changes and technological improvements (Knick *et al.* 2011, p. 208) could increase the likelihood of conversion of sagebrush on poor soils. Agricultural lands are typically associated with private or Tribal ownership (Stiver *et al.* 2006, Appendix C-2, pp. 11–13), and those lands have the greatest potential for additional conversion should economic incentives be sufficient. Restrictions proposed on BLM- and USFS-administered lands will likely restrict any intentional conversion of these lands to seeded pastures.

The model results conflict with previous expert opinion that expressed concern with continuing habitat loss and fragmentation from agricultural conversion (RISCT 2012, p. 7; USFWS 2013, pp. 16–29). However, this is the first quantitative model we are aware of that examines future agricultural capability within this region. There is no doubt that agricultural conversion played a significant role in shaping the current sage-grouse landscape, resulting in habitat loss and loss of population connectivity, and there are lingering indirect effects (e.g., fragmentation, predators; Knick et al. 2011, p. 208). However, based on the above model results we do not believe that new areas of conversion will have significant impacts on sage-grouse distribution in the future.

Threat Amelioration

The voluntary Conservation Reserve Program (authorized in 1985) allows private landowners to receive annual payments in exchange for establishing permanent vegetation on idle or erodible lands that were previously used for growing crops. Enrolled lands are set aside for 10 to 15 years and cannot be grazed except under emergency drought conditions. The enrollment of CRP lands can be detrimental to sage-grouse when sagebrush rangelands are converted to marginal croplands then subsequently converted to grasslands (USFWS 2013, p. 48). Conversely, depending on the type of vegetation established and proximity to sagebrush, CRP lands can provide nesting, brood-rearing, and wintering habitat for sage-grouse (Schroeder and Vander Haegen 2006, p. 32; Schroeder and Vander Haegen 2011, pp. 524–528). Enrollment in the CRP has benefited sage-grouse, especially in the Columbia Basin (MZ VI) and Great Plains (MZ I; Knick *et al.* 2011, p. 208). The CRP is currently the largest effort to restore sage-grouse habitat in the Columbia River Basin (MZ VI), with approximately 109,480 ha (270,322 ac) of former agricultural lands enrolled in CRP in occupied habitat (Stinson 2014, p. 16). The proportion of sage-grouse nests in CRP lands in Washington State increased from 31 percent in 1992 to 1994 to 50 percent in 1995 to 1997 (Schroeder and Vander Haegen 2006, p. 4). This increase appeared to be associated with maturation of CRP lands, characterized by increased height and cover of perennial grasses and invasion by sagebrush. Nesting success in CRP lands was comparable to nesting success in native sagebrush (Schroeder and Vander Haegen 2011, p. 525). The sage-grouse population in north-central Washington, an area with abundant CRP lands, was the only population in Washington with increasing population trends (Schroeder and Vander Haegen 2006, p. 6; Schroeder and Vander Haegen 2011, p. 528).

After enrollment in CRP expires (10 to 15 years), landowners may re-enroll lands or convert the land to some other use. Federal funding and economics related to crop prices can affect enrollment, and the long-term effectiveness of the CRP is uncertain. However, in Washington, lands have frequently remained enrolled since the late 1980s—long enough to allow for re-establishment of sagebrush and use by sage-grouse for nesting habitat (Schroeder and Vander Haegen 2011, p. 524). Other areas with abundant CRP lands (northern Utah, southeast Idaho, western Colorado, and eastern Montana) have not been similarly examined (Schroeder and Vander Haegen 2011, p. 529).

The Environmental Quality Incentives Program (EQIP), a voluntary NRCS program provides financial and technical assistance to agricultural producers through 10 year contracts that plan and implement conservation practices. The NRCS is using this program to fund SGI and assist producers in improving habitat for sage-grouse (see ***Non-regulatory Conservation Efforts*** section). Some of the conservation practices under SGI address farming practices, such as conservation crop rotation, critical area planting on erodible soils, and pasture/hayland planting of forage species compatible with sage-grouse (USFWS 2010, pp. 20–21).

Conservation easements allow private landowners to enter into a voluntary agreement with a land trust (e.g., The Nature Conservancy), the NRCS, or other organizations or agencies that maintain the land in private ownership with development restrictions that are typically permanent. Conservation easements can permanently protect sagebrush habitat from conversion to cropland or subdivision while providing compensation to landowners. The NRCS estimates that since the SGI was begun in 2010, 183,013 ha (451,884 ac) have been enrolled in conservation easements in the sage-grouse range (NRCS 2015, p. 6). Unfortunately many of these easements have occurred in areas with low risk of sage-grouse population exposure to agricultural conversion (Doherty, unpublished data). Highly productive riparian habitats, which are typically privately-owned, are critical to the survival of sage-grouse chicks (Copeland *et al.* 2013, p. 12). Conserving relatively small parcels of private lands along streams and wet meadows via conservation easements may have a disproportionately large beneficial impact on surrounding uplands (Donnelly 2014, in litt).

The Farm Bill of 2014 “Sodsaver” provision may directly affect future conversion of sagebrush rangelands to tilled crops in portions of MZ I (Montana, North Dakota, and South Dakota). This provision reduces the Federal crop insurance subsidy available to landowners on any lands they convert to cropland (NRCS 2015, p. 14). This reduces the incentive to convert native rangelands to tilled crops. Unfortunately we have no information on the on-the-ground application of this provision, nor of any benefit to sage-grouse.

Candidate Conservation Agreements with Assurances entered into by the Service, a non-Federal landowner, and potentially other parties, can also conserve sage-grouse habitat for sage-grouse. Similarly, Candidate Conservation Agreements (CCAs) serve a similar purpose, but can be entered into by Federal agencies. Over 809,371 ha (2 million ac) of sage-grouse occupied range are currently enrolled in 10 sage-grouse CCAAs and over 242,811 ha (600,000 ac) are currently enrolled in 3 CCAs (see ***Non-regulatory Conservation Efforts*** section). Lands currently enrolled in CCAAs and CCAs include restrictions on agricultural conversion, habitat fragmentation, and removing sagebrush. State programs such as State Acres for Wildlife Enhancement (SAFE) may also support sagebrush rangelands if sagebrush conservation is encouraged. The success of these efforts will be enhanced if they are located in areas where sage-grouse populations are at a higher risk of exposure to agricultural conversion.

Through the CED, the Service collected information relating to conservation actions that were completed, in progress, or planned. Projects that address agricultural conversion entered in the CED as "completed" by data providers, and data from other relevant projects provided to the Service through our data call, total nearly 344,000 ha (850,000 ac) rangewide (Appendix D). A unique total area of conservation effort addressing agricultural conversion for each MZ is difficult to calculate owing to extensive duplication: some large projects listed more than one MZ but the reported acres were not allocated by MZ in the database. The estimated area of this threat to sage-grouse in MZ I is 288, 124 ha (711, 970 ac) (a rangewide estimate was not calculated and is forthcoming)

Of the projects deemed completed by the project proponents the Service reviewed projects in MZs I and VI as these MZs are the key areas in the sage-grouse range where this threat occurs, or is likely to occur. An example of an effective conservation action were easements that preclude future conversion of lands for agricultural development. Most of the acres assessed as effective in our review (Table 8-2) were acres assessed as effective for conifer removal as well.

Table 8-2. Summary of completed projects and agreements determined to be effective in the Service. review of CED projects addressing agricultural conversion. Some of the projects addressed two threats (e.g., agricultural conversion and urbanization), or spanned more than one MZ. These are indicated separately.

Management Zone	Conservation Efforts	ha (ac)
I	unique acres (MZ & threat) [1]	80,937 (200,000)
	same acres & MZ, > 1 threat [2]	393 (970)
	same acres & >MZ, > 1 threats [3]	206794 (511,000)
VI	unique acres (MZ & threat) [1]	None in CED
	same acres & MZ, > 1 threat [2]	
	same acres & >MZ, > 1 threats [3]	
TOTAL		**288,124 (711,970)**

[1] projects in one MZ addressing one threat
[2] projects in one MZ addressing more than one threat
[3] projects crossing more than one MZ addressing more than one threat

In addition to the conservation efforts described above, lands currently enrolled in CCAAs and CCAs have restrictions on agricultural conversion, habitat fragmentation, and removing sagebrush. Approximately 0.17 percent of occupied range in MZ I, 0.78 percent of MZ II, 2.47 percent of MZ IV, and 4.67 percent of MZ V are enrolled in CCAAs in Wyoming and Oregon. Federal lands enrolled in CCAs in Wyoming, Oregon, and Idaho account for 0.04 percent of occupied range in MZ I, 0.21 percent of MZ II, 3.13 percent of MZ IV, and 4.67 percent of MZ V. See the ***Non-regulatory Conservation Efforts*** section Table 28-7 for approximate acreages and additional information.

[NEED TO ADD A STATEMENT REGARDING THE EFFICACY OF THESE EFFORTS ONCE THEY ARE DISPLAYED SPATIALLY AND COMPARED TO THE POPULATION RISK EXPOSURE MAP]

[INSERT FIGURE]

Figure 8-X: Location of known conservation programs throughout the sage-grouse range. A bi-panel showing area of high risk for conversion Figure tillage model and sg population in MZ I]

The State plans for Wyoming and Montana have regulatory mechanisms that effectively reduce agricultural conversion in these States on applicable lands. The Wyoming Governor's Executive Order is in place, applies to all lands within Wyoming, and enacts a 5 percent disturbance limit from agricultural conversion in core areas (State of Wyoming 2011, p. X). The Wyoming Executive Order also requires that project proponents minimize the removal of vegetation, use timing restrictions, and requires that sagebrush treatments follow State-enforced protocols (State of Wyoming 2011, p. X). If enacted, Montana's state plan would also limit total disturbance to less than 5 percent on State Trust Lands and would allow the State to prohibit agricultural conversion and the eradication of sagebrush on State Trust Lands in core, general habitat, and connectivity areas (State of Montana 2014, pp. 7, 14). Therefore, Wyoming's state plan is an existing regulatory mechanism that is effectively reducing the threat of agricultural conversion on all lands, and if enacted, the Montana state plan would effectively reduce the threat of agricultural conversion on State Trust Lands.

Although agricultural conversion is no longer occurring on a large scale in Colorado, the Colorado state plan encourages landowners to reduce agricultural conversion by enrolling in CRP and to restore sage-grouse habitats on all lands in the State (Colorado Division of Wildlife 2008, pp. 99, 309, 310, 349). Colorado's plan also provides technical assistance and equipment to landowners who restore sage-grouse habitats (Colorado Division of Wildlife 2008, pp. 309, 310). Although these efforts are in place and help reduce agricultural conversion in Colorado, they are entirely voluntary and are not regulatory mechanisms. A summary of state regulations and conservation plans addressing fire, and other threats is in the Regulatory Mechanisms chapter (pp.X).

BLM and USFS plans were not specifically designed to address agricultural conversion, as BLM and USFS lands are not used or converted for agricultural production, although lands have been converted to seeded pastures in the past. However, BLM and USFS lands classified as PGMA and GHMA for sage-grouse will be retained in federal management, which would prevent agricultural conversion. Exceptions to this include: (1) the agency can demonstrate that disposal of the lands will provide a net conservation gain to the sage-grouse; or (2) the agency can demonstrate that the disposal of the lands will have no direct or indirect adverse impact on conservation of the sage-grouse. While agricultural conversion is expected to continue to occur on adjacent private lands, BLM and USFS's proposed plans provides that sage-grouse habitat will be retained unless a conservation gain to sage-grouse can be demonstrated. For additional details on BLM and USFS plans, see the ***Regulatory Mechanisms*** section.

Timescale for Projecting Impacts from Agricultural Conversion

Habitat loss and fragmentation due to agricultural conversion will continue as long as it remains economically viable. We cannot define an exact time-frame as future agricultural economics and technologic advances that may permit successful agricultural production in currently unsuitable areas are unknown. Therefore, we have to conclude that additional habitat loss and fragmentation due to future agricultural conversion may continue indefinitely.

Likelihood of Future Impacts

While several literature sources predict that habitat loss and fragmentation due to agricultural conversion will continue into the foreseeable future, the rate on conversion is limited by the availability of suitable soils that will support economically viable crops. New cropland acreages are declining within the range of sage-grouse, perhaps in part to the limitations posed by local soil and water conditions, suggesting that the rate of habitat conversion may be slowing. Many conservation efforts are providing protection from conversion, particularly on private lands where the continued risk is the greatest. While many of these programs are not focused in the areas at greatest risk, they are still conserving sage-grouse habitats. Additionally, the population exposure model suggests future areas of conversion will not overlap with most of the remaining sage-grouse occupied range. While the literature strongly supports that agricultural conversion has had significant impacts on sage-grouse distribution and numbers, future direct effects are unlikely to have population level effects. However, indirect effects of agricultural activities (e.g., impacts to brood-rearing habitats, potential WNv outbreaks associated with agricultural water) are likely to continue into the foreseeable future. In 2010, we identified agricultural conversion as one of three major factors contributing to habitat loss and fragmentation. We can no longer state that this factor will be a major cause of future habitat loss and fragmentation based on the minimal exposure of extant populations to areas suitable for crop production. Indirect effects of agricultural activities will likely continue to have negative impacts on sage-grouse near those areas, particularly in MZs I, IV and VI.

CHAPTER 9: NONRENEWABLE ENERGY DEVELOPMENT

During the last half-century, global demand for energy increased by more than 50 percent and according to the National Petroleum Council (2007, p. 46) a similar increase is anticipated to occur by 2030. The demand for energy in the U.S. is projected to increase by 0.5 to 1.3 percent annually (National Petroleum Council 2007, p. 46). Despite a growing recognition of negative global impacts to the environment from CO_2 emissions, fossil fuels remain the largest source of energy worldwide (Naugle *et al.* 2011, p. 55). Interest in developing oil and natural gas resources in North America has been cyclic based on demand, market conditions, and technological advances (Braun *et al.* 2002, p. 2; Applegate and Owens 2014, p. 287). The Energy Policy and Conservation Act (EPCA; 42 United States Code (U.S.C.) 6201 et seq.) includes mandates for increasing energy development, and to secure energy supplies and increase the availability of fossil fuels. Reauthorization and amendments to the EPCA continue, such as Energy Policy Act of 2000 (Public Law (P.L.) 106-469) that mandates the inventory of Federal nonrenewable resources (42 U.S.C. 6217), and the 2005 Energy Policy Act that requires resolution of impediments to timely granting of Federal leases and post-leasing development (42 U.S.C. 15851), and mandated Federal land management agencies to designate energy transport corridors on Federal land in 11 western States for oil, gas and hydrogen pipelines, and electricity transmission and distribution facilities (42 U.S.C. 15926). Nonrenewable fossil fuel energy development (e.g., petroleum products, coal) has been occurring in sage-grouse habitats since the late 1800s (Connelly *et al.* 2004, p. 7-28), with historical well locations concentrated in MZs I, II, VII and the eastern portion of MZ III (Wyoming, eastern Montana, western Colorado, and eastern Utah; IHS Incorporated 2006).

Current Impacts

The development of oil and gas[2] resources requires surveys for economically recoverable reserves, construction of well pads and access roads, subsequent drilling and extraction, and transport of oil and gas, typically through pipelines. Ancillary facilities can include compressor stations, pumping stations, electrical generators, and power lines (Connelly *et al.* 2004, p. 7-39; BLM 2007c, p. 2-110). Surveys for recoverable resources occur primarily through seismic activities, using vibroesis buggies (thumpers) or shot hole explosives. Well pads vary in size from 0.10 ha (0.25 ac) for coal-bed natural gas (CBNG) wells to greater than 7 ha (17.3 ac) for deep gas wells and multiwell pads (Connelly *et al.* 2004, p. 7-39; BLM 2007c, p. 2-123). Pads for compressor stations require 5 to 7 ha (12.4 to 17.3 ac) (Connelly *et al.* 2004, p. 7-39). A recent technological shift from vertical to horizontal and directional drilling allows multiple wells to be placed on one pad, reducing the level of surface disturbance Depending on spacing, horizontal drilling from a single well pad (average initial disturbances of 4.1 to 4.9 ha) could take the place of 8 to 16 vertical wells (Applegate and Owens 2014, p. 288). Additionally, a smaller number of well pads results in a concomitant reduction in roads, power lines, and product pipelines associated with individual well pads. Energy development impacts sage-grouse and sagebrush habitats through direct habitat loss from well pads, construction activities, seismic surveys, associated infrastructure (e.g., roads, power lines), and pipelines ; indirectly from noise, gaseous emissions, changes in surface water availability and quality, decreased habitat quality through increased exposure to invasive plants, predators, and disease, and increased human activity and presence (Suter 1978, pp. 6–13; Aldridge 1998,

[2] For purposes of this discussion, the term “gas” will be used to generally describe natural gas, coal-bed natural gas, coal-bed methane, and other types of gas unless otherwise specified.

p. 12; Braun 1998, pp. 144–148; Aldridge and Brigham 2003, p. 31; Knick *et al.* 2003, pp. 612, 619; Lyon and Anderson 2003, pp. 489–490; Connelly *et al.* 2004, pp. 7-40 to 7-41; Holloran 2005, pp. 56–57; Holloran 2007, pp. 18–19; Aldridge and Boyce 2007, pp. 521–522; Walker *et al.* 2007a, pp. 2652–2653; Zou *et al.* 2006, pp. 1039–1040; Doherty *et al.* 2008, p. 193; Leu and Hanser 2011, pp. 267–271).

Results of Impact

A growing body of scientific literature documents negative impacts from energy development activities (primarily oil, gas, CBNG, and the extensive infrastructure associated with each) on sage-grouse populations (see Appendix E). Research has been focused primarily in eastern portions of the species range (Powder River Basin (NE WY; MZ I), Pinedale Anticline project (SW WY; MZ II), Manyberries Oil Field (Canada; MZ I), Cedar Creek Anticline (MT, ND, SD; MZ I)) that are experiencing ongoing, rapid and widespread energy development (Naugle *et al.* 2011, p. 59).

The Powder River Basin, in northeastern Wyoming and southeastern Montana (MZ I), has experienced significant shallow CBNG development. Between 1997 and 2007, approximately 35,000 producing wells were in place on Federal, State, and private holdings in the Powder River Basin area (Naugle *et al.* 2011, p. 492). Between 2001 and 2005, sage-grouse lek count indices declined by 82 percent inside gas fields compared to 12 percent outside development (Walker *et al.* 2007a, p. 2648). By 2004 to 2005, fewer leks remained active (38 percent) inside gas fields compared to leks outside fields (84 percent) (Walker *et al.* 2007a, p. 2648).

In the Powder River Basin, population trends projected a decline of almost 90 percent by 2037 (Garton *et al.* 2011, p. 310). This projection is consistent with the estimate provided by Walker *et al.* (2007a, p. 2651),that the probability of lek persistence would decline to 5 percent in the Powder River Basin with full field development over a similar time frame, resulting in declining population trends. In 2013, this area of Wyoming had the lowest average peak male lek attendance in the state, averaging 9 males per active lek versus the statewide average of 17 males (Northeast Wyoming Sage-grouse Working Group, 2014, p. 4). Additionally in 2013, a significant decrease in the percentage of active leks was recorded.

The population declines and increased numbers of inactive leks associated with energy development result from decreased lek attendance and behavioral avoidance (Holloran 2005, pp. 38-39, 50; Kaiser 2006, p. 23; Walker *et al.* 2007a, p. 2648; Harju *et al.* 2010, p. 443), lower nest initiation (Lyon 2000, p. 109; Lyon and Anderson 2003, p. 5), poor nest success (Aldridge and Boyce 2007, p. 517; Webb *et al.* 2012, p. 9), decreased survival (Holloran 2005, p. 54; Kaiser 2006, p. 34; Aldridge and Boyce 2007, p. 517; Holloran *et al.*, 2010, p. 70; Kirol 2012, p. 15;), and avoidance of infrastructure in important wintering habitat (Doherty *et al.* 2008, pp. 192-193; Carpenter *et al.* 2010, p. 1811; Dzialak *et al.* 2012, p. 12; Dzialak *et al.* 2013, p. 16; Smith *et al.* 2014, p. 15). At current maximum permitted well density (12 wells per 359 ha [888 ac]), planned full field development will impact the remaining wintering habitat in the basin (Doherty *et al.* 2008, pp. 192, 194). Winter habitats are limiting and thus their loss can have disproportionate impacts on populations. Populations are negatively affected by energy development activities, especially those that degrade sagebrush habitat, even when mitigated measures are implemented (Braun 1998, p. 144; Lyon 2000, pp. 25-28; Holloran 2005, pp. 56-57; Naugle *et al.* 2006, pp. 8-9; Walker *et al.* 2007a, p. 2651; Doherty *et al.* 2008, p. 192; Harju *et al.* 2010, p. 445).

The biological response of sage-grouse populations to development may not be immediate. A growing number of studies have identified time lags between the onset of energy development activity and population-level impacts (i.e., declines in numbers of sage-grouse on leks, population extirpation) (Holloran 2005; Walker *et al* 2007a, p. 2651; Doherty 2008, p. 78; Doherty *et al* 2010, p. 5; Harju *et al.* 2010, pp. 441-445; Gregory and Beck 2014, p. e97132). Population level impacts may not become apparent for up to 10 years following the onset of development (3 to 4 years, Walker *et al* 2007a, p. 2651; 4 years, Doherty 2008, p. 78; 4 years, Doherty *et al* 2010, p. 5; 2 to 10 years, Harju *et al.* 2010, pp. 441–445; 4 to 5 years, Gregory and Beck 2014, p. 6). The lag time is likely the result of a combination of factors, including the pace and extent of development, the high site fidelity but reduced survival of adults, and lowered recruitment and behavioral avoidance exhibited by yearling sage-grouse (Harju *et al.* 2010, p. 443; Holloran *et al* 2010, p. 70; Taylor *et al.* 2012, p. 8; Gregory and Beck 2014, p. e97132). Identification of time lags is vitally important to understanding the impacts of energy development on sage-grouse persistence across the range; impacts from recent (within the past 4 years) development have likely not been fully realized.

Direct habitat loss, degradation, and resulting fragmentation of remaining habitat contribute to decreased population numbers and distribution of the sage-grouse (Knick *et al.* 2003, p. 1; Connelly *et al.* 2004, p. 7-40; Aldridge *et al.* 2008, p. 983; Copeland *et al.* 2009, p. 6; Knick *et al.*, 2011, pp. 247250; Leu and Hanser 2011, p. 270). The amount of direct habitat loss within an area is ultimately determined by well densities and the associated loss from ancillary facilities ().

While the physical footprint of oil and gas infrastructure including pipelines is estimated to be less than one percent of the current occupied range; however, the estimated ecological footprint (i.e., the extended effect of the infrastructure or activity beyond its physical footprint and determined by a physical or behavioral response of the sage-grouse) is much greater (Knick *et al.* 2011, p. 240) based on applying a zone of influence to estimate potential avoidance, increased mortality risk, and lowered fecundity in the vicinity of development (Lyon and Anderson 2003, p. 459; Walker *et al.* 2007a, p. 2651; Holloran *et al.* 2010, p. 70). Knick *et al.* (2011, p. 240) estimated more than 8 percent of sagebrush habitats within the 2004 sage-grouse range (plus a 50 km buffer) are affected by energy development, with MZs I, II and VI most affected (estimated 20, 20 and 29 percent sagebrush affected respectively; (Knick *et al.* 2011, p. 240). Models based on current (not proposed) BLM RMPs indicated a minimum of 2.3 million additional hectares (5.7 million ac) would be directly impacted by oil and natural gas development by the year 2030 based on 20-year reasonable foreseeable development projections (Copeland *et al.* 2009, p. 6)). The corresponding ecological footprint is likely much larger. Copeland *et al.* (2009, p.4) projected this increase in oil and natural gas energy development within the sage-grouse range would reduce the population by 7 percent from today's numbers.

Roads associated with oil and gas development were suggested to be the primary impact to sage-grouse due to their persistence and continued use even after drilling and production ceased (Lyon and Anderson 2003, p. 489). Daily vehicular traffic along road networks for oil wells can impact sage-grouse breeding activities based on lek abandonment patterns (Braun *et al.* 2002, p. 5). Declines in male lek attendance were reported within 3 km (1.9 mi) of a well or haul road with a traffic volume exceeding one vehicle per day (Holloran 2005, p. 40; Walker *et al.* 2007a, p. 2651). Sage-grouse also may be at increased risk for collision with vehicles simply due to the increased traffic associated with oil and gas activities (Aldridge 1998, p. 14; BLM 2003, p. 4¬222).

Noise can drive away wildlife, cause physiological stress, and interfere with auditory cues and intraspecific communication. Aldridge and Brigham (2003, p. 32) reported that, in the absence of stipulations to minimize the effects of noise, mechanical activities at well sites may disrupt sage-grouse breeding and nesting activities. Females nesting near oil and gas development in the upper Green River Basin of Wyoming (MZ II) selected nest sites with greater cover females nesting away from disturbance, likely due in part to the road noise associated with drilling (Lyon 2000, p. 109). However, noise could not be separated from the potential effects of increased predation resulting from the presence of a new road. In the same area lek attendance declined downwind from a drilling rig, indicating that noise likely affected male presence (Holloran 2005, p. 49). More recent research found that leks experimentally exposed to noise had an average 51 percent decline in male lek attendance and a similar decline in female attendance (48 percent; Blickley *et al.* 2012, p. 467). The impact of the noise on leks was immediate and sustained, and the response was similar over the 3 consecutive breeding seasons, which suggests that sage-grouse did not become sensitized to this disturbance (Blickley *et al.* 2012, p. 467). Sage-grouse did return to normal attendance levels following cessation of the noise. Chronic noise (from either source) also increased stress hormone levels and masked the male vocalizations that females use to locate leks and assess potential mates (Blickley *et al* 2012, p. 5; Blickley and Patricelli 2012, pp. 30¬–32; Koch *et al.* 2015, pp. 353–357).

Seismic surveys are used to explore for oil and gas resources. Dynamite in shot holes, dropped weights, or multiple vibroseis trucks working simultaneously are used to create acoustical waves in the subsurface of the area under exploration. In general, surveys crush vegetation and trails, compact soils, and increase human activity, noise and disturbance from large vehicles and helicopters. There are likely immediate impacts from noise and disturbance that could disrupt breeding or nesting activities (Braun 2003, p. 6), and impacts from potentially resulting habitat fragmentation could be long term (citation, p. X). The extent of surveys varies by area but can be significant. For example, North Dakota BLM reported that since 1997, 1,675,722 ha (6,470 mi^2) have been surveyed with three-dimensional seismic data, including a minimum of107,380 dynamite shotholes (BLM 2009, p. 63). We are unaware of any research on the impact of seismic surveys to sage-grouse, however, there are likely associated negative impacts from habitat fragmentation and disturbance.

Water quality and quantity may be affected by oil and natural gas development. In many large field developments, potential exposure to contamination is minimized by storing water produced by the gas dehydration process in tanks. However, water also may be depleted from natural sources for drilling or dust suppression purposes and concentrating wildlife and domestic livestock may increase habitat degradation at remaining water sources. Negative effects of changes in water quality, availability, and distribution are a reduction in habitat quality (e.g., trampling of vegetation, changes in water filtration rates), and habitat degradation (e.g., poor vegetation growth), which could result in brood habitat loss. Alternatively, water produced by coal-bed natural gas drilling may benefit sage-grouse through expansion of existing riparian areas and creation of new areas (BLM 2003, p. 4¬223) if the water quality of discharge has not been significantly compromised. However, proximity to natural gas discharge reservoirs negatively influenced nest success in the Powder River Basin in Wyoming (Kirol *et al.* 2015, p. 104) by attracting predators commonly associated with water and riparian areas (e.g. raccoons and skunks) . The increased surface-water on the landscape may also negatively impact sage-grouse populations by providing an environment for disease vectors that transmit WNv (Walker and Naugle 2011, p. X). (see ***Disease*** and ***Predation*** chapters). Produced water also could result in direct habitat loss through prolonged flooding of sagebrush areas, or if the discharged water is of poor quality because of high salt or other mineral content, either of which could result in the loss of sagebrush or grasses and forbs necessary for foraging broods (BLM 2003, p. 4-223).

Air quality could be affected where combustion engine emissions, fugitive dust from road use and wind erosion, natural gas-flaring, fugitive emissions from production site equipment, and other activities (BLM 2008d, p. 4-74) occur in sage-grouse habitats. Presumably, as with surface mining, these emissions are quickly dispersed in the windy, open conditions of sagebrush habitats (Moore and Mills 1977, p. 109), minimizing the potential effects on sage-grouse. However, high-density development could produce airborne pollutants that reach or exceed quality standards in localized areas for short periods of time (BLM 2008d, pp. 4-82 to 4-88). For example, emissions from well flaring in the Pinedale Anticline area of Wyoming (MZ II) contained alkali elements (Walker 2008, entire), and samples from other oil and natural gas production sites showed high concentrations of volatile compounds including benzene, formaldehyde, and hydrogen sulfide (Macey *et al.* 2014, p. 8) at levels that exceeded human health-based risk standards. No information is available regarding the effects to sage-grouse of gaseous emissions produced by oil and gas development.

The extent of indirect impacts (the area of influence beyond the direct footprint of a project) range widely for energy projects and their associated infrastructure (Appendix E). Impacts are more severe when development is in close proximity to the lek (i.e., within nesting habitat), however, negative impacts can remain discernable for much greater distances. Impacts to sage-grouse in Wyoming were not detected at low levels of development (approximately 1 well per section [259 ha or 640 ac]) (Doherty *et al.* 2010, p. 4). Above this level, however, lek losses were 2 to 5 times greater inside than outside of developed areas. Leks that remained active in developed areas experienced a 32 to 77 percent decline. It has been hypothesized that a more clustered distribution of wells may explain less negative responses to similar densities of development (Doherty 2008, p. 79; Gregory and Beck 2014, p. 7). Seventy-five percent of the sage-grouse breeding habitat is within 3 km (2 mi) of development in the Powder River Basin (Service 2008b). Our analyses show that subpopulations of sage-grouse in MZ II have up to 35 percent of breeding habitat within 3.2 km (2 mi) of development, and where data are available for populations in the Uintah–Piceance Basin of Colorado and Utah, 100 percent of the breeding habitat is affected by oil and gas development (USFWS 2008b).

The BLM is the primary Federal agency managing the U.S.' energy resources and has the legal authority to regulate and condition oil and gas leases and permits. Although the restrictive stipulations that BLM applies to permits and leases are variable, a 0.4-km (0.25-mi) radius around sage-grouse leks is generally restricted to no surface occupancy (NSO) during the breeding season, and noise and development activities are often limited during the breeding season within a 0.8- to 3.2-km (0.5- to 2-mi) radius of sage-grouse leks. Well densities and spacing are typically designed to maximize recovery of the resource and are administered by State oil and gas agencies and the BLM (Connelly *et al.* 2004 pp. 7-39 to 7-40). Density of wells for current major developments on federal lands in the sage-grouse range vary from 1 well per 32 ha (80ac) to 1 well per 16 ha (40 ac) (Naugle *et al.*, 2011, pp. 497). Holloran (2005, pp. 38–39, 50) reported that male sage-grouse attendance at leks decreased over 23 percent in gas fields where well density was 5 or more within 3 km (1.9 mi). Sage-grouse are less likely to occupy areas with wells at a 32 ha (80 ac) spacing than a 400 ha (988 ac) spacing (Doherty *et al.* 2008, p. 193).

Negative effects of direct habitat disturbance can be offset by successful reclamation. Reclamation of areas disturbed by oil and gas development can be concurrent with field development or conducted after the shut-in or abandonment of the well or field. Sage-grouse may repopulate the area as disturbed areas are reclaimed. However, there is no evidence that populations will attain their previous size, and reestablishment may take 20 to 30 years (Braun 1998, p. 144). For most developments, return to pre-disturbance population levels is not expected due to a net loss and fragmentation of habitat (Braun *et al.* 2002, p. 150). In some reclaimed areas in Alberta sage-grouse have not returned (Aldridge and Brigham 2003, p. 31).

Location and Extent

Extensive oil and gas reserves are identified in the Williston Basin of western North Dakota, northwestern South Dakota, and eastern Montana (MZ I); Montana Thrust Belt in west-central Montana (MZ I); Powder River Basin of northeastern Wyoming and southeastern Montana (MZ I); Wyoming Thrust Belt of extreme southwestern Wyoming, northern Utah, and southeastern Idaho (MZ II and IV); Southwest Wyoming Basin including portions of southwestern and central Wyoming, northeastern Utah, and northwestern Colorado (MZ II); Uinta–Piceance Basin of west-central Colorado and east-central Utah (MZ VII); Eastern Great Basin in eastern Nevada, western Utah, and southern Idaho(MZs III and IV); and Paradox Basin in south-central and southeastern Utah (MZ III; Stiver et al. 2006, p. 1-11). Currently, oil, conventional gas, or coal-bed natural development is concentrated in the eastern portion of the occupied range. Four geological basins are most affected by a concentration of development—Powder River (MZ I), Williston (MZ I), Southwestern Wyoming (MZ II), and the Uinta–Piceance (MZs II, III, VII) coinciding with the highest proportion of high-density areas of sage-grouse, the greatest number of leks, and the highest male sage-grouse attendance at leks compared with any other area in the eastern part of the range (Doherty *et al.* unpublished data). Between 1997 and 2007, approximately 35,000 producing wells were in place on Federal, State, and private holdings in the Powder River Basin area (Naugle *et al.* 2011, p. 492). In 2008, the BLM in Montana completed a supplement to the 2003 Environmental Impact Statement (EIS) and Record of Decision (ROD) to allow for 5,800–16,500 new coal bed natural gas wells in the Montana portion of the Powder River Basin over the pursuant 20 years (BLM 2008b, pp. 4.2, 4.4-4.5). Energy development in the Powder River Basin is predicted to continue to actively reduce sage-grouse populations and sagebrush habitats over the next 20 years. The BLM concluded that local populations may be extirpated in areas of concentrated development and sage-grouse habitats would not be restored to pre-disturbance conditions for an extended time (BLM 2003, pp. 4¬268, 270). Using GIS analysis, we calculated that 70 percent of the sage-grouse breeding habitat is currently impacted by oil and gas development in the Powder River Basin (USFWS 2008b). The 70 percent figure is conservative because the most comprehensive well point data is dated and does not reflect the development since 2006. Ranching, tillage agriculture, and energy development are the primary land uses in the Powder River Basin. The presence of human features and road densities are high in areas where all three activities coincide to the level that every 1 km2 could be bounded by a road and bisected by a power line (Naugle *et al.* 2011, p. 493).

The 9.6millionha (23.9millionac) Williston Basin (which includes the Bakken field) underlies the northeastern corner of the current sage-grouse range in Montana, North and South Dakota. Oil production has occurred in the Williston Basin for at least 80 years with oil production peaking in the 1980s (Advanced Resources International 2006, p. 3-3) but advances in technology including directional drilling and coal-bed natural technology have boosted development of oil and gas in the basin

(Advanced Resources International 2006, p. 3.2; Zander 2008, p. 1). Large, developed fields are concentrated in the Bowdoin Dome area of north-central Montana and the 193km (120mi) long Cedar Creek Anticline area of southeastern Montana, southwestern North Dakota, and northwestern South Dakota. Extensive energy development in the Cedar Creek Anticline area could be isolating the very small North Dakota population from sage-grouse populations in central Montana and the northern Powder River Basin. Active drilling operations are expected to occur over 10 to 15 years, and gas production is expected to extend the project life 30 to 50 additional years (BLM 2008c, p. 1). Foreseeable development is expected to further reduce the remaining sage-grouse habitat within developed oil and gas fields, and contribute to future range and population reductions (Copeland *et al.* 2009, p. e7400).

The Southwestern Wyoming geological basin (MZ II) also is experiencing significant growth in energy development. This area is a stronghold for sage-grouse with some of the highest estimated densities of males anywhere in the remaining range of the species (Connelly *et al.* 2004, pp. 6–62, A5-23) and has been identified as one of two remaining areas of contiguous range essential for the long-term persistence of the species (Wisdom *et al.* 2011, p. 467). This area is home to the Pinedale Anticline Project Area, where approximately 457 wells on 322 well pads are in production (BLM 2008d, p. 6). Approximately 250 new well pads are proposed in addition to pipelines and other facilities (BLM 2008d, p. 36). Total initial direct disturbance acres for the entire Pinedale project are approximately 10,400 ha (25,800 ac) with more than 7,200 ha (18,000 ac) in sagebrush land cover type (BLM 2008d, p. 4-52). The Jonah Gas Infill Project also is underway in the Pinedale Anticline area. In 2006, the BLM issued a ROD to extend the existing project to an additional 3,100 wells and up to 6,556 ha (16,200 ac) of new surface disturbance (BLM 2006, p. 2-4). In addition, well density would be at least 64 well pads per 259 ha (640 ac), and up to 761 km (473 mi) of pipeline and roads, 56 ha (140 ac) of additional disturbance for ancillary facilities (p. 2-5) would occur. The project life of 76 years includes 13 years of development and 63 years of production (BLM 2006, p. 2¬15). Existing and planned energy development influences over 20 percent of the sagebrush area in the Wyoming Basin (MZ II) (Knick *et al.* 2011, p. 240). The Greater Green River area of southwest Wyoming (MZ II) and the Uintah– Piceance basin (MZ VII) also are, in addition to oil and gas, important reserves of oil shale and tar sands that are expected to supply more of the nation's resource needs in the future (EIA 2009b, p. 30). Sage-grouse in the Uintah-Piceance basin occur in four small, isolated populations, a likely consequence of past urban and agricultural development (Knick *et al.* 2011, pp. 208, 212; Leu and Hanser 2011, p. 270). Knick *et al.* (2011, p. 240) estimated existing energy development affects over 30 percent of sagebrush habitats in this area. We expect that the development of energy resources will continue based on available reserves and recent development history (Copeland *et al.* 2009, p. 5).

Projected Future Impacts

PLACEHOLDER OIL & GAS ANALYSIS

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Anticipated Changes from Present

Forecasts to the year 2030 predict fossil fuels to continue to provide for the United States' energy needs while not necessarily in conventional forms or from present extraction techniques (EIA 2009b, pp. 2¬4, 109). Recent concerns about curbing greenhouse gas emissions associated with fossil fuel use are being addressed through government policy, legislation, and advanced technologies and are likely to effect a transition in fuel form (EIA 2009b, pp. 2–3, 78).

The decline in use of conventional fossil fuels for power generation in the future is expected to be supplemented with biomass, unconventional oil and gas, and renewable sources—all of which are existing or potentially available in current sage-grouse habitats (DOE 2006, p. 3; National Petroleum Council 2007, p. 6; BLM 2005a, p. 2-4; NREL 2008a, entire; Idaho National Engineering and Environmental Laboratory 2003, entire; EIA 2009b, pp. 2–4). For example, oil shale and tar sands are unconventional fossil fuel liquids predicted for increased development in the sage-grouse range. Extraction of this resource involves removal of habitat and disturbance similar to oil and gas development. National reserves of oil shale lie primarily in the Uinta–Piceance area of Colorado and Utah (MZs II, III, and VII), and the Green River and Washakie areas of southwestern Wyoming (MZ II). These 1.4 million ha (3.5 million ac) of Federal lands contain an estimated 1.23 trillion barrels of oil—more than 50 times the U.S.' proven conventional development of nonrenewable energy resources.

Results of our modeling effort suggest that up to 21 and 25 percent of sage-grouse in MZ I and II, respectively are likely to be exposed to energy development in the future, not considering the benefits of conservation actions. Residual exposure of sage-grouse after applying land use restrictions on BLM lands and the tenets of the Wyoming Core Area Strategy in Wyoming reduce the exposure to an estimated maximum of 14 and 9 percent in MZ I and MZ II respectively. As neither conservation provision provides absolute protection, the actual level of exposure will likely be between the two bounded maximum estimates. As the mean USGS development estimates have been achieved, or nearly so in many areas across the MZs I and II we are deferring to the maximum estimates to estimate the potential for future impacts. However, this may be an erroneous assumption at local areas and exposure to nonrenewable energy development may be less at those locations.

Threat Amelioration

Conservation Efforts Database Projects

Through the CED, the Service collected information relating to conservation actions that were completed, in progress, or planned. Thirteen projects addressing energy development were entered in the CED as "completed" by data providers. These projects occur in MZs I through IV, and total more than 263,000 ha (650,000 acres), with the greatest total amount of effort in MZs I and II (Appendix D). Only projects in MZs I, II, and VII were considered in our analyses of efforts as these are the key areas in the sage-grouse range where this threat occurs, or is likely to occur. Conservation efforts that are completed and effective for minimizing the threat of energy development total 118,833 ha (293,642 ac; Table 9-3).

Table 9-3. Summary of projects determined to be effective in the Service review of completed CED projects addressing energy development. Some of the projects addressed multiple threats, or spanned more than one MZ. These are indicated separately.

Management Zone	Conservation Effort	ha (ac)
I	unique acres (MZ & threat) [1]	84 (207)
	same acres & MZ, > 1 threat [2]	0
	same acres & >MZ, > 1 threats [3]	113,717 (281,000)
II	unique acres (MZ & threat) [1]	0
	same acres & MZ, > 1 threat [2]	5,032 (12,435)
	same acres & >MZ, > 1 threats [3]	0
VII	unique acres (MZ & threat) [1]	0
	same acres & MZ, > 1 threat [2]	0
	same acres & >MZ, > 1 threats [3]	0
TOTAL		118,833 (293,642)

[1] projects in one MZ addressing one threat
[2] projects in one MZ addressing more than one threat
[3] projects crossing more than one MZ addressing more than one threat

Candidate Conservation Agreements with Assurances and Candidate Conservation Agreements

Lands currently enrolled in CCAAs typically have split-estate development and therefore surface owners have limited control of non-renewable energy development. If energy development occurs on lands enrolled in CCAAs, the landowner is required to attempt to negotiate with the energy developer to reduce impacts to sage-grouse and their habitat, however, energy development may still occur. Approximately 0.17 percent of occupied range in MZ I, 0.78 percent of MZ II, 2.47 percent of MZ IV, and 4.67 percent of MZ V are enrolled in CCAAs in Wyoming and Oregon. Federal lands enrolled in CCAs in Wyoming, Oregon, and Idaho account for 0.04 percent of occupied range in MZ I, 0.21 percent of MZ II, 3.13 percent of MZ IV, and 4.67 percent of MZ V. However, none of the CCAAs or CCAs directly address impacts from nonrenewable energy development. See the ***Non-regulatory Conservation Efforts*** section and Table 9-3 for approximate acreages and additional information.

State Plans

State plans in Nevada, Idaho, Oregon, Utah, Montana, and Wyoming include regulatory mechanisms to reduce impacts associated with energy development on applicable lands in each state. The Wyoming, Montana, and Idaho state plans incorporate stipulations and conservation measures such as controlled surface use, seasonal and noise restrictions, consultation requirements, density of development restrictions, and lek buffers to reduce impacts associated with energy development on state lands in Idaho, on all lands within core areas in Wyoming (State of Wyoming 2011, pp. 8–10; Idaho Department of Lands 2015, pp. 25–26). If enacted, Montana's state plan would similarly reduce impacts associated energy development in core areas on state lands and private lands where state authorization is required (State of Montana 2014, pp. 13–19).

Utah's state plan provides for sage-grouse conservation within identified sage-grouse management areas (SGMAs). The plan directs that extractive and renewable energy development follow a management protocol to avoid, minimize, and mitigate impacts within sage-grouse habitats and to reclaim habitats as projects advance or are completed (State of Utah 2013, p. 15). Utah's plan also dictates that new, permanent tall structures for renewable energy should not be located within one mile of a lek if the structure would be visible by the birds (State of Utah 2013, p. 17). Utah's plan would apply only to Federal lands within the SGMAs, and would be completely voluntary on private, SITLA, and local government lands unless the landowner agrees to incorporate the conservation provisions (State of Utah 2013, p. 19). However, Utah's recently issued Executive Order directs the Utah Division of Oil, Gas, and Mining (UDOGM) to coordinate with the Utah Division of Wildlife Resources (UDWR) on UDOGM regulatory actions on state and private land to ensure compliance with the requirements of the state plan and to implement conservation recommendations (State of Utah 2015, p. 4). Accordingly, while Utah's state plan is only regulatory on Federal lands, Utah's Executive Order and existing state authorities that govern oil, gas, and mining would regulate and reduce impacts to sage-grouse from energy development on state and private lands. Therefore, in conjunction with the Executive Order and other existing authorities, Utah's state plan effectively reduces impacts associated with energy development within the identified SGMAs. Under Utah's state plan, sage-grouse habitats located outside of SGMA's will not receive the same protective considerations. Therefore, in areas not managed as a SGMA, Utah's state plan in conjunction with the Executive Order is not expected to effectively reduce impacts associated with energy development.

According to Oregon's draft state plan, energy development should be designed to ensure that it will not "impinge upon stable or increasing sage-grouse population trends" on all lands with sagebrush habitat in the state (State of Oregon 2015, p. 56). Oregon regulates some energy development through the state's Energy Facility Siting Council, but only for large-scale developments, and it is unclear how and when rulemaking, mitigation, and adaptive management will link to the state plan (State of Oregon 2015, p. 57). Oregon's state plan is a draft and has not been implemented, so it does not effectively reduce impacts associated with energy development.

Although its provisions are not regulatory, Colorado's state plan influences the Colorado Oil and Gas Conservation Commission (COGCC) and the Colorado Department of Reclamation and Mining Safety (CDRMS) to consider impacts to sage-grouse during the permitting process for new wells and mines. During the permitting process, Colorado Parks and Wildlife (CPW) makes recommendations to the COGCC and the CDRMS to impose restrictions from the state's conservation plan that may help to reduce impacts to sage-grouse from energy development (State of Colorado 2008, pp. 22, 109, 123, 313, 325–331). A summary of state regulations and conservation plans addressing nonrenewable energy development, and other threats is in the Regulatory Mechanisms chapter (pp.X).

BLM Resource Management Plans and USFS Land and Resource Management Plans

The BLM and USFS will prioritize leasing and development of fluid mineral resources outside of PHMA and GHMA. When analyzing leasing and authorizing development of fluid mineral resources, in PHMA and GHMA, and subject to applicable stipulations for the conservation of sage-grouse, priority will be given to development in non-habitat areas first and then in the least suitable habitat for sage-grouse. The implementation of these priorities will be subject to valid existing rights and any applicable law or regulation, including, but not limited to, 30 U.S.C. 226(p) and 43 C.F.R. 3162.3-1(h).

Where a proposed fluid mineral development project on an existing lease could adversely affect sage-grouse populations or habitat, the BLM will work with the lessees, operators, or other project proponents to avoid, reduce and mitigate adverse impacts to the extent compatible with lessees' rights to drill and produce fluid mineral resources. The BLM will work with the lessee, operator, or project proponent in developing an APD for the lease to avoid and minimize impacts to sage-grouse or its habitat and will ensure that the best information about the sage-grouse and its habitat informs and helps to guide development of such Federal leases.

Additionally, BLM and USFS plans include NSO in all PHMA with no waivers or modifications. The BLM plans include closure or NSO for all PHMA with limited exceptions, as follows:
The Authorized Officer may grant an exception to an oil and gas lease NSO stipulation only where the proposed action:

(i) Would not have direct, indirect, or cumulative effects on sage-grouse or its habitat; or,

(ii) Is proposed to be undertaken as an alternative to a similar action occurring on a nearby parcel, and would provide a clear conservation gain to sage-grouse.

Exceptions based on conservation gain (ii) may only be considered in: (a) PHMAs of mixed ownership where federal minerals underlie less than 50 percent of the total surface; or (b) areas of the public lands where the proposed exception is an alternative to an action occurring on a nearby parcel subject to a valid Federal oil and gas lease existing as of the date of this RMP [revision or amendment]. Exceptions based on conservation gain must also include measures, such as enforceable institutional controls and buffers, sufficient to allow the BLM to conclude that such benefits will endure for the duration of the proposed action's impacts.

Any exceptions to this lease stipulation may be approved by the Authorized Officer only with the concurrence of the State Director. The Authorized Officer may not grant an exception unless the applicable state wildlife agency, the Service, and the BLM unanimously find that the proposed action satisfies (i) or (ii). Such finding shall initially be made by a team of one field biologist or other sage-grouse expert from each respective agency. In the event the initial finding is not unanimous, the finding may be elevated to the appropriate BLM State Director, Service State Ecological Services Director, and state wildlife agency head for final resolution. In the event their finding is not unanimous, the exception will not be granted. Approved exceptions will be made publically available at least quarterly." For already leased fluid minerals, the BLM will work with lessee, operator, or project proponent in developing an Application for Permit to Drill for the lease to avoid and minimize impacts

BLM and USFS plans mimic the Wyoming executive order, which was designed to address the impacts of energy development. For additional details, see the ***Regulatory Mechanisms*** section.

Threat Summary

In our 2010 Finding we concluded, "Energy development is a significant risk to the greater sage-grouse in the eastern portion of its range (Montana, Wyoming, Colorado, and northeastern Utah – MZs I, II, VII and the northeastern part of MZ III), with the primary concern being the direct effects of energy development on the long-term viability of greater sage-grouse by eliminating habitat, leks, and whole populations and fragmenting some of the last remaining large expanses of habitat necessary for the species' persistence." We anticipate that nonrenewable energy development will continue into the future for minimally 70 years (as predicted by EISs). Past and current nonrenewable energy development has already affected sage-grouse populations, resulting in significant declines in some areas. Indirect effects will likely continue in and near areas of current development, and more direct impacts (such as population declines) may be realized due to a time lag in sage-grouse response to disturbance. The exposure risk for new impacts in MZs I and II, when ameliorated by conservation actions, are relatively small (maximum of 9 and 14 percent, respectively). However, the risk may greater in local areas where conservation actions do not apply or are not entirely effective. Therefore, nonrenewable energy development will continue to affect sage-grouse populations, primarily in the eastern portion of the range, but likely at a reduced level than past development. Impacts will be concentrated in some areas with the greatest density and numbers of sage-grouse (MZ II).

CHAPTER 10: MINING

Mining activities have occurred throughout the range of sage-grouse since the mid-1800s (Legends of the West 2014, p.1; Nevada Mining Association 2015), and continue today (American Mining Association 2014). Historically mining in the West used both hand and mechanical tools; the advent of new methods in the late 19th century facilitated the expansion of mining activities. Currently, surface and subsurface mining activities, extracting at least 50 mineral products ((Minerals Education Coalition 2015, National Mining Association 2014a), are conducted in all 11 States across the sage-grouse range.

Mining is generally divided into three categories based upon the type of mineral extracted (i.e., locatable, leasable, and salable minerals); each type with its own regulations. The extent of mining for any individual mineral varies widely, as does the size and activity of individual mines, making generalizations of impacts difficult.

Current impacts

Surface and subsurface mining for mineral resources results in direct loss of sagebrush habitats. The amount of direct habitat loss varies widely with the type and size of mine, ranging from many thousands of acres for large industrial mines (e.g., coal, copper, gold, trona) to 10 acres or less for smaller operations (e.g., gravel and sand). The direct impact from surface mining is typically greater than it is from subsurface mining. Habitat loss from mining can be exacerbated by the storage of overburden (soil removed to reach subsurface resources) in otherwise undisturbed habitat. If the construction of mining infrastructure is necessary, additional loss of habitat could result from associated infrastructure common to all types of mines, including haul and access roads and fences which can pose collision risks to sage-grouse.

Indirect impacts from mining activity include degradation and fragmentation of the area surrounding the mine. The habitat quality of the surrounding area is reduced for sage-grouse through increased levels of human activity, disturbance and noise from traffic, increased dust, reduced air quality, changes in vegetation and topography, and increased abundance of predators (Moore and Mills 1977, entire; Brown and Clayton 2004, p. 2). Blasting, to remove overburden or the target mineral and seismic surveys to locate minerals also produce noise and ground shock. The full effect of ground shock on wildlife is unknown, but repeated use of explosives during the breeding season could potentially result in lek or nest abandonment (Moore and Mills 1977, p. 137). Noise from mining activity could mask vocalizations resulting in reduced female attendance and yearling recruitment as seen in sharp-tailed grouse (*Pedioecetes phasianellus*) (Amstrup and Phillips 1977, pp. 23, 25–27). Recent research has demonstrated that sage-grouse are sensitive to noise (Blickley *et al* 2012, p. 467). Noise from mining activities, which includes traffic noise, could have similarly negative impacts on sage-grouse. Amstrup and Phillips (1977) found that coal mining activities produced considerable noise that was continuous across days and seasons and did not diminish as it traveled from its source. Maximum and minimum noise levels recorded at distances of almost 0.5 km (0.3 mi) were 83 and 28 decibels, respectively (Amstrup and Phillips 1977, p. 24), which exceed recommendations of no more than ambient noise plus 10dB to minimize impacts to sage-grouse (Patricelli et al. 2013, p. 124). Habitat loss and fragmentation could preclude seasonal habitat movements (Connelly *et al.* 2011b, pp. 82–83; Knick and Hanser 2011, entire). Mining operations can contribute contamination to water sources in sage-grouse habitat as a result of blasting chemicals (ammonium nitrate, fuel oil) or metal leachate from waste rock or overburden (Moore and Mills 1977, pp. 115, 133; Adams and Picket 1998, p. 486; Ramirez and Rogers 2002, p. 434–435). Altering of water regimes could lead to decreased surface water and eventual habitat degradation from wildlife or domestic livestock concentrating at remaining sources, and degradation of riparian areas resulting in a loss of brood habitat. Alternatively, creation of settling ponds could provide breeding areas for mosquitos and increase the risk of WNv (Walker and Naugle 2011, p. X; see ***Disease*** section).

Few studies have specifically examined the impact of mining on sage-grouse. Male lek attendance declined at leks within 2 km (1.3 mi) of three active surface coal mines in North Park, Colorado. .One lek became inactive and the others declined, likely as a result of declining recruitment of juvenile males(Braun 1986, pp. 228–229; Remington and Braun 1991, pp. 131–132). .Two leks that were abandoned adjacent to mine areas were reestablished when mining activities ceased or were operating at greatly reduced levels, suggesting disturbance rather than habitat loss was the limiting factor (Remington and Braun 1991, p.132). Those leks never achieved pre-disturbance lek numbers (Remington and Braun 1991, pp. 130–131).

Female survival and nest success did not appear to be negatively impacted in a population of sage-grouse near large surface coal mines in northeast Wyoming (Brown and Clayton 2004, p. 1). However, the authors concluded that continued mining would result in fragmentation and eventually impact sage-grouse persistence if adequate reclamation was not employed (Brown and Clayton 2004, p.16). The lek complex monitored for this study was later classified as destroyed as it was eventually excavated as a result of mining activity (USFS 2007, p. 27). Local sage-grouse populations could decline if several leks are affected by coal mining, but the loss of one or two leks in a regional area is not likely to limit local populations (Hayden-Wing Associates 1983, p. 81).

Quantifying how many leks have been lost rangewide due to mining is difficult because the information is not available in published literature, and is instead, anecdotal or only available from the mining companies that did the original work (Braun 1986, p. 227). For example, the Southwest Wyoming Local Sage-grouse Working Group (2013, p. 62) reported that all of the mine sites in southwest Wyoming overlapped with sage-grouse habitat and historical leks near heavily impacted areas had been destroyed or become unoccupied. As of 2006, eight leks within the Powder River Basin coal mining area were classified as destroyed due to coal mining activity (Northeast Wyoming Sage-grouse Working Group 2014, p. 139). Walker *et al.* (2007, p. 2648) excluded four leks "known to have been destroyed by coal mining" from their analysis on impacts to sage-grouse from coal bed methane. Unlike research on impacts from mining, there is a substantial amount of information on the impacts of oil and gas development on sage-grouse. Research on oil and gas development has shown significant negative impacts to sage-grouse (avoidance, decreased recruitment, decreased survival; see ***Nonrenewable Energy*** chapter). Because the mechanisms for potential impacts from mining are likely similar to those for oil and gas (e.g., fragmentation, increased noise, road traffic, infrastructure, human activity), we expect similar negative impacts to sage-grouse in areas developed for mining of other minerals. We recognize, however, that although mechanisms for impacts are similar, they may not be entirely representative of the direct and indirect impacts for various mining techniques. For example, large individual mines and their associated infrastructure can be concentrated in a relatively small area in comparison with more dispersed oil and gas development. However, there is some evidence that the spatial configuration of development on the landscape can have biological consequences for sage-grouse (Doherty 2008, p. 79; Gregory and Beck 2014, p. 7). Areas of dense mine development with many closely situated mines exist in the occupied range of sage-grouse, which makes the potential for impacts in these areas high.

Restoration of sage-grouse habitats following mining is challenging due to the changes in micro-climate and topography resulting from surface mining. Additionally, mine restoration on private lands is dictated by the surface owner, often resulting in permanent habitat conversion if returning to sage-grouse habitat is not the desired condition. In sagebrush areas where restoration to pre-existing habitat conditions is desired, reclamation seed mixtures typically include native forbs and sagebrush. There have been some limited successes in sagebrush re-establishment, and we anticipate that restoration techniques for sagebrush habitats will be further improved as the science improves. Currently recovery of impacts from mining is slow, and often not fully successful.

Location and Extent

Minerals are not distributed evenly across the sage-grouse landscape. For instance, coal and uranium, mining are more prevalent in Wyoming and Montana (MZs I and II), while gold and other hard rock mining is more common in Nevada and Utah (MZs III, IV and VII). Coal is primarily found in the Rocky Mountain States while lithium has been mined exclusively in Nevada (although a more recent discovery has been made in southwestern Wyoming (Mining.com 2014). Precious metals, while being mined to some degree in all 11 states across the sage-grouse range, primarily occur in Nevada and Colorado (USGS 2013b). As a result, depending upon the type of mineral, the associated mining activities tend to be localized or regional, and their impacts likewise tend to be similarly localized. Currently non-coal mining activities are primarily impacting MZs II, III, IV, and VII. Coal mining is exclusively impacting MZs I, II, III, and VII

[PLACEHOLDER FOR GIS ANALYSES AND MAPS]
Until these analyses are received we cannot assess the actual impact of mining on sage-grouse

Likelihood of future impacts

Market prices for any specific mineral commodity vary greatly making projections of continued and new mining activities difficult. The overall extent of mining activity in the U.S. has remained fairly consistent over the past five years (National Mining Association 2014b), although coal production, including the mines within the range of sage-grouse has generally declined since 2008 (see Table 6.1 in EIA 2015a,). We anticipate that mining will minimally remain a continuous activity with the range of sage-grouse indefinitely. However, the intensity of mining will vary locally depending on the extent of the desired mineral resource, development of new mining techniques, and market conditions.

In the U.S., mining activity is authorized under an array of statutes primarily administered or leased by the BLM, both on Federally-administered lands as well as other lands where mineral rights have been reserved to the U.S. (i.e., split-estate lands). Coal is administered by the Office of Surface Mining Reclamation and Enforcement (OSM), which in turn may delegate their authority to the States. Statutory authority for mining originated with The General Mining Law of 1872, as amended (30 USC 22-54 and 43 CFR 3809); subsequent statutes have provided additional standards and processes for

Federal administrative oversight for specific classes of mineral deposits. The BLM's statutory and regulatory authority depends upon the nature of the mineral deposit (i.e., leasable, salable or locatable). The General Mining Law of 1872 called for all locatable mineral deposits in on Federal lands to be free and open to exploration and purchase (BLM 2011, entire), limiting the ability to manage these activities for sage-grouse conservation. Only areas that have been withdrawn to mineral entry by a special act of Congress, regulation, or public land order are truly closed to locatable mineral entry.

Threat amelioration

Conservation Efforts Data Base Projects

Through the CED, the Service collected information relating to conservation actions that were completed, in progress, or planned. Fifteen projects addressing mining were entered in the CED as "completed" by data providers (Appendix C). Of the projects deemed completed by the project proponents the Service reviewed projects in MZs II, III, and V as these MZs are the key areas in the sage-grouse range where this threat occurs, or is likely to occur. Two projects in Montana (totaling 113, 716 ha; 281,000 ac; Table 10-1) listed more than one MZ in their CED entry, but the total number of acres reported for these projects were not allocated among MZs.

Table 10-1: Summary of projects determined to be as effective in the Service review of completed CED projects addressing mining. Some of the projects addressed more than one threats (e.g., easements precluding mining and urban development), or spanned more than one MZ. Those are indicated separately in the following table.

Management Zone	Conservation Effort	ha (ac)
II	unique acres (MZ & threat) [1]	2 (5)
	same acres & MZ, > 1 threat [2]	4,627 (11,434)
	same acres & >MZ, > 1 threats [3]	113,716 (281,000)
III	unique acres (MZ & threat) [1]	0
	same acres & MZ, > 1 threat [2]	421 (1,040)
	same acres & >MZ, > 1 threats [3]	0
V	unique acres (MZ & threat) [1]	0
	same acres & MZ, > 1 threat [2]	0
	same acres & >MZ, > 1 threats [3]	0
TOTAL		118,767 (293,479)

[1] projects in one MZ addressing one threat
[2] projects in one MZ addressing more than one threat
[3] projects crossing more than one MZ addressing more than one threat

Candidate Conservation Agreements with Assurances and Candidate Conservation Agreements

Lands currently enrolled in CCAAs typically have split-estate development and therefore surface owners may have limited control of mining development. If mining occurs on lands enrolled in CCAAs, the landowner is required to attempt to negotiate with the mining operator to reduce impacts to sage-grouse and their habitat. Approximately 0.17 percent of occupied range in MZ I, 0.78 percent of MZ II, 2.47 percent of MZ IV, and 4.67 percent of MZ V are enrolled in CCAAs in Wyoming and Oregon. Federal lands enrolled in CCAs in Wyoming, Oregon, and Idaho account for 0.04 percent of occupied range in MZ I, 0.21 percent of MZ II, 3.13 percent of MZ IV, and 4.67 percent of MZ V. However, none of the

CCAAs or CCAs directly address impacts from mining. See the ***Non-regulatory Conservation Efforts*** section and Table 28-7 for approximate acreages and additional information.

State Plans

Nine of the 11 states within the occupied sage-grouse range recognize sage-grouse as a species of conservation concern (or similar designation). All states within the 11 state range have completed, or are in the process of completing, individual State plans to address sage-grouse conservation. All these State plans address mining to some degree, although their discussions vary significantly in scope. Some states (e.g., Nevada, Colorado, Wyoming) also require projects to provide compensatory mitigation for unavoidable impacts to sage-grouse and its habitat.

State plans in Idaho, Wyoming, Utah, and Montana include regulatory mechanisms that reduce impacts to sage-grouse from mining on applicable lands. The state plans in Idaho and Wyoming incorporate controlled surface use, lek buffers, and seasonal and noise restrictions to reduce impacts on State lands in Idaho and in core areas in Wyoming (Idaho Department of Lands 2015, pp. 25–26; State of Wyoming 2011, pp. 8–10). Montana's state plan is similar to Wyoming's plan and if enacted would include controlled surface use, lek buffers, and noise and seasonal restrictions to reduce mining related impacts in core areas on State lands and private lands where state authorization is required (State of Montana 2014, pp. 14–19). Although Utah's state plan does not specifically address mining, regulatory mechanisms in the State require avoidance, minimization, and mitigation on State and Federal lands to reduce impacts to sage-grouse, but these requirements are voluntary on private, SITLA and local government lands (State of Utah 2012, p.19). Therefore, state plans in Idaho, Wyoming, and Utah include existing regulatory mechanisms that effectively reduce impacts associated with mining on applicable lands.

If a mining project will disturb sage-grouse on any lands in the State, Nevada's state plan requires that project proponents consult with the State's Sagebrush Ecosystem Technical Team (SETT) to avoid, minimize, or mitigate potential impacts (State of Nevada 2014, p. 100). If avoidance cannot be reasonably accomplished, Nevada's plan requires that project proponents minimize impacts with design features (State of Nevada 2014, p. 101). Nevada's plan also guides project proponents to bury power lines and install anti-nesting or perching devices on power lines where technically and economically feasible (State of Nevada 2014, pp. 101–102). However, the BLM would be responsible for enforcing this consultation process on the majority of land in Nevada, but this process has yet to be implemented and is not an existing regulatory mechanism. A summary of state regulations and conservation plans addressing mining, and other threats is in the Regulatory Mechanisms chapter (pp.X).

BLM Resource Management Plans and USFS Land and Resource Management Plans

Mineral development on federal lands will be managed as per the direction provided in the new LUPs currently being drafted by the BLM and USFS (see ***Regulatory Mechanisms*** section As currently proposed as BLM-designated priority habitats (similar to PACs and IPAs) will either be closed to new permits, with the exception of Wyoming, and expansion of existing operations will be subject to disturbance caps and compensatory mitigation. These actions should minimize the impacts of future development of mineral resources in priority habitats for the life of the management plans (approx. 20 years). Wyoming will remain open to new mining activities within PACs, but those activities will be restricted by a disturbance and density cap as per the Wyoming Governor's core area strategy (see ***Regulatory Mechanisms*** section). General sage-grouse habitats (those falling outside of BLM-designated priority habitat) will be open to mineral development subject to stipulations to protect sage-grouse. Locally, Federal land managers may close general sage-grouse area. Currently, habitats of significant conservation value (i.e., strongholds or Sagebrush Focal Areas [SFA]) have been proposed as recommended withdrawal areas for locatable mineral exploration and development (USFWS 2014b). If these areas are withdrawn, disturbance from new locatable mineral development will not be permitted.

Threat Summary

[TO BE COMPLETED AFTER GIS ANALYSES OF THE THREAT, AND AMELIORATION ACTIVITIES IS COMPLETED]

It is difficult to accurately predict the future impacts of mining due to the market driven nature of the activity. As advances in mining technology are developed mining activity could be occur in areas which are currently unprofitable. Additionally, the need for new minerals, not currently required to the extent to make their mining economically viable, could provide new markets, and therefore new pressure, on sage-grouse habitats. The scattered nature and intensity of this activity, coupled with market uncertainty make it difficult to assess the actual impact to sage-grouse on a rangewide basis. However, mining clearly has significant impacts on local populations of sage-grouse and their habitats.
Proposed LUP amendments by BLM and USFS, combined with additional conservation efforts by the individual States, will minimize potential impacts of new mining to in BLM-designated priority habitats, and provide additional conservation in remaining general sage-grouse habitats. Expansion of existing operations will also proceed with a reduced impact. These regulatory provisions will be essential in minimizing the future footprint of mining on sage-grouse habitats as restoration efforts are currently minimally unsuccessful. Mining of private minerals on private lands will continue and could be locally significant.

CHAPTER 11: RENEWABLE ENERGY

Development of commercially viable renewable energy – wind, solar and geothermal – is increasing across the entire range of sage-grouse, with current development in areas already experiencing significant traditional energy development (e.g., MZs I and II; EIA 2015, entire; DOE 2014, entire; see ***Cumulative Effects*** section). There is little published scientific literature examining the effects of renewable energy on sage-grouse and sagebrush-steppe ecosystems. Given the similarity in required infrastructure, the effects of renewable energy development are likely similar to those of nonrenewable energy, specifically oil and gas. Renewable energy development is a relatively recent activity in sage-grouse habitats. For example, commercial wind energy in the U.S. began in the 1850s but it was not until 1992 with the onset of the Energy Policy Act, followed by the 2008 U.S. Department of Energy 20 percent Wind Energy by 2030 initiative, that wind energy production became a large source of renewable electricity (DOE 2014, entire). Development of renewable energy is specifically encouraged and/or required by several States. For example, the states of Idaho and California provide tax incentives and loan programs for renewable energy development (AFWA and Service 2007, p. 14; State of Idaho, 2012; California Energy Commission, 2015), Colorado state law requires incremental increases of renewable generation from 3 percent in 2007 to 20 percent by 2020 (AFWA and Service 2007, p. 8), and the State of Nevada requires that 25 percent of electricity sold to retail consumers must be from renewable sources by 2025 (Nevada Public Utilities Commission, 2015).

Wind

Wind development is occurring throughout the range of sage-grouse (Table 11-1, Figure 11-1), and over 14 percent of the sagebrush landscape within the sage-grouse range have high potential for commercial wind power (BLM 2005, pp. 5-103NREL 2014, p. 2). Wind harvesting potentials are most concentrated and geographically extensive in MZs I and II, with areas of highest commercial potential including up to 40 percent of the available sagebrush habitats in these MZs. Management Zones III through VII each have approximately 1 to 14 percent of sagebrush habitats that are commercially viable for wind energy development (Table 11-1, Figure 11-1,).

Table 11-1: Area of sagebrush habitat with wind energy development potential by management zone.

Management Zone (MZ)	Area of Sagebrush with Developable Wind Potential		
	km^2	mi^2	Percent of MZ
I	141937	54802	40.42%
II	56275	21728	23.07%
III	3880	1,498	1.22%
IV	12,703	4,905	3.92%
V	6,365	2,457	3.91%
VI	1,528	590	2.36%
VII	19	7	0.01%
Total	222,708	85,988	13.74%

While the BLM administers more land areas of high wind resource potential than any other land management agency, currently developed wind energy facilities are located primarily on private lands (72 percent). Only 21 percent of wind energy developments are located on BLM-administered lands.

In 2005, the BLM completed the Wind Energy Final Programmatic EIS (PEIS) that provides overarching guidance for wind project development on BLM-administered lands (BLM 2005a, entire). This EIS provided an avenue to accomplish the DOE's initiative to increase wind energy production by 20 percent by 2030 which was designed to assist with the nation's energy demands while not contributing to climate change. Approximately 600 km^2 (232 mi^2) of BLM-administered lands are likely to be developed within the sage-grouse's range before 2025 (BLM 2005a, pp. ES-8, 5-2). This estimate could be conservative considering the interest in reducing green-house emissions (e.g., the DOE initiative) and the institution of State renewable energy mandates and incentives that have occurred since 2005. With the advent of Federal tax credits for wind energy facilities, wind development increased 20 percent in 2013 (Easterly and Gellman 2013, p. 3). Active leases for wind energy development on BLM-administered lands increased from 9.7 km^2 (3.7 mi^2) in 2002 to 5,113 km^2 (1,973 mi^2) in 2008, with an additional 5,381 km^2 (2,077 mi^2) of lease requests were pending approval in the sage-grouse range (Knick *et al.* 2011a, p. 244). A recent increase in wind energy development is most notable within the range of the south-central Wyoming subpopulation of sage-grouse in MZ II where 1,387 km^2 (535 mi^2) have active wind leases and an additional 2,828 km^2 (1,092 mi^2) are pending (Knick *et al.* 2011, p. 136). In mid-2009, wind energy production facilities in operation or under construction in the sage-grouse range had a capacity of 11.93 GW (AWEA 2009, entire). To achieve predicted levels of between 49 to greater than 90 GW capacity (DOE 2008, p. 10), the generation capacity would need to increase by 400 to 800 percent by 2030. The forecasted increase in production would require approximately 37,000 to 78,000 or more turbines based on the existing technology and equipment in use (AWEA 2013, entire). To meet this capacity, an estimated additional 50,000 km^2 (19,305 mi^2) of land in the sage-grouse range would be required to meet the desired level of wind-generated electricity by 2030 (Copeland *et al.* 2009, p. 1). Interest in wind energy development is high, as reflected by the number of recently issued Right-of-Ways (ROWs) for wind on BLM-administered lands (Table 11-2).

Table 11-2: Area of BLM wind (ROWs) within the occupied range of greater sage-grouse.

Management Zone	BLM Wind ROW Footprint (km^2/acres)
I	9.8/2,414
II	1541.3/380,869
III	2064.4/510,126
IV	3038.7/750,882
V	4031.4/996,182
VI	1.1/278
VII	114.5/28,293

Table 11-3. Direct disturbance of wind turbine footprint on sage-grouse habitat.

Management Zone	Wind Turbines Direct Disturbance Footprint				
	Within Occupied Range		Intersect: Breeding Distribution		Intersect: Population Index
	Acres	**%**	**Acres**	**%**	**%**
I	1,167	0.003	538	0.005	0.00410
II	1,407	0.004	605	0.005	0.00219
II	328	0.001	0	0.000	0.00004
IV	555	0.001	33	0.000	0.00013
V	0	0.000	0	0.000	0.0000
VI	0	0.000	0	0.000	0.0000
VII	0	0.000	0	0.000	0.0000
Range wide [1]	**3,458**	**0.0**	**1,176**	**0.0**	

[1] All range wide calculations will not include Bi-State population or the Canadian portion of the range.

Table 11-4. Indirect area of influence of wind turbines on sage-grouse habitat.

Management Zone	Wind Turbines Indirect Area of Influence [1]				
	Within Occupied Range		Intersect: Breeding Distribution		Intersect: Population Index
	Acres	**%**	**Acres**	**%**	**%**
I	278,786	0.6	82,890	0.8	0.904
II	315,589	0.9	127,202	1.1	0.516
III	87,444	0.3	5,702	0.1	0.013
IV	123,092	0.3	8,783	0.1	0.029
V	3,886	0.0	0	0.0	0.000
VI	18,394	0.7	11,056	1.0	0.076
VII	0	0.0	0	0.0	0.000
Range wide [2]	**827,192**	**0.0**	**235,634**	**0.0**	

[1] Indirect 5.0km radius buffer around Turbines (Lebeau et al. 2014).
[2] All range wide calculations will not include Bi-State population or the Canadian portion of the range.

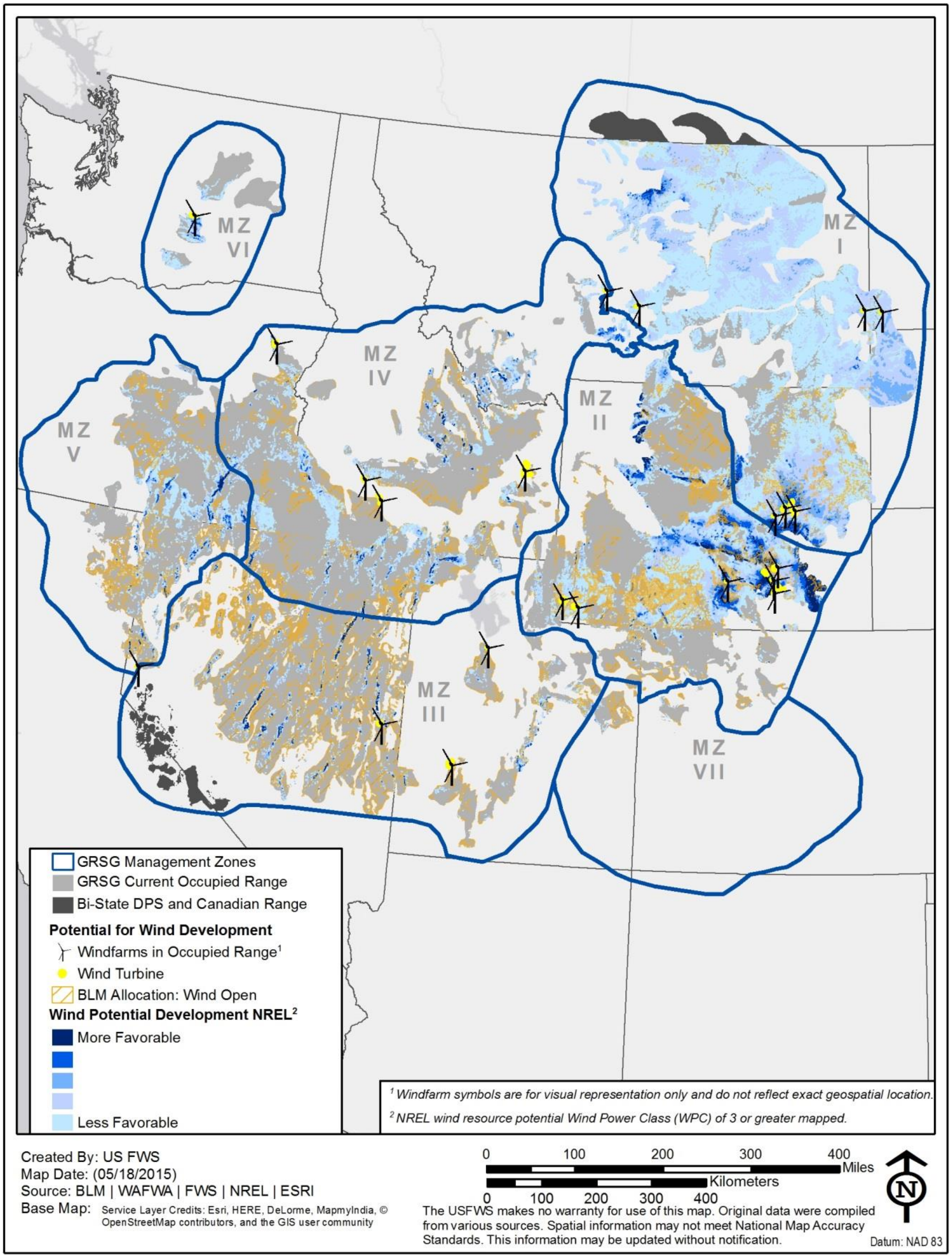


Figure 11-1: Current wind developments, and potential areas of development based on NREL wind resource potential Wind Power Classes (WPC), and BLMs 'open' land use designation for wind development.

Currently, the BLM and USFS are proposing to exclude wind development in PHMA until such a time wind energy technology advances to the point that there are no impacts to sage-grouse populations. Some of these plans are extending this protection to ROW exclusion, which will permit no impacts in PHMA due to wind and solar development. Associated transmission lines are addressed separately in the draft proposed RMPs, with some plans designating transmission corridors as exclusion areas (no new construction), while others will be avoidance areas (areas with more flexibility for development). Transmission lines and roads could still be constructed under an avoidance designation.

Wyoming (MZ II), where wind development potential is high, does not have a requirement for increased reliance on renewable energy sources and no specific wind siting authority. However, large commercial construction projects in the State are subject to compliance with the State's Core Area Strategy, as implemented by Executive Order 2011-5. This EO is designed to prevent harmful effects to sage-grouse from development or new land uses in designated core areas (PACs). Currently wind development is not permitted in PACs under this EO. While this EO is currently being revised, no changes to wind siting restrictions are anticipated. In Idaho wind power is currently unregulated at any level of government (AFWA and USFWS 2007, p. 14). The North Dakota Public Service Commission only regulates siting of wind power facilities with a capacity of greater than 100 MWs, but then only uses the Service's interim voluntary guidelines (USFWS 2003, entire). In Montana wind energy development will be excluded from sage-grouse Core Areas. This provision will be reevaluated on a continuous basis as new science, information, and data emerges (State of Montana, 2013). The State of Idaho guidance on wind energy development states that projects must also comply with the 2012 U.S. Fish and Wildlife Service's Wind Energy Guidelines (State of Idaho, 2012). In 2009, the Colorado Greater Sage-grouse Steering Committee wrote a conservation plan for greater sage-grouse the guidance on wind energy development states that technically and economically feasible, locate *new* utility corridors, communication towers, wind turbines, and other above-ground facilities outside Sage-grouse seasonal habitats, with particular attention to lek sites. The State of Utah will apply the necessary stipulations and conditions related to transmission lines associated with renewable energy projects should focus on disturbance during construction (Utah Division of Wildlife, 2013).

Solar

The BLM manages more than 7 million ha (19 million ac) of public lands with excellent solar energy potential in 6 states: California, Nevada, Arizona, New Mexico, Colorado, and Utah (BLM 2014c). In 2012, the BLM finalized the Western Solar Plan for development on their lands, providing a blueprint for utility-scale (20 MW or more) solar energy permitting and associated transmission connections to existing electricity transmission grids within the 6 western States. To meet the objectives of BLM's sage-grouse conservation policy, the associated PEIS for Energy Development (2012, entire) excluded identified sage-grouse habitat (currently occupied, brood-rearing, and winter habitat) located on BLM public lands in Nevada and Utah (the only area of overlap with sage-grouse). Draft EIS for the current BLM/FS planning efforts indicate that solar developments are excluded in priority sage-grouse habitats (generally PACs). Therefore, any commercial development of solar projects within the range of sage-grouse on Federal lands will be limited to general sage-grouse habitats. Smaller facilities (less than 20 MW) on BLM-administered lands would be developed under the criteria established within each local BLM Resource Management Plans.

Solar energy systems require, depending on local conditions, 1.6 ha (0.016 km^2, 4 ac) to produce 1 MW of electricity.

Geothermal

The greatest potentials for commercial geothermal energy development are within MZ III, IV, and V (EIA 2009e, entire; Fig 11-3). Currently, approximately 1,800 km^2 (694 mi^2) of active geothermal leases exist on public lands primarily in the Southern (MZ IV) and Northern Great Basin (MZ III) and 1,138 km^2 (439 mi^2) of leases are pending (Knick *et al.* 2011, p. 245). Nevada is predicted to experience the greatest increase in geothermal growth across the U.S. – doubling production from geothermal sources by 2025 (BLM and USFS 2008b, p. 2-35).

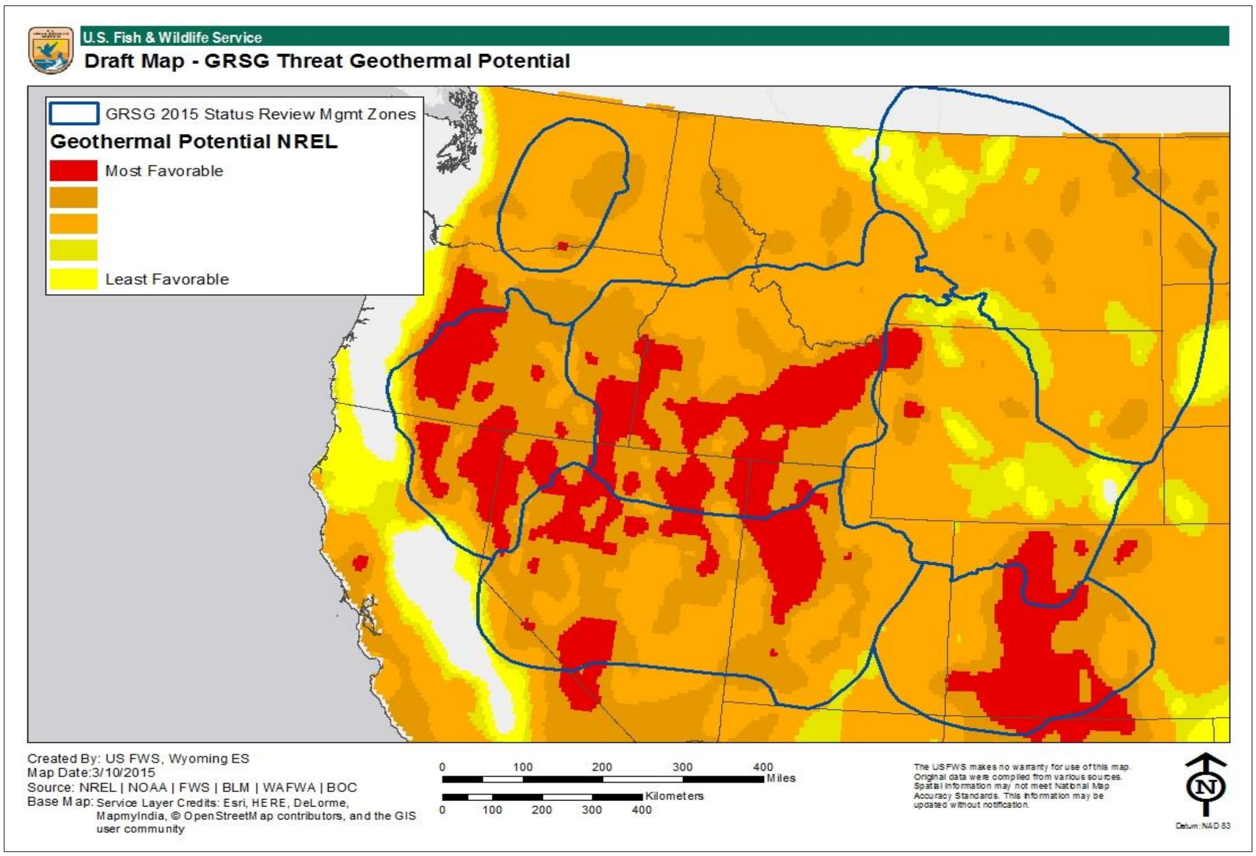


Figure 11-3: Geothermal energy potential within the occupied range of greater sage-grouse.

The BLM has the authority to lease geothermal resources in 11 western States, eight of which are within current sage-grouse range. A programmatic EIS for geothermal leasing and operations was completed in 2008 (BLM and USFS 2008a, entire), containing BMPs for minimizing the effects of geothermal development and operations on sage-grouse. The BMPs are general and guidance only (BLM and USFS 2008a, pp. 4.82–4.83). The proposed draft BLM/FS plan amendments have subsequently closed priority sage-grouse habitats to fluid mineral development (which includes geothermal) or will be imposing major constraints, such as no surface occupancy restrictions. General sage-grouse habitats will still be open for development, although many RMPs will still impose moderate constraints (e.g., buffers, seasonal closures). Currently there are 4 geothermal facilities within the range of sage-grouse (Figure 11-5; MZs III and IV).

Table 11-5. Geothermal power plants within occupied habitat by management zone.

Management Zone	Geothermal Power Plants				
	Within Occupied		Intersect:		Intersect: Population Index
	Acres	%	Acres	%	%
I	0	0.00	0	0.0	0.00
II	0	0.00	0	0.0	0.00
III	6	0.00	0	0.0	0.00
IV	6	0.00	0	0.0	0.00
V	0	0.01	0	0.0	0.00
VI	0	0.02	0	0.0	0.00
VII	0	0.01	0	0.0	0.00
Range wide [1]	**12**	**0.0**	**0**	**0.0**	

[1] All range wide calculations will not include Bi-State population or the Canadian portion of the range.

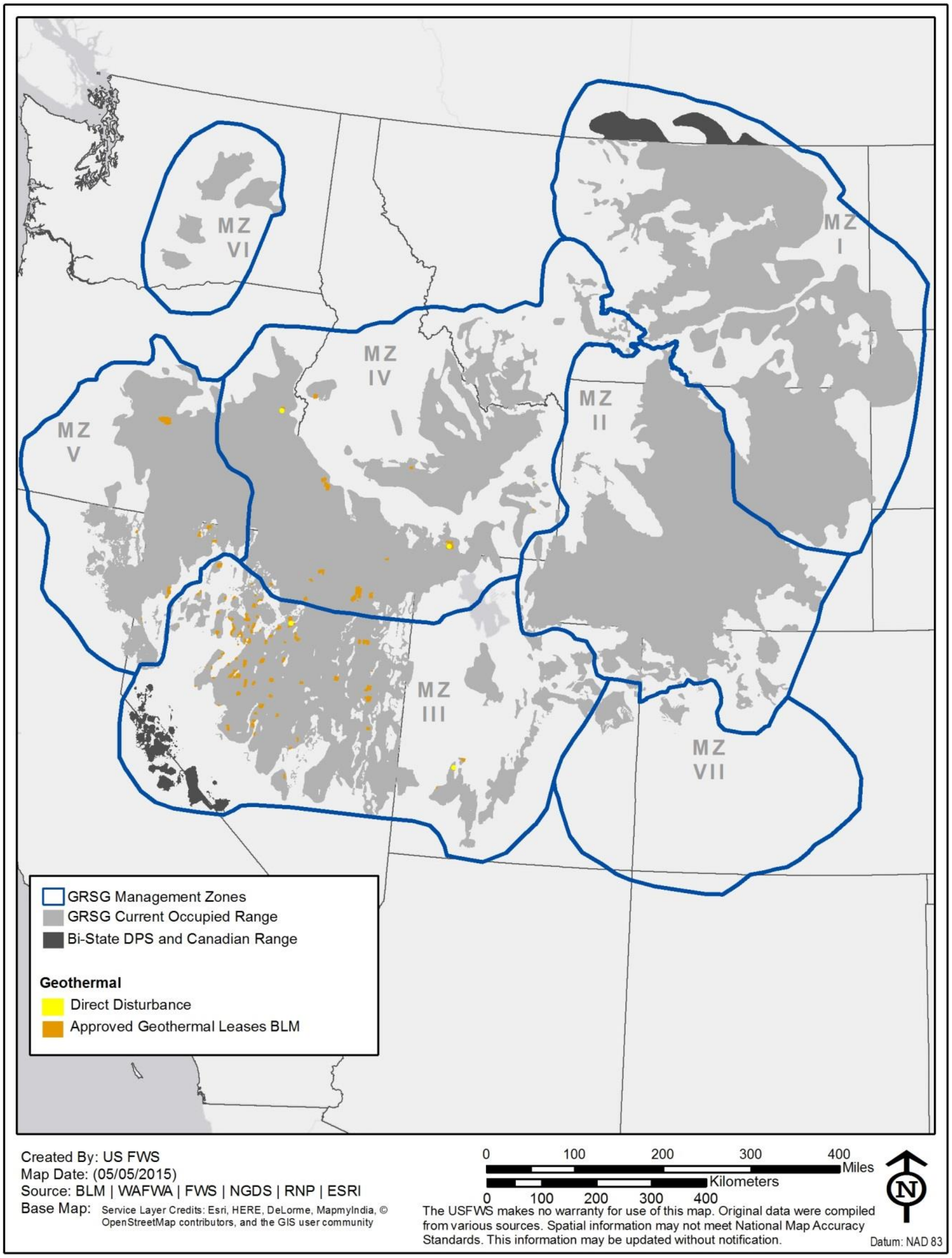


Figure 11-4: Geothermal facilities within the occupied range of greater sage-grouse.

Current Impacts

Studies examining the impacts of renewable energy development on sage-grouse populations are limited. Renewable energy facilities typically require many of the same features for construction and operation as do nonrenewable energy resources and therefore we anticipate the impacts will be similar. This includes direct habitat losses and habitat fragmentation through construction and operation of an energy facility, and indirect effects resulting from the presence of power lines, human activity, introduction of invasive weeds and novel predators, and noise (Connelly *et al.* 2004, pp. 7-40 to 7-41; Holloran 2005, p. 1; Pruett *et al.* 2008, p. 6, Patricelli *et al.* 2013, p.231; Howe *et al* 2014, p. 46; see ***Nonrenewable Energy***, ***Mining***, and ***Infrastructure*** chapters).

Wind

The average footprint of an individual wind turbine unit is relatively small (0.004 to 0.12 km^2; 1 to 3 ac; BLM 2005a, pp. 3.1–3.4), but wind farm developments also require power lines, roads, power substations, meteorological towers and sometimes office and work facilities. The number and spacing of turbines, which influences the size of the entire wind development (and therefore the amount of direct and indirect habitat loss) and need for appurtenant facilities is largely based on local meteorological data.

Most published reports of the effects of wind development on birds focus on the risks of collision with towers or turbine blades (Pruett *et al.* 2009, p. 1257). Sage-grouse could be killed by flying into turbine rotors or towers (Erickson *et al.* 2001, entire) although reported collision mortalities have been few; average tower heights, flight elevations of sage-grouse, and diurnal migration habitats minimize the risk of collision. At wind farms in Wyoming, there have been 8 reported sage-grouse collision mortalities from 2009 through 2012, including one collision with an associated meteorological tower (USFWS 2015a, pers. comm.). These data could be an underestimate of actual mortality due to the sampling design for estimating avian mortality in wind farms, and scavenging of carcasses by predators prior to detection (USFWS 2015a, pers. comm.). For sage-grouse, the highest collision probabilities appear to occur when structures are located in areas where sage-grouse typically fly between foraging and loafing habitats (Johnson and Holloran 2010, p. 9).

At a wind facility in Wyoming, female survival did not appear to be related to distance to turbines, unlike research results from natural gas fields for sage-grouse (LeBeau *et al.* 2014, p. 528). However, sage-grouse nest and brood survival did decrease in habitats in close proximity to wind turbines, likely the result of increased predation, which may have been a product of anthropogenic development and habitat fragmentation (LeBeau *et al.* 2014, p. 522). Primary sage-grouse nest predators may be attracted to wind energy developments because of subsidized food resources from deaths of birds by turbines, combined with low levels of human activity (LeBeau *et al.* 2014, p. 528).

Sage-grouse and greater and lesser prairie-chickens (*Tympanuchus cupido* and *T. pallidicinctus*, respectively) avoid human-made structures such as power lines and roads (e.g., Holloran 2005, p. 1; Pruett *et al.* 2008, p. 6). New power lines and possibly other tall structures, such as wind turbines, may be avoided in previously suitable habitats and serve as barriers to movement (Pruett *et al.* 2008, p. 2, and references therein). Habitat fragmentation could potentially negatively affect demographic rates due to increased risk of predation or energy use (Gibson *et al.* 2013, p.2). If habituation to new disturbance does not occur, population level response could contribute to behavioral avoidance to wind development resulting in functional habitat loss (Winder *et al.* 2014, p.11).

Noise is produced by wind turbine mechanical operation (gear boxes, cooling fans) and airfoil interaction with the atmosphere. Although recent research demonstrates negative effects of noise from natural gas developments on sage-grouse (e.g., Patricelli *et al.* 2013, entire), there are no published studies focused specifically on the effects of wind power noise and sage-grouse. However, other types of anthropogenic noise sources (e.g., infrastructure from oil, geothermal, and mining, as well as wind development, off-road vehicles, highway traffic, and urbanization) are similar in acoustic frequency, amplitude, and timing, and response by sage-grouse to these other noise sources may be similar to those observed at natural gas developments (Patricelli *et al.* 2013, p.231). In oil and gas fields, noise affected sage-grouse abundance, habitat selection, and lek attendance (Holloran 2005, pp. 49, 56) and also increases stress and alters breeding behavior (Patricelli *et al.* 2013, p. 231). Sage-grouse do not appear to habituate to anthropogenic noise over time (Patricelli *et al.* 2013, p. 231). Noise may also increase predation risk by masking the sounds of approaching predators and increasing stress levels by increasing the perception of predation risk. All of these factors may interfere with normal foraging, resting, and breeding behaviors and contribute to higher stress levels and reduced fitness (Patricelli *et al.* 2013, p. 231).

Wind turbines can change the microclimate by generating changes in mean wind, pressure, and turbulence resulting in potential changes in heat fluxes of heat, moisture, and CO_2 (Rajewski *et al.* 2013, p. 655). The changes in microclimate are known to persist up to 15 rotor diameters (1,372m [4,500 ft.]) downwind of a wind turbine, potentially resulting in vegetative changes extending beyond the habitat loss associated with direct footprint of a wind farm (Rajewski *et al*. 2013, p. 656). Increasing CO_2 does facilitate the spread of cheatgrass (Chambers and Pellant 2008, p. 32; Global Climate Change Impacts in the United States 2009, p. 83; see ***Invasive Plants*** chapter). While changes in microclimates could affect sage-grouse habitat quality, we do not know of any research demonstrating how wind turbine-generated microclimate changes will affect sagebrush ecosystems.

Sage-grouse response to the construction of a wind facility may not be immediately obvious. The actual impacts of a facility may not be realized for several years following construction or addition of new turbines due to the time lags associated with sage-grouse population response to infrastructure (Manier *et al.* 2013, p. 60).

Solar

Commercial solar generation results in direct habitat loss, fragmentation, roads, power lines, increased human presence, and disturbance during facility construction with likely similar effects to sage-grouse as reported with other energy development. The primary concerns with solar facilities are the large area necessary for solar panels (potential habitat loss) and water consumption (potentially affecting brood habitat; Manier *et al.* 2013, p. 66). Solar energy infrastructure is often ancillary to other development, and large-scale solar-generating systems have not yet contributed to any calculable direct habitat loss for sage-grouse; however, this may change as more systems come on line for commercial electricity generation.

Geothermal

Impacts from geothermal energy development have not been studied due to the recent appearance of this type of development in sage-grouse habitat (Knick *et al.* 2011, p. 203) Geothermal energy production is similar to oil and gas development as it requires surface exploration, exploratory drilling, field development, and plant construction and operation (Manier *et al.* 2013, p. 70). Each drill site could disturb approximately 0.4 to 2.0 ha (1 to 5 ac). The number of wells, and therefore potential loss of habitat, depends on the thermal output of the well and expected production of the plant (Suter 1978, p. 3). Direct habitat loss occurs from development of well pads, structures, roads, pipelines, and transmission lines. The development of geothermal energy requires intensive human activity during field development and operation (EIA 2009e, entire). Wells drilled to access the thermal source could take 7 to 60 days of continuous drilling (BLM 2007, pp. 2–4; BLM 2011, pp. 9, 15) depending on the depth of the well, and can potentially cause toxic gas releases depending on the geological formation (BLM 2013k, p. 427). Water is necessary for drilling operations and later for condenser cooling at the generation plants, which are similar in size to coal- or gas-fired plants. Thus, local water depletions may be a concern for sage-grouse if they result in the loss of brood-rearing habitat.

Location and Extent

Wind

The maximum potential wind development scenario was constructed by the National Renewable Energy Laboratory (NREL), a DOE laboratory focused on research of renewable energy resources. NREL has modeled and mapped the wind resources in each of the states and assigned class designations to indicate the potential for wind power generation. Wind power classes range from 1 to 7; Class 7 has the highest potential wind power generation and Class 1 has the lowest. On the basis of projected wind technology development, NREL has determined that wind resources in Class 3 and higher could be economically developable over the next 20 years. All of the MZs exhibit areas where Class 3 through 7 has been modeled (Table 11-6). Across MZs I and II, most of the wind resources are Class 3 and higher. However, in MZs VI, V, IV, III, and VII the wind resources are scattered and cover areas (Figure 11-1). Due to advances in wind energy technology (NREL 2014, entire) developers may be able to put wind turbines in locations previously considered uneconomical, expanding into habitats they may not have previously considered for development.

Table 11-6: NREL Wind potential within greater sage-grouse occupied range.

MZ	WPC 3 Acres	WPC3 % CR	WPC 4 Acres	WPC4 % CR	WPC 5 Acres	WPC5 % CR	WPC 6 Acres	WPC6 % CR	WPC 7 Acres	WPC7 % CR
I	23,941,216	50%	9,198,907	19%	1,530,751	3%	345,782	1%	56,692	0%
II	7,471,162	20%	3,412,153	9%	1,538,397	4%	1,080,381	3%	403,859	1%
III	476,699	2%	152,181	1%	61,528	0%	46,626	0%	26,840	0%
IV	2,350,426	6%	498,516	1%	182,839	0%	81,459	0%	25,826	0%
V	1,153,113	6%	252,096	1%	92,930	0%	52,044	0%	22,545	0%
VI	248,594	9%	94,480	3%	27,686	1%	6,757	0%	79	0%
VII	3,918	0%	659	0%	130	0%	11	0%	1	0%

While the direct footprint of existing wind turbines in the range of sage-grouse is relatively small (7.3 km^2 [1800 ac]; Manier *et al.* 2013, p. 60), the BLM has issued several ROWs in support of continued and future wind development that may influence sage-grouse habitats (Table 11-7). Actual development of these ROWs in to commercial facilities is not certain, and ROWs are most likely to be developed where there is access to transmission corridors (Manier *et al.* 2013, p. 61). There is currently only one active industrial-scale wind energy generation facilities in the current occupied range of sage-grouse (BLM 2013a, p. 104), the 30-MW Diamond Willow wind farm in Fallon County near Baker, Montana. This wind farm consists of 20 1.5 MW wind turbines and is within a PAC (MZ I; Dakotas population). We are aware of four preliminary, planning-stage wind project proposals in Montana (MZ I) that may encroach into sage-grouse habitat; however, whether or not these proposals may be further refined, or even constructed, is unknown (USFWS 2015 pers. comm.). The 1,000 turbine Chokecherry/Sierra Madre proposed wind farm on 693 km^2 (171,251ac) site in south-central Wyoming (MZ II) is within sage-grouse habitat (but outside of PAC), and is currently under NEPA review. In an assessment of renewable resources on BLM–administered lands, Wyoming was determined to have a high potential for wind-energy development (ranked 8th in the nation; BLM 2013j, p. 3-52).

Table 11-7: Direct disturbance footprint associated with wind energy development, and it's intersect with occupied range, breeding habitat distribution, and the population index

Management Zone	Wind Energy Direct Disturbance Footprint				
	Within Occupied Range		Intersect: Breeding Distribution		Intersect: Population Index
	Acres	%	Acres	%	%
I	1,167	0.003	538	0.005	0.00410
II	1,407	0.004	605	0.005	0.00219
II	328	0.001	0	0.000	0.00004
IV	555	0.001	33	0.000	0.00013
V	0	0.000	0	0.000	0.0000
VI	0	0.000	0	0.000	0.0000
VII	0	0.000	0	0.000	0.0000
Range wide [1]	**3,458**	**0.0**	**1,176**	**0.0**	

Solar

All currently constructed solar projects on Federal lands occur outside of priority sage-grouse habitats (Figure 11-2,). Currently there are two solar projects (Nevada, MZ III and Oregon, MZ V) within the range of sage-grouse. There are no current solar ROWs in sage-grouse habitats (BLM 2013h, p. 3-99), and therefore we have no data to suggest that further solar development in sage-grouse habitat on Federal lands is likely to occur. However, development on private lands is possible.

Geothermal

Geothermal exploration and development activity on federal lands has been sporadic, due largely to economic factors. However, there has been a marked increase in geothermal interest. There are four current geothermal facilities within the range of sage-grouse range (MZ III and IV), totaling 57,384 ha (141,800 ac.; Manier *et al.* 2013, p. 70). However, there are several approved geothermal leases on BLM-administered lands throughout MZs III, IV and V (Table 11-8). While these ROWs may not be currently developed the presence of a lease suggests the potential for future development. There are currently 25 federal leases for geothermal development in Idaho, covering approximately 24,281 ha (60,000 ac). Most of these leases are scattered across southern Idaho and 17 are located in sage-grouse habitat. These leases have existing stipulations protecting sage-grouse seasonal habitats (BLM 2013c, p. 3-103). Utah BLM currently has 59 authorized geothermal leases encompassing 65,642 ha (162,205 ac). As of early 2013, there were 41 geothermal wells in f Utah, none of which are found sage-grouse habitat. While there are several additional geothermal prospects being evaluated, future development of geothermal resources within sage-grouse habitat in Utah is unlikely (BLM, 2013i, p. 3-184 – 3-186). There is no geothermal development in MZ I and II although geothermal potential is present across the specie's range (Table 11-9; Manier *et al.* 2013, p. 70; Figure 11-4).

Table 11-8: BLM-approved geothermal leases within the greater sage-grouse occupied range.

Management Zone	BLM Lease Acres	% of Occupied Range
I	0	0
II	0	0
III	322,593	1.12
IV	111,522	0.29
V	74,098	0.38
VI	0	0
VII	0	0
Total:	508,213	0.29

Table 11-9: Acres of geothermal resource potential within occupied range of greater sage-grouse (Manier *et al.* 2013, p. 71).

Management Zone	Priority Habitat Management Area (km2/acres)	General Habitat Management Area (km2/acres)
I	6,622/1,636,400	140,276/ 34,663,000
II and VII	70,723/17,476,000	77,700/19,200,200
III	40,584/10,028,500	137,472/33,970,100
IV	88,750/21,930,600	44,347/10,958,500
V	28,721/7,097,200	23,504/5,808,000
VI	No Data	No Data

Threat Amelioration

Candidate Conservation Agreements with Assurances and Candidate Conservation Agreements

Lands currently enrolled in CCAAs restrict habitat fragmentation and removing sagebrush, thereby limiting renewable energy in and near sage-grouse habitat. Approximately 0.17 percent of occupied range in MZ I, 0.78 percent of MZ II, 2.47 percent of MZ IV, and 4.67 percent of MZ V are enrolled in CCAAs in Wyoming and Oregon. Federal lands enrolled in CCAs in Wyoming, Oregon, and Idaho account for 0.04 percent of occupied range in MZ I, 0.21 percent of MZ II, 3.13 percent of MZ IV, and 4.67 percent of MZ V. See the ***Non-regulatory Conservation Efforts*** section and Table 28-7 for approximate acreages and additional information.

BLM Resource Management and USFS Land and Resource Management Plans

Existing developments can use solar or wind to power onsite operations only, and only if there is no sage-grouse impacts. The new LUPs generally exclude new utility scale and commercial solar and wind developments from PHMAs. Geneartl Habitat Management Areass are minimally "avoidance" areas with limited exceptions and may be available for location of new utility scale and/or commercial development/ROWs with special stipulations. Limited exceptions must be based on an explicit rationale that biological impacts to sage-grouse are being avoided with the exception. In Nevada, California, Utah, and Colorado, the Solar Energy Development Programmatic EIS (BLM 2012, entire) excludes sage-grouse habitat from solar development outside the Solar Energy Zones and variance areas protecting a majority of the habitat areas in these states. The Wyoming plans follow the Wyoming Executive Order, recommending that wind not be developed in core areas, but will be re-evaluated on a continuous basis. For additional details, see the ***Regulatory Mechanisms*** section.

Time Scale of Threat

Given the incentives provided by EPCA, and state mandates, we anticipate the development of commercially viable renewable energy will continue indefinitely. We also anticipate that the development of renewable energy sources will accelerate over current rates due to the completion of existing NEPA processes and approaching deadlines imposed by EPCA and other incentives.

Assessment of Potential Threat

Habitat removal, fragmentation, and degradation are the primary threat to sage-grouse as a result of renewable energy development. While scientific literature specific to renewable energy development on sage-grouse is limited, the infrastructure associated with wind, solar and geothermal extraction is similar to non-renewable energy extraction. Therefore, we expect the effects to sage-grouse and their habitats to be similar.

Renewable energy resources are widely, but not evenly, distributed across the range of sage-grouse. The extent of the resulting impacts will therefore not be equally distributed. Wind energy is the most developed of the renewable energy sources reviewed, and has the greatest potential for commercial expansion. Regulatory provisions at the Federal levels, if implemented, will limit future development in priority sage-grouse habitats (PACs and similar designations on Federal lands). However, these provisions don't extend to general habitats or supporting infrastructure, such as power lines. Neither solar nor geothermal energy facilities currently have a large footprint within the range of sage-grouse and impacts are currently minimal. The potential for development of these resources appear limited at this time.

Our conclusions regarding renewable energy have not changed since our 2010 finding. While some additional development of all renewable energy resources discussed here has occurred, we did not find any information that suggested those additions have significantly contributed to loss of sage-grouse or their habitats since 2010. However, future development of wind resources is currently more imminent that reported in 2010.

CHAPTER 12: INFRASTRUCTURE

Infrastructure is a broad category of manmade physical structures; however, this chapter focuses on the direct and indirect effects associated with roads, railroads, power lines, and communication towers. Infrastructure impacts sage-grouse and their associated habitat both directly (physical footprint) and indirectly (ecological footprint). The physical footprint of roads, power lines, railroads, and communication towers degrade and fragment sage-grouse habitat and contribute to direct mortality through collisions. Often, the area of influence (AOI) of the ecological footprint is much larger than the physical footprint, influencing sage-grouse use of otherwise suitable habitats adjacent to infrastructure and may increase predators and the spread of invasive plants.

Current Impacts

Fragmentation of sagebrush habitats is 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). Fragmentation can result from direct habitat losses that leave the remaining habitat in non-contiguous patches or from alteration of habitat 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 and physical barriers that preclude use of otherwise suitable areas. 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). Furthermore, these factors likely act in concert with other stressors, thus causing the recovery of the sagebrush community to be challenging.

Roads

Roads are linear structures common throughout the range of sage-grouse. Road types range from large multi-lane interstate highways to unpaved two-tracks, all occurring within sage-grouse habitat. Due to the potential spread of invasives, wildfire ignition source, and an increase in predator occurrence, the indirect influence of roads extends out beyond the physical footprint (Manier *et al.* 2013, p. 31).

Lekking sage-grouse avoid roads and related activities (especially traffic volume) (Lyon and Anderson 2003, p. 489; Wisdom *et al.* 2011, p. 18; LeBeau 2012, p. 28; Knick *et al.* 2013, p. 1544). Additional effects of roads to sage-grouse may result from the bird's behavioral avoidance of roads because of noise or visual disturbance (Blickley *et al.* 2012, p. 26). The absence of vegetation in arid and semiarid regions to buffer these indirect impacts exacerbates this effect (Suter 1978, p. 6). Direct mortality of sage-grouse from vehicle collisions does occur (Patterson 1952, p. 81), but may be under reported. Roads can provide corridors for predators to move into previously unoccupied areas (Forman and Alexander 1998, p. 212; Forman 2000, p. 33; Connelly *et al.* 2004, p. 7-25). For example, ravens (*Corvus corax*) have been documented using roads as travel routes, expanding into new areas and using road kill carcasses as food subsidies (Knight and Kawashima 1993, p. 268; Connelly *et al.* 2004, p. 12-3; Bui 2009, p. 31). Additionally, highway rest areas and designated road kill carcass disposal sites provide food source for corvids and raptors, facilitating their movements into surrounding areas (Connelly *et al.* 2004, p. 7-25).

Road networks contribute to the spread of 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 plants are not restricted to roadsides, but also encroach into surrounding habitats (Forman and Alexander 1998, p. 210; Forman 2000, p. 33; Gelbard and Belnap 2003, p. 427). Converting unpaved four-wheel drive roads to paved roads has been shown to increase cover of invasives within the interior of adjacent plant communities (Belnap 2003, p. 426). 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 spread of invasives facilitates frequent fires. Additionally, roads serve as sources for human-caused fires (Miller *et al.* 2011, p. 171).

Railroads

Railroads are low profile linear structures first constructed in the western U.S. in the mid-1800s. Direct mortality of sage-grouse from train collisions likely does occur, although there are no estimates of sage-grouse mortality rates documented in the literature (Erickson *et al.* 2001, p. 8). Railroads presumably have the same potential mechanisms of eliciting behavioral changes (most likely avoidance) and increasing predator presence as do roads because they create similar linear corridors within sagebrush habitat. Additionally, railways and the cattle they transported were primarily responsible for the initial spread of cheatgrass in the intermountain region (Connelly *et al.* 2004, p. 7-25). Cheatgrass readily invaded the disturbed soils adjacent to railroads and fires created by trains facilitated the spread of cheatgrass into adjacent areas (Connelly *et al*. 2004, p. 7-25;Havlina *et al*. 2014, p. 2).

Power lines

Power lines are an elevated linear structure common to nearly every type of anthropogenic habitat use. Sometimes power lines serve as connectors between States and occur in otherwise relatively undisturbed areas. Due to the potential spread of invasives, wildfire ignition source, 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 beyond the physical footprint (Knick *et al.* 2011, p. 219; Gibson *et al.* 2013, p. 23; Dinkins *et al.* 2014b, p. 325).

Power lines directly affect sage-grouse by posing collision and electrocution hazards (Borell 1939, p. 85; Braun 1998, p. 145; and Connelly *et al.*2000a, p. 974; Aldridge and Brigham 2003, p. 31; Beck *et al.* 2006, p. 1075). Generally, collision with power lines has not been explicitly studied, but it does not appear to be a substantial source of mortality (Messmer *et al.* 2013, p. 283) and the previous studies were not designed to estimate the extent to which collision mortality played a role in population dynamics.

Based on presence of power lines and associated increased presence of predators, sage-grouse have been observed to shift their habitat use away from these areas. Sage-grouse use of suitable habitat near power lines decreased approximately 500m from the pole (Braun 1998, p. 146; Hanser *et al.* 2011, p. 130;

Gillan *et al.* 2013, p. 307). Additionally, sage-grouse were observed to avoid transmission lines during brood-rearing (Dinkins *et al.* 2014a, p. 636). Synthesis of connectivity work in Washington State suggests that transmission lines show resistance to sage-grouse movement, gene flow, and lek activity (Shirk *et al.*, in press, p. 14)

Power line structures provide hunting perches and nesting substrate for avian predators, often in habitats that are typically devoid of trees or other natural tall structures (Steenhoff *et al.* 1993, p. 27; Connelly *et al.* 2000a, p. 974; Manville 2002, p. 7; Vander Haegen *et al.* 2002, p. 503; Howe *et al.* 2014, p. 43). Raptors and ravens have been shown to use power lines during the breeding season post-construction (Steenhoff *et al.* 1993, p. 275), leading to large increases in nesting pairs of avian predators (Steenhoff *et al.* 1993, p. 275; Atamian *et al.* 2007, p. 2). In the Virginia Mountains of northwestern Nevada, ravens were the most common sage-grouse nest predator (Lockyer *et al.* 2013, p. 246) and were shown to preferentially select transmission line structures as nesting substrate (Howe *et al.* 2014, p. 41). Although a direct causal link between the presence of transmission line structures and sage-grouse demography has not been demonstrated (Messmer *et al.* 2013, p. 286), studies suggest that increased numbers of predators are facilitated by power line structures, which leads to increased predation of sage-grouse.

The construction and maintenance of power lines can also facilitate the spread of invasive plants (such as cheatgrass) as equipment is found off road and in habitats that would not normally be traveled (Gelbard and Belnap 2003, pp. 424–426; Knick *et al.* 2003, p. 620; 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. The spread of invasives leads to facilitation of more frequent fires. Of 8,028 fires that burned from 2005 through 2014 in sage-grouse habitats, 28 percent (n = 2,268) were human caused. The most common human fire starts were from power lines, vehicles, and equipment use (Havlina *et al.* 2014, p. 2).

Communication Towers

Communication towers are antenna structures taller than 60 m (200 ft.) above ground level which include cellular and radio towers. Generally, collision with communication towers has never been explicitly studied, but it does not appear to be a substantial source of mortality. Communication towers presumably have the same potential mechanisms for impacts to sage-grouse as do transmission lines because they consist of isolated tall structures with similar perchability, nesting, construction methods leading to spread of invasive plants, and provide similar wildfire ignition sources.

Estimating the impact of habitat fragmentation caused by infrastructure is complicated by the nonrandom placement of these features on the landscape and time lags associated with the species' response to habitat change (Garton *et al.* 2011, p. 371). These relatively long-lived birds continue to return to altered breeding season habitats due to strong site fidelity despite nesting or productivity failures (Wiens and Rotenberry 1985, p. 666; Harju *et al.* 2010 p. 441-445). Furthermore, these factors likely act in concert with other impacts, which adds to the difficulty in accurately estimating the impacts of habitat fragmentation caused by infrastructure.

In a comparative study between extirpated and extant sage-grouse populations, seven anthropogenic variables (agriculture, human density, road density, distance to highways, distance to electric transmission lines, distance to cellular towers, and land ownership) were included in the model (total of fifteen significant variables) to describe extirpated sage-grouse range (Wisdom *et al.* 2011, p. 462). Occupied range was greater than 8 km (4 mi), 15 km (9 mi), and 21 km (13 mi) from highways, transmission lines, and cellular towers, respectively. Roads were approximately 25 percent more dense in extirpated range. The authors noted that the significance of distance to cellular tower and sage-grouse extirpation was an unexpected result, given that no other studies had evaluated that type of infrastructure. However, the cellular tower variable may be confounded because distance to communication towers is also indicative of human developments, concentrated along major highways, and within and near larger urban areas (Wisdom *et al.* 2011, p. 467). Investigating ecological minimum requirements for the distribution of sage-grouse leks, Knick *et al.* (2013, p. 1544) found that active leks were in areas that had lower densities of secondary roads (less than 1.0km/km^2), highways (0.05km/km^2), interstate highways (0.01 km/km^2), power lines (less than 0.06 km/km^2), and communication towers (less than 0.01 km/km^2). Ninety-three percent of active leks were found below the threshold density of interstate highways and leks were absent from areas where power line densities exceeded 0.20 km/km^2 and communication towers exceeded 0.08 km/km^2. Another study intended to identify areas where future extirpations can be expected based on past extirpation data did not identify distance to or density of roads as a significant factor in predicting sage-grouse persistence. This may indicate that traffic volume may be an important factor in sage-grouse habitat selection (Aldridge *et al.* 2008, p. 992).

Results of Impact

Roads and Railroads

In Wyoming, declines in male sage-grouse lek attendance were observed within 3 km (1.9 mi) of a road with traffic volume exceeding one vehicle per day (Holloran 2005, p. 40). No leks were found within 2km (1.25-mi) and male attendance and number of leks increased when they occurred greater than 7.5km (4.7mi) from Interstate 80 (Connelly *et al.* 2004, pp. 12–13). In an experimental study in central Wyoming, leks treated with road noise relative to paired controls exhibited a 73 percent decrease in lek attendance, suggesting noise avoidance to be the causal factor (Blickley *et al.* 2012, pp. 467–469). 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). Alternative mechanisms may influence attendance, such as increased on-lek mortality due to masked predator sounds.

In south-central Wyoming, sage-grouse avoided nesting and summering near major roads with light use (1 to 12 vehicles per day) within 3 km (1.9 mi) of leks during the breeding season (LeBeau 2012, p. 28), resulting 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).

Generally, the documented negative effects (described above) of proximity to road are positively correlated with increased traffic density and speed (Forman and Alexander 1998, p. 214); however, the timing of the vehicle activity can also affect the response of sage-grouse to traffic (Holloran 2005, p. 40). 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 (Braun 1986, p. 229). In southwestern Wyoming, male lek attendance rate declined as traffic volumes on roads near leks increased, with vehicle activity during the early morning strutting period having a greater influence on male lek attendance compared to roads with no vehicle activity during the strutting period (Holloran 2005, p. 40). Thus, impact of roads on sage-grouse appears to vary by road type, activity level, and timing of traffic events.

Railroads presumably have the same potential impacts as roads, but on a much smaller scale due to the decreased amount of railroads in sage-grouse habitat, however, there are no studies that focus on the impacts associated with railroads.

Power lines and Communication Towers

Although power line collisions have been documented (e.g., Braun 1998, p. 145; Connelly *et al.* 2000, p. 974; Beck *et al.* 2006, p. 1075), these studies were not designed to estimate the extent to which collision mortality played a role in population dynamics. However, research suggests that power lines are influencing sage-grouse demographic vital rates and these vital rates are likely being influenced by increased predation (Ellis 1985, p. 10; Gibson *et al.* 2013, p. 23; Dinkins *et al.* 2014b, p. 325). 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 lek attendance (Ellis 1985, p. 10). In addition, the frequency of interactions between raptors and sage-grouse increased 65 percent during the lekking season and interactions with golden eagles (*Aquila chrysaetos*) increased 47 percent between pre- and post-installation (Manier *et al.* 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.* (2007, 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. Additionally density of power lines within a 0.27km radius of female locations negatively affected nesting female survival but similar effects were not observed for non-reproductive females or females in flocks (Dinkins *et al.* 2014b).

Due to sage-grouse site fidelity, sage-grouse do not appear to select nest sites away from transmission lines, (Gibson *et al.* (2013, p. 23) but those sage-grouse that nested closer to the line demonstrated decreased nest success and lowered female survival (Gibson *et al.* 2013, p. 22). Gibson *et al.* (2013, pp. 25–27) found a weak but apparent negative effect on adult survival, where survival increased as distance from the power line increased. Ultimately, nest survival improved 6 percent and female survival improved approximately 2 percent for each 5km (3 mi) incremental increase between the nest and the transmission line with inferences out to 20km (13 mi) from the project centerline (Gibson *et al.* 2013, p. 23).

When compared to sage-grouse locations in extirpated areas of their range (as determined by museum species and historical observations) and currently occupied habitats, proximity to communication towers was a strong indicator of extirpation, and the distance to cellular towers was nearly twice as far from sage-grouse locations in currently occupied habitats than extirpated areas (Wisdom *et al.* 2011, p. 463). Distance to communication towers are also indicative of the most intensive human developments, concentrated along major highways, and within and near larger urban areas which could confound the effect of communication towers. However, such associations between communication towers and other indicators of human development were low (Wisdom *et al.* 2011, p. 467). Additionally, 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.). Electromagnetic fields can 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) noted that birds vary in their sensitivities to electromagnetic fields, with domestic chickens being very sensitive and many raptor species less affected. 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 communication towers is a response to increased predation risk.

Location and Extent

Impacts from infrastructure are present throughout the range of sage-grouse; however, distribution and quantity of infrastructure impact each MZ to varying degrees (Table 12-1). Existing roads, railroads, power lines, and communication towers degrade and fragment sage-grouse habitat and contribute to direct mortality through collisions. In addition, infrastructure can influence a much larger ecological footprint by negatively affecting sage-grouse use of otherwise suitable habitats, and may increase predators and invasive plants.

Table 12-1: Summary of the direct influences of infrastructure across Management Zones.

	Management Zone							
Occupied Range	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**Total**
Interstate (73.2-m footprint)	15,989 (0.03%)	15,402 (0.04%)	6,888 (0.02%)	11,026 (0.03%)	994 (0.01%)	1,772 (0.06%)	NA	52,070 (0.03%)
Highway Federal or State, Canadian (25.6-m footprint)	23,752 (0.05%)	26,614 (0.07%)	14,142 (0.05%)	17,326 (0.05%)	10,021 (0.05%)	2,450 (0.09%)	NA	94,305 (0.05%)
Other roads	219,125 (0.45%)	200,736 (0.54%)	117,263 (0.41%)	176,980 (0.46%)	132,926 (0.69%)	25,042 (0.91%)	7,553 (0.64%)	879,625 (0.5%)
All roads	258,866 (0.54%)	242,752 (0.65%)	138,293 (0.48%)	205,331 (0.54%)	143,941 (0.75%)	29,264 (01.06%)	7,553 (0.64%)	1,026,000 (0.58%)
Railroad Line (9.4-m footprint)	5,610 (0.01%)	5,416 (0.01%)	2,622 (0.01%)	2,491 (0.01%)	919 (<0.1%)	605 (0.02%)	3 (<0.1%)	17,666 (0.01%)
High Voltage Line >115kv (200-m footprint)	226,064 (0.47%)	427,658 (01.15%)	235,834 (0.82%)	364,805 (0.95%)	120,817 (0.63%)	65,726 (02.38%)	2,161 (0.18%)	1,443,065 (0.82%)
Low Voltage Line <= 115kv (200-m footprint)	298,648 (0.62%)	282,707 (0.76%)	80,061 (0.28%)	102,457 (0.27%)	70,569 (0.37%)	36,684 (01.33%)	96 (0.01%)	871,221 (0.5%)
All power lines	524,712 (1.09%)	710,365 (1.91%)	315,895 (1.1%)	467,262 (1.22%)	191,387 (0.99%)	102,410 (3.71%)	2,257 (0.19%)	2,314,286 (1.32%)
FAA obstacles of interest to aviation Total (buffered to 56.4m)	1,862 (<0.1%)	4,881 (0.01%)	1,371 (<0.1%)	1,155 (<0.1%)	802 (<0.1%)	112 (<0.1%)	8 (<0.1%)	10,191 (0.01%)
FCC	5,642 (0.01%)	6,251 (0.02%)	2,504 (0.01%)	2,570 (0.01%)	1,367 (0.01%)	686 (0.02%)	125 (0.01%)	19,145 (0.01%)
All communication towers	7,504 (0.02%)	11,132 (0.03%)	3,875 (0.01%)	3,725 (0.01%)	2,169 (0.01%)	798 (0.03%)	133 (0.01%)	29,336 (0.02%)
TOTAL	796,691 (1.65%)	969,664 (2.61%)	460,686 (1.6%)	678,809 (1.78%)	338,416 (1.76%)	133,076 (4.83%)	9,945 (0.84%)	3,387,288 (1.93%)

Roads

Roads are a ubiquitous feature throughout the range of sage-grouse, directly influencing 415,207 ha (1,026,000 ac) or 0.06 percent of the species' range (Table 12-2). With the inclusion of the AOI, more than XX million acres of sage-grouse range are impacted by roads. Traffic volume varies substantially across all roads, as does individual populations' exposure. In general, locations associated with energy development and major travel corridors have the most significant daily road traffic volume. The greatest density of roads in sage-grouse habitat occurs in the Columbia Basin (MZ VI) and the lowest density of roads is found in the Southern Great Basin (MZ III; Figure 12-1).

Table 12-2: (A) Direct disturbance calculation and (B) quantification of indirect areas of influence associated with Interstate Highways in occupied greater sage-grouse habitat, by Management Zone

(A)

	Interstate Highways Direct Disturbance Footprint				
Management Zone	**Within Occupied Range**		**Intersect: Breeding Distribution**		**Intersect: Population Index**
	Acres	**%**	**Acres**	**%**	**%**
I	16,774	0.04	1,852	0.02	0.03
II	15,251	0.04	1,122	0.01	0.01
III	6,888	0.02	396	0.00	0.01
IV	11,026	0.03	2,198	0.02	0.02
V	994	0.01	0	0.0	0.00
VI	1,772	0.06	411	0.04	0.03
VII	0	0.00	0	0.0	0.00
Range wide [1]	**52,704**	**0.0**	**5,979**	**0.0**	

(B)

	Interstate Highways Indirect Area of Influence [2]				
Management Zone	**Within Occupied Range**		**Intersect: Breeding Distribution**		**Intersect: Population Index**
	Acres	**%**	**Acres**	**%**	**%**
I	2,752,289	6.0	321,332	3.1	4.18
II	1,967,258	5.3	351,168	2.9	2.58
III	1,052,355	3.7	96,415	1.1	1.38
IV	1,964,764	5.1	326,407	2.8	3.50
V	172,333	0.9	6,381	0.2	0.01
VI	209,486	7.6	65,167	5.9	4.89
VII	6,310	0.5	256	0.2	0.12
Range wide [3]	**8,124,796**	**0.05**	**1,167,126**	**0.02**	

[1] All range wide calculations will not include Bi-State population or the Canadian portion of the range.

[2]Indirect 7.5km radius buffer around Interstate Highways (Connelly et al. 2004).
[3] All range wide calculations will not include Bi-State population or the Canadian portion of the range.

Table 12-3: (A) Direct disturbance calculation and (B) quantification of indirect areas of influence associated with Federal and State Highways in occupied greater sage-grouse habitat, by Management Zone

(A)	Federal and State Highways Direct Disturbance				
Management Zone	Within Occupied Range		Intersect: Breeding Distribution		Intersect: Population Index
	Acres	**%**	**Acres**	**%**	**%**
I	23,462	0.05	2,703	0.03	0.03
II	26,317	0.07	6,962	0.06	0.06
II	14,142	0.05	5,534	0.07	0.05
IV	17,535	0.05	4,499	0.04	0.03
V	10,021	0.05	612	0.02	0.03
VI	2,450	0.09	856	0.08	0.04
VII	0	0.0	0	0.0	0.00
Range wide [1]	**93,927**	**0.001**	**21,166**	**0.0**	

[2] All range wide calculations will not include Bi-State population or the Canadian portion of the range.

(B)	Federal and State Highways Indirect Area of Influence [1]				
Management Zone	Within Occupied Range		Intersect: Breeding Distribution		Intersect: Population Index
	Acres	**%**	**Acres**	**%**	**%**
I	5,812,988	12.6	710,754	6.9	7.1
II	6,374,926	17.2	1,793,002	15.1	15.4
III	3,477,026	12.1	1,342,671	15.8	12.5
IV	4,434,105	11.5	1,187,110	10.3	8.0
V	2,437,598	12.6	241,312	7.0	7.2
VI	666,803	24.2	238,940	21.7	12.2
VII	0	0.0	0	0.0	0.0
Range wide [2]	**23,203,448**	**0.1**	**5,513,790**	**0.1**	

[1] Indirect 3.3km radius buffer around Federal and State Highways (Patricelli et al. 2013; noise dispersal).
[2] All range wide calculations will not include Bi-State population or the Canadian portion of the range.

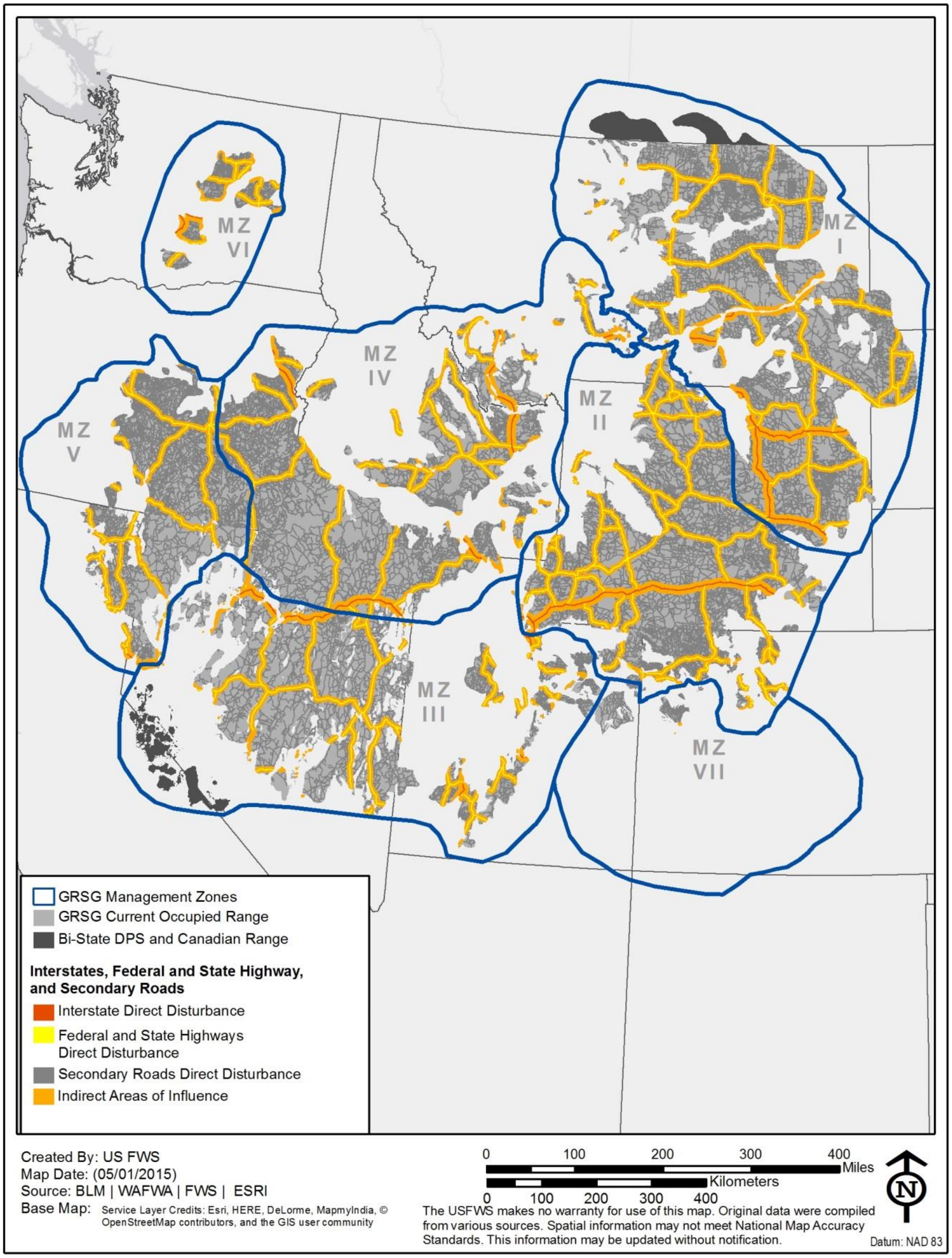


Figure 12-1. Interstates, Federal and State highways, and secondary roads within the occupied range of greater sage-grouse. Indirect areas of influence are also displayed for interstates and highways.

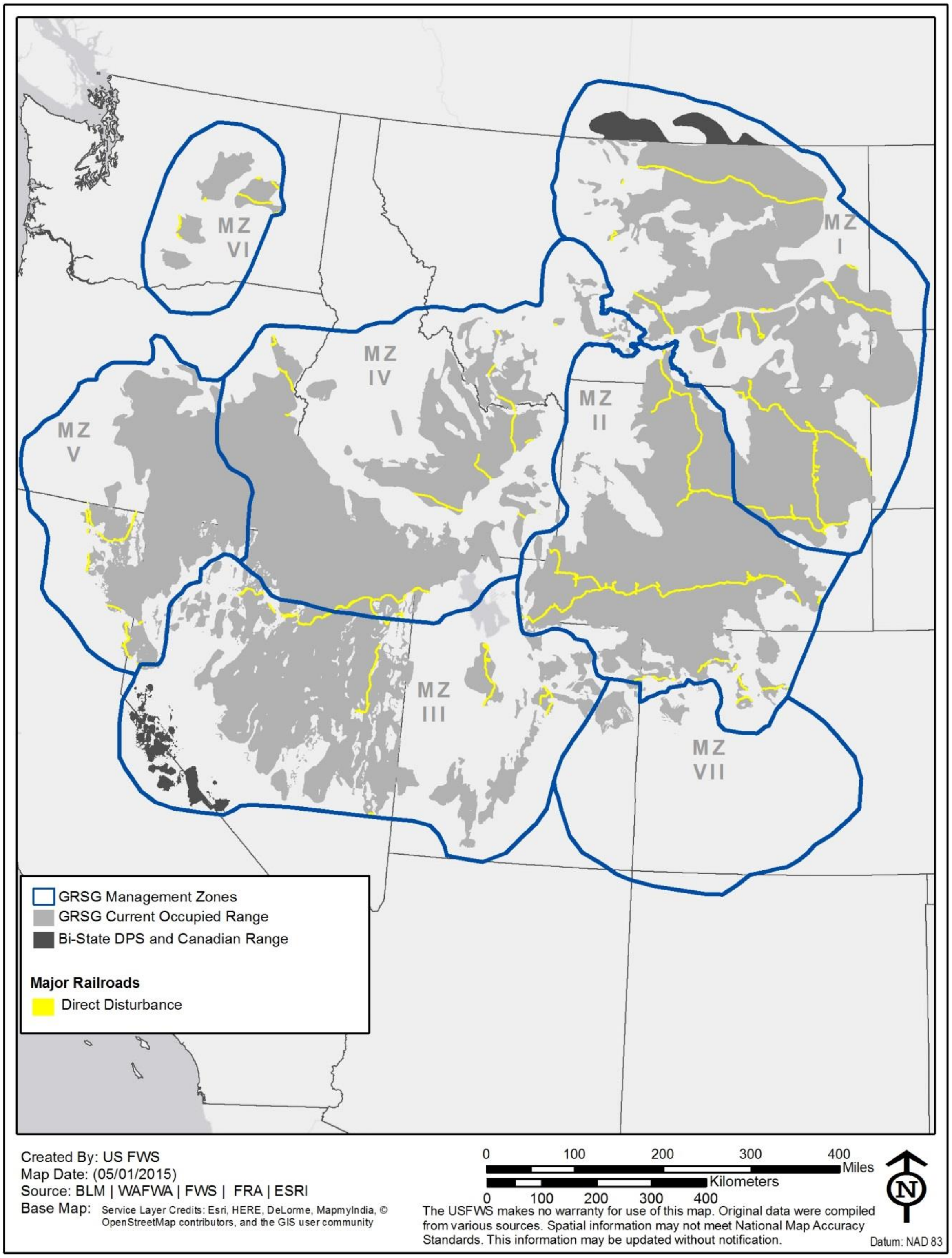
Railroads

Railroads do not occur in large numbers, impacting 7,149 ha (17,666 ac) or only 0.01 percent of the species' range (Table 12-3). Likely, the largest impact from railroads is through the past and continuing spread of invasive plants (Connelly *et al.* 2004, p. 7-25) and human-induced fire starts (Havlina *et al.* 2014, p. 2). The highest density of railroads occurs in the Columbia Basin (MZ VI) which also has the highest density of human populations (Knick *et al.* 2011, p. 212), power lines, and roads. The Great Plains (MZ I; 5,610 ac) and Wyoming Basin (MZ II; 5,416 acres) contain more than half of the railroads present within the current range (Figure 12-4).

Table 12-4: Impacts of major railroads in occupied greater sage-grouse range, by Management Zone

	Major Railroads Direct Disturbance				
	Within Occupied Range		**Intersect: Breeding Distribution**		**Intersect: Population Index**
Management Zone	**Acres**	**%**	**Acres**	**%**	**%**
I	4,807	0.01	324	0.00	0.0046
II	5,130	0.01	686	0.01	0.0054
III	2,072	0.01	284	0.00	0.0028
IV	2,139	0.01	369	0.00	0.0032
V	855	0.00	0	0.00	0.0001
VI	382	0.01	20	0.00	0.0001
VII	3	0.00	0	0.00	0.0000
Range wide [1]	**15,389**	**0.0**	**1,683**	**0.0**	

[1] All range wide calculations will not include Bi-State population or the Canadian portion of the range



Figures 12-2. Major railroads within the occupied range of greater sage-grouse.

Power lines

Transmission lines and local distribution lines are widespread throughout the range of sage-grouse, directly impacting over two million acres within the current range of sage-grouse (Table 12-4). Power lines are present at the greatest density within the Columbia Basin (MZ VI; 3.71%), due to the large production of hydroelectric power stemming from the Columbia River system(Figure 12-3). The largest direct footprint of power lines occurs in the Wyoming Basin (MZ II; 298,474 ha [710,365 ac]) which primarily serves to transport energy between MZs (Figure 12-5).

Table 12-5: Impacts of power lines by Management Zone

		Power lines High/Low (> <115kV) Existing Direct Disturbance Footprint [1]				
Management Zone		**Within Occupied Range**		**Intersect: Breeding Distribution**		**Intersect: Population Index**
	Line Class kV	**Acres**	**%**	**Acres**	**%**	**%**
I	Both kV	15,996	0.03	499	0.00	tbd
	High kV	118,503	0.26	15,021	0.15	tbd
	Low kV	221,514	0.48	26,911	0.26	tbd
II	Both kV	26,842	0.07	6,316	0.05	tbd
	High kV	146,989	0.40	46,175	0.39	tbd
	Low kV	212,198	0.57	40,558	0.34	tbd
III	Both kV	6,931	0.02	1,838	0.02	tbd
	High kV	109,209	0.38	32,088	0.38	tbd
	Low kV	67,524	0.23	11,676	0.14	tbd
IV	Both kV	7,149	0.02	1,602	0.01	tbd
	High kV	169,224	0.44	49,361	0.43	tbd
	Low kV	92,103	0.24	18,484	0.16	tbd
V	Both kV	1,536	0.01	20	0.00	tbd
	High kV	73,115	0.38	14,343	0.41	tbd
	Low kV	67,041	0.35	4,589	0.13	tbd
VI	Both kV	4,317	0.16	1,804	0.16	tbd
	High kV	24,322	0.88	9,905	0.90	tbd
	Low kV	26,845	0.97	7,935	0.72	tbd
VII	Both kV	12	0.00	0	0.0	tbd
	High kV	1,823	0.15	0	0.0	tbd
	Low kV	55	0.00	0	0.0	tbd
Range wide [1]		**1,393,249**	**0.008**	**289,125**	**0.006**	

[1] All range wide calculations will not include Bi-State population or the Canadian portion of the range.

Indirect Disturbance[1]		Power lines High/Low (> <115kV) Existing				
Management Zone		**Within Occupied Range**		**Intersect: Breeding Distribution**		**Intersect: Population Index**
	Line Class kV	**Acres**	**%**	**Acres**	**%**	**%**
I	High kV	11,193,378	24.3	1,576,874	15.3	tbd
	Low kV	2,159,307	4.7	381,703	3.7	tbd
II	High kV	12,579,259	34.0	4,332,616	36.4	tbd
	Low kV	2,170,436	5.9	453,783	3.8	tbd
III	High kV	9,015,016	31.3	2,696,396	31.8	tbd
	Low kV	688,370	2.4	141,391	1.7	tbd
IV	High kV	13,538,149	35.0	3,952,888	34.2	tbd
	Low kV	1,060,411	2.7	213,255	1.8	tbd
V	High kV	6,198,588	32.0	1,164,305	33.6	tbd
	Low kV	680,063	3.5	72,928	2.1	tbd
VI	High kV	1,541,095	55.9	615,421	55.8	tbd
	Low kV	274,521	10.0	97,512	8.8	tbd
VII	High kV	128,365	10.9	8,258	5.1	tbd
	Low kV	4,119	0.3	2,717	1.7	tbd
Range wide [2]		**61,231,077**	**0.4**	**15,710,050**	**0.3**	

[1] Indirect disturbance accounts for both High/Low kV (10.5km/2.2km) overlap and Low kV independent of High kV.

[2] All range wide calculations will not include Bi-State population or the Canadian portion of the range.

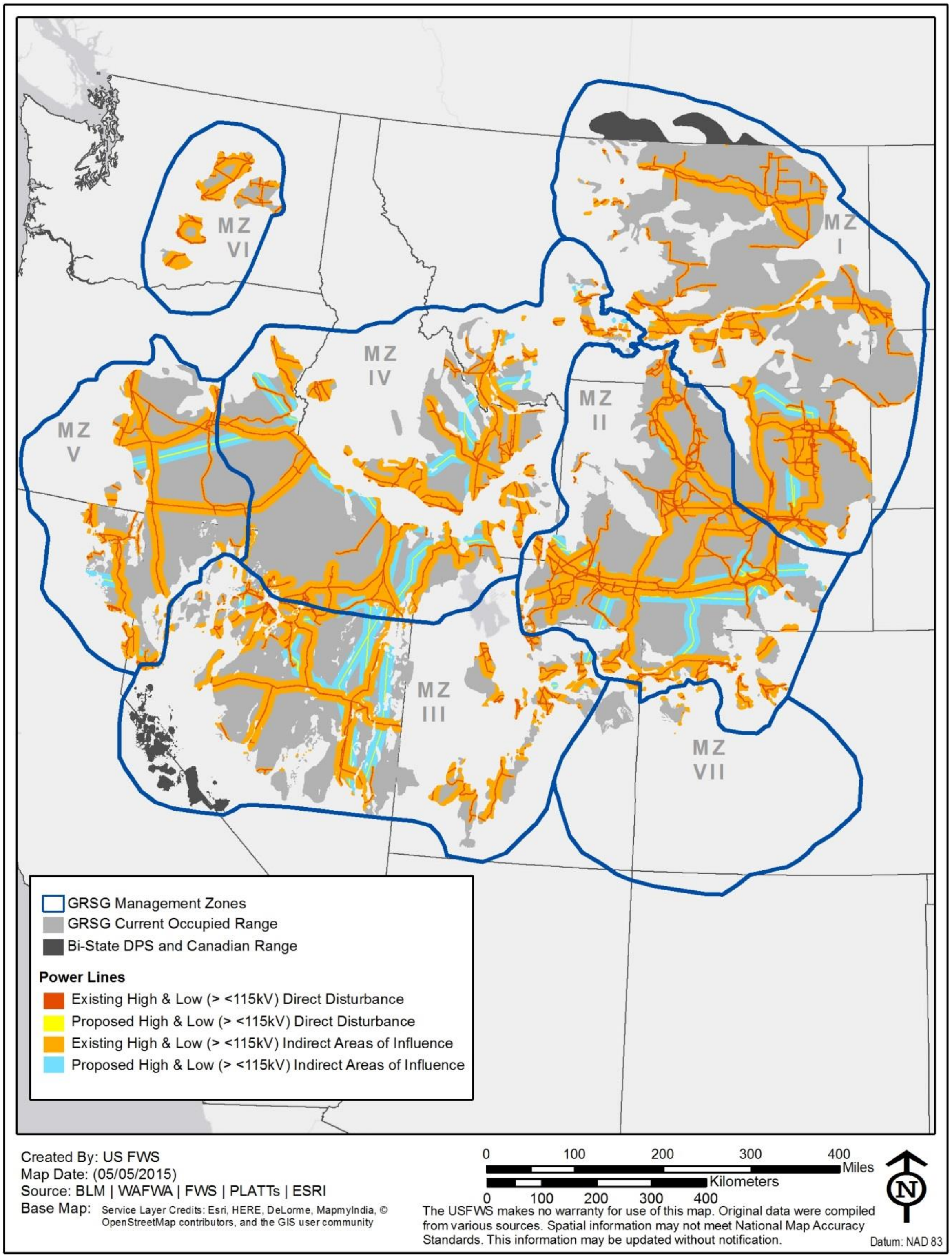


Figure 12-3 Major existing high (>115 kV) and low (<115 kV) voltage power lines, proposed high and low voltage power lines, and indirect areas of influence.

Communication Towers

Communication towers are widespread and directly influence approximately 12,000 ha (29,000 ac) or 0.02 percent of sage-grouse range (Table 12-5). Relative to other types of infrastructure, communication towers have the smallest total physical footprint and AOIs. Management Zones II and VI have the highest percentages (0.03 percent) of communication towers, while MZs IV, V, and VII have the smallest percentage of sage-grouse range impacted by communication towers (Figure 12-6).

Table 12-6: Impacts of communication towers and non-wind vertical structures in occupied range of greater sage-grouse, by Management Zone

Management Zone	Vertical Structures and Communication Towers, FAA and FCC				
	Within Occupied Range		Intersect: Breeding Distribution		Intersect: Population Index
	Acres	%	Acres	%	%
I	5,699	0.012	457	0.004	0.005
II	7,652	0.021	1,168	0.010	0.011
III	3,306	0.011	944	0.011	0.006
IV	3,032	0.008	884	0.008	0.005
V	1,792	0.009	55	0.002	0.001
VI	670	0.024	158	0.014	0.013
VII	133	0.011	21	0.013	0.015
Range wide [1]	**22,284**	**0.0**	**3,688**	**0.0**	

[1] All range wide calculations will not include Bi-State population or the Canadian portion of the range

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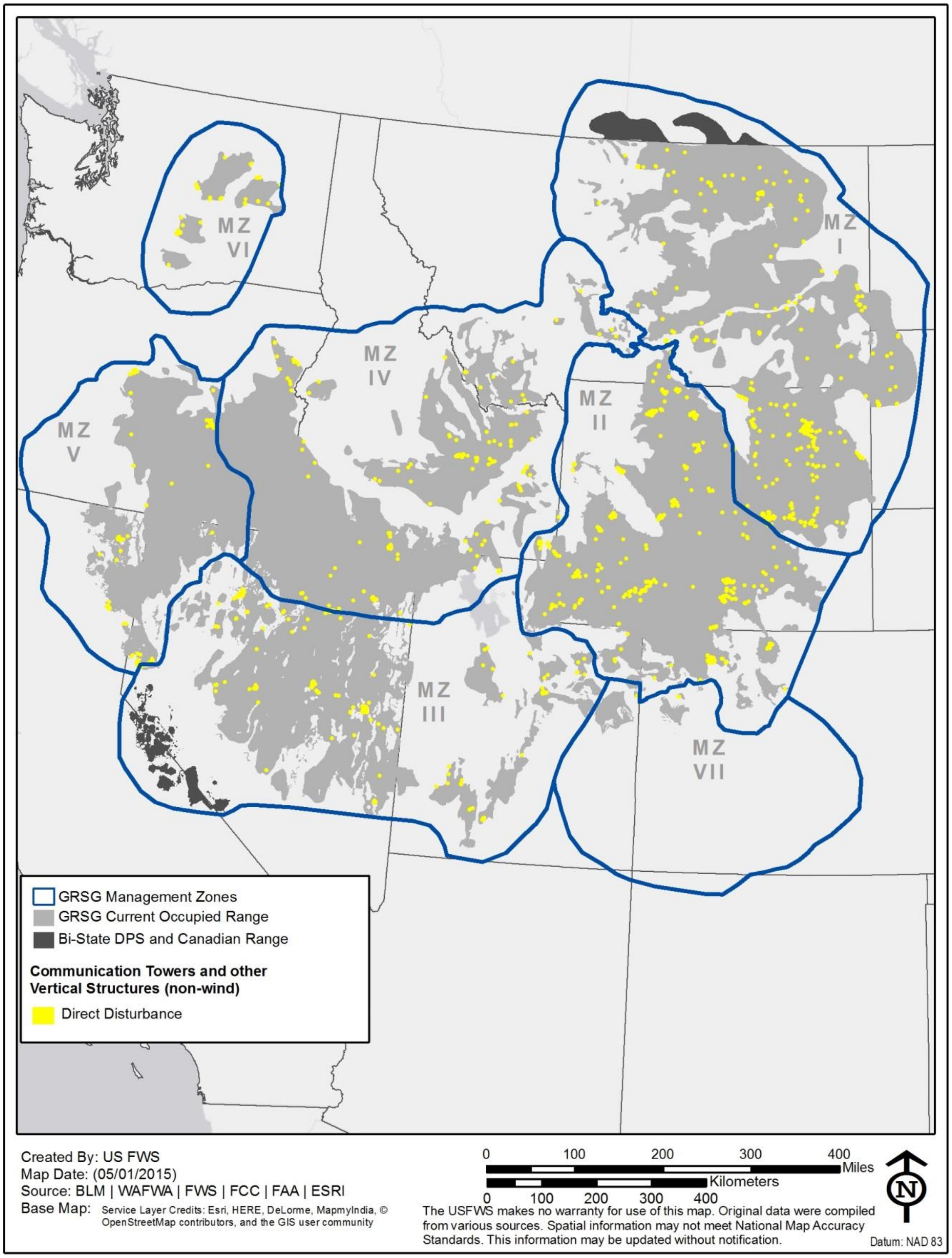

Figure 12-4. Communication towers and other vertical structures within the occupied range of greater sage-grouse.

Projected Future Impacts

Roads

An extensive network of roads currently occurs throughout the range of sage-grouse. We anticipate that most existing paved roads will remain in place for the foreseeable future. Many roads constructed in support of building projects may be reclaimed (e.g., oil fields, coal mines, etc.); however, we also anticipate that new roads will be added to accommodate growth in energy development and/or human population growth and expansion based on past trends in site development. Since a road network already occurs throughout the range of sage-grouse and roads are known to result in both direct and indirect impacts to the species we anticipate impacts will continue to increase indefinitely.

Railroads

A network of railroads occurs in every State throughout the range of sage-grouse. Currently, most rail service is dedicated to freight transportation, however, there is reason to believe that expansion of passenger based railroad networks may occur. The U.S. High Speed Rail Association has proposed 27,359 km (17,000 mi) of national high speed rail system constructed over the next 30 years with some government support (U.S. High Speed Rail Association 2014). This plan includes proposed high speed railroads in Colorado, Utah, Nevada, Idaho, Oregon, and Washington, and would be constructed in sage-grouse habitat. Future increases in railroad infrastructure would contribute to additional habitat loss, fragmentation, facilitate invasive species propagation, increase fire risk, increase mortality through collision, and increase predator populations.

Power lines

A variety of power lines (transmission and distribution) occur throughout the range of sage-grouse, although their direct footprint is less than that of roads. We anticipate that power lines will continue to increase into the foreseeable future based on the anticipated increase in power line development supported by the November 2009 Memorandum of Understanding signed by nine Federal agencies (USDA, Department of Commerce; DOD, DOE, EPA, CEQ, FERC, Advisory Council on Historic Preservation, and DOI) to expedite the building of new power lines on Federal lands USDA *et al.* 2009, entire), particularly given the increasing development of energy resources, additional urban developments, and the increasing need to move power across state lines. Hundreds of miles of new transmission line projects are currently proposed within the range of sage-grouse.

Since a power line network already occurs throughout the range and power lines are known to result in both direct and indirect impacts to sage-grouse, we anticipate impacts will continue to increase indefinitely. Of greatest concern is the addition of new power line development and increasing width of power line corridors as multiple transmission lines are expected to be consolidated into common corridors.

Communication Towers

We do not have any information to suggest the likelihood or location of future placements of cellular towers. However, based on past trends in site development, we anticipate that existing communication towers will remain in place, new communication towers will be added at existing tower sites, and additional communication towers will be constructed at new sites. Since communication towers already occur throughout the range of sage-grouse and are known to result in direct habitat impacts and have potential to cause sage-grouse mortality, we anticipate impacts will continue to persist and are likely to increase in the foreseeable future.

Threat Amelioration

Conservation Efforts Database Projects

Through the Conservation Efforts Database (CED), the Service collected information relating to conservation actions that were completed, in progress, or planned. A total of 156 projects addressing the threat of infrastructure were entered in the CED as "completed" by data providers (Appendix D). These projects were conducted in every MZ (Table 12-7).

Table 12-7. Summary of completed and effective projects evaluated by the Service at addressing the threat of infrastructure. Some projects addressed multiple threats, or spanned more than one MZ and are denoted. Examples of projects include miles of fence marked and number of fences removed. The metrics for several projects were reported for multiple MZs; these numbers of acres, miles, and structures (in boldface) are reflected only once in the table totals.

Management Zone	Conservation Effort	ha (ac)	km (mi)	Structures Removed
I	unique acres (MZ & threat)[1]	1,104 (2,728)	251 (156)	0
	same acres & MZ, > 1 threat[2]	393 (970)	0	0
	same acres & >MZ, > 1 threats[3]	**113,717 (281,000)**	0	0
II	unique acres (MZ & threat)[1]	1,196 (2,956)	87 (54)	1
	same acres & MZ, > 1 threat[2]	64,778	0	0
	same acres & >MZ, > 1 threats[3]	**113,717 (281,000)**	0	0
	same metrics, > 1 MZ[4]	0	**25,225 (15,674)**	0
III	unique acres (MZ & threat)[1]	0	229 (142)	0
	same acres & MZ, > 1 threat[2]	16/40	0	0
	same acres & >MZ, > 1 threats[3]	0	0	0
	same metrics, > 1 MZ[4]	0	**25,225 (15,674)**	**28**
IV	unique acres (MZ & threat)[1]	0	499 (310)	2
	same acres & MZ, > 1 threat[2]	405 (1,000)	0	0
	same acres & >MZ, > 1 threats[3]	**113,717 (281,000)**	0	0
V	unique acres (MZ & threat)[1]	0	82 (51)	0
	same acres & MZ, > 1 threat[2]	0	0	0
	same acres & >MZ, > 1 threats[3]	0	0	0
	same metrics, > 1 MZ[4]	0	0	**28**
VI	unique acres (MZ & threat)[1]	None reviewed-		0
	same acres & MZ, > 1 threat[2]			0
	same acres & >MZ, > 1 threats[3]			0
VII	unique acres (MZ & threat)[1]	10,606	0	0
	same acres & MZ, > 1 threat[2]	0	0	0
	same acres & >MZ, > 1 threats[3]	0	0	0
	same metrics, > 1 MZ[4]	0	**25,225 (15,674)**	0
TOTALS*		147,337 (364,078)	26,370 (16,386)	31

[1] projects in one MZ addressing one threat

[2] projects in one MZ addressing more than one threat
[3] projects crossing more than one MZ addressing more than one threat
[4] projects crossing more than one MZ but addressing only one threat

Candidate Conservation Agreements with Assurances and Candidate Conservation Agreements

In addition to these conservation efforts, lands currently enrolled in CCAAs have restrictions on building infrastructure within sage-grouse habitat and require consolidation of existing infrastructure when feasible. Approximately 0.17 percent of occupied range in MZ I, 0.78 percent of MZ II, 2.47 percent of MZ IV, and 4.67 percent of MZ V are enrolled in CCAAs in Wyoming and Oregon. Federal lands enrolled in CCAs in Wyoming, Oregon, and Idaho account for 0.04 percent of occupied range in MZ I, 0.21 percent of MZ II, 3.13 percent of MZ IV, and 4.67 percent of MZ V. See the ***Non-regulatory Conservation Efforts*** section and Table 28-7 for approximate acreages and additional information.

State Plans

The Wyoming and Idaho state plans include existing regulatory mechanisms to reduce habitat loss and fragmentation due to infrastructure on applicable lands. The Governor of Wyoming's Executive Order enforces no surface occupancy restrictions, structure density limits, timing stipulations, buffers, habitat disturbance caps, and project-specific reviews to reduce the threat of infrastructure on all lands in Wyoming for activities existing in Core Population Areas prior to August 1, 2008 will not be managed under Core Population Area Stipulations and should be allowed to continue within the existing boundary, even if the use exceeds recommended stipulations. (State of Wyoming 2011, pp. 2 and 3). Areas permitted after August 1, 2008 within Core Population Areas are subjected to stipulations pertaining to surface disturbance limitations, surface occupancy, seasonal use limitations, location of road infrastructure, overhead power lines, noise levels, vegetation removal and habitat reclamation (State of Wyoming 2011, pp.8–10). . Similarly, Idaho's state plan incorporates controlled surface use, seasonal restrictions, buffers, and noise restrictions to effectively reduce habitat loss and fragmentation due to infrastructure on Idaho State lands (Idaho Department of Lands 2015, pp. 25–26). Therefore, the Wyoming and Idaho state plans are existing regulatory mechanisms that effectively reduce the threat of infrastructure in these States on applicable lands.

Montana's state plan would reduce the threat of infrastructure on State lands and private lands where state authorization is required by using surface occupancy restrictions, buffers, and seasonal, timing, and noise restrictions (State of Montana 2014, pp. 14, 15, 19, 20). Montana's state plan would likely effectively reduce the threat of infrastructure for some roads, pipelines, and similar facilities in core areas, but lek buffers for tall structures in core and general habitats would not likely effectively reduce the threat associated with such structures. Although Utah's state plan does not directly address infrastructure, the plan has existing regulatory mechanisms to minimize and mitigate direct disturbance from construction, such as disturbance caps, siting restrictions, and required reclamation following construction (State of Utah 2013, pp. 19–20, 27). However, these Utah regulations apply only to State and Federal lands, are entirely voluntary on private, SITLA, and local government lands, and have a less-restrictive disturbance cap that may not effectively reduce the threat of infrastructure. Therefore, state plans in Montana and Utah do not effectively reduce the threat of infrastructure on lands where they apply in these States.

If an infrastructure project will disturb sage-grouse on any lands in the State, Nevada's state plan requires that project proponents consult with the State's Sagebrush Ecosystem Technical Team (SETT) to avoid, minimize, or mitigate potential impacts. Nevada's plan also guides project proponents to bury power lines and install anti-nesting or perching devices on power lines where technically and economically feasible (State of Nevada 2014, pp. 101–102). However, the BLM would be responsible for enforcing this consultation process on the majority of land in Nevada, but this process has yet to be implemented and is not an existing regulatory mechanism. A summary of state regulations and conservation plans addressing infrastructure, and other threats is in the Regulatory Mechanisms chapter (pp.X).

BLM Resource Management Plans and USFS Land and Resource Management Plans

The BLM and USFS plans limit new infrastructure primarily through land use allocations, lek buffers, and disturbance caps. Priority Habitat Management Areas are minimally designed avoidance areas with limited exceptions for new ROWs. Any exceptions must include explicit rationale that biological impacts to sage-grouse are being avoided. Existing designated corridors for major transmission lines and pipelines will remain open (subject to the ongoing settlement agreement) under the new Land Use Plans (LUPs). Any impacts from new infrastructure will require mitigation and will be counted toward the 3 percent disturbance cap (5 percent in Wyoming). The BLM/USFS plans also include seasonal timing restrictions, noise restrictions, and buffer distances from leks, to minimize impacts from new infrastructure on sage-grouse. In Wyoming, BLM and USFS plans mimic the Wyoming sage-grouse Executive Order. For additional details, see the ***Regulatory Mechanisms*** section.

Threat Amelioration Summary

Large, contiguous tracts of sagebrush habitats are one of the best landscape predictors of sage-grouse persistence (Aldridge *et al.* 2008, p. 987; Doherty *et al.* 2008, p. 191; Wisdom *et al.* 2011, p. 461). Increasing expansion of human populations into the western U.S. has led to an increase in demand for natural resources and the necessary infrastructure (e.g., roads, railroads, power lines, communication towers, etc.) to support them. Development of roads, railroads, power lines, and communication towers result in habitat loss, fragmentation, and may cause sage-grouse habitat avoidance. These types of infrastructure can also provide sources for the introduction and propagation of invasive plants, increase fire risk, and increase concentrations of predators.

Within the current range of sage-grouse, the physical footprint of infrastructure is approximately 930,776 ha (2.3 million ac; 1.93 percent). The largest acreage of infrastructure is found in the Wyoming Basin (MZ II; approximately 392,140 ha [969,000 ac]); the least amount of infrastructure is found in the Colorado Plateau (MZ VII; 4,024 ha [9,945 ac]). The Columbia Basin (MZ VI) which is considerably smaller than MZ II contains the highest density of infrastructure (4.83 percent of sage-grouse habitat impacted). Infrastructure associated with power lines accounts for the greatest disturbance (930,776 ha; 2.3 million ac) across the range.

Federal agencies manage the majority (64 percent; Knick *et al.* 2011, Table 3) of sage-grouse habitat in the U.S. Federal agencies have discretionary regulatory authority over infrastructure development, therefore regulatory mechanisms adopted that require strategic siting of infrastructure away from core sage-grouse habitats is the most likely source to ameliorate the threat.

The 2010 finding for sage-grouse concluded habitat loss and fragmentation resulting from infrastructure development is a primary threat to the species and could be expected to continue in to the foreseeable future (75 FR 13910, March 23, 2010). There have been no substantial changes to the stressors posed by infrastructure, growth and necessity for continued increases in infrastructure, or the regulatory mechanisms the would prevent development within important sage-grouse habitats. Therefore, based on the best available science, we conclude that infrastructure continues to be a primary threat to the species by directly contributing to the destruction, modification, and curtailment of sage-grouse habitat and range (Factor A) and indirectly increasing predation (Factor C) and that these will continue to increase into the foreseeable future.

CHAPTER 13: FENCES

Fences are barriers enclosing an area to mark a boundary, control access, or prevent escape. They are typically upright, elevated structures made of wood or wire and they are known to cause collision mortality in tetraonids (i.e., upland game birds in the family Phasianidae, subfamily Tetraoninae, which includes grouse) (Baines and Summers 1997, p. 941; Bevanger and Brøseth 2000, p. 121). Tetraonids, such as sage-grouse, are thought to be more susceptible to collisions with manmade structures due to biological factors including poor maneuverability, lack of acute vision, and crepuscular activity patterns (Call and Maser 1985, p. 22; Bevanger 1998, p. 67)

Mortality risk to tetraonids from fences may vary based on time of year, behavior patterns, topographical variation, and fence design, but there is little information on what factors make an area high risk for most species. For example, more red grouse (*Lagopus lagopus scotica*) and black grouse (*Tetrao tetrix*) fence collisions occurred in spring at the same time as peak male territorial and lekking displays whereas more capercaillie (*Tetrao urogallus*) collisions occurred in autumn when young are dispersing (Baines and Summers 1997 p.946). In addition to time of year, the aforementioned collisions were also influenced by ground vegetation and typically occurred on flat or sloping ground (Baines and Summers 1997 p.946). In lesser prairie-chickens, fence collisions were more frequent in females than males and in adult females than subadult females (Wolfe *et al.* 2007, p. 95). Ptarmigan (*Lagopus* spp.) collisions were associated with fence location and ptarmigan densities (Bevanger and Brøseth 2000, p. 125), but not with fence design (as was found in sage-grouse populations; Stevens et al. 2012a, p. 1370). In models of sage-grouse collisions, the fence post type and segment widths of the fence increased the probability of collision as did sage-grouse abundance and proximity to leks, whereas the ruggedness of the landscape decreased collision probability (Stevens *et al.* 2012a, p. 1370). Further studies by Stevens *et al.* (2012b, p. 3) demonstrated temporal variation in collisions within the lekking season with a peak occurring from mid-March to mid-April and steady collision rates through the end of the breeding season.

In addition to collisions, fences may pose an indirect threat to sage-grouse due to increased predation risk and habitat fragmentation (75 FR 13929; Braun 1998, p. 145; Connelly *et al.* 2004, p. 7-3). Local predator densities can affect the productivity, parental behavior, and nest site selection of grouse species (Manzer and Hannon 2005, p. 110, Coates and Delehanty 2010, p. 240). In sage-grouse studies, corvid abundance has been associated with depredation of eggs and nestlings (Coates *et al.* 2008, p. 421; Coates and Delehanty, 2010 p. 74; Lockyer *et al.* 2013, p. 242) such that sage-grouse alter incubation behavior (Coates and Delehanty 2008, p. 627). In addition, females select nesting and brood-rearing locations that have lower densities of both raptors and corvids (Dinkins *et al.* 2012, p. 600) and that are further away from potential raptor and corvid perches (Dinkins *et al.* 2014a, p. 637). Since fence posts are potential avian predator perch sites, sage-grouse are likely to avoid these areas, which can lead to habitat fragmentation even though habitat is physically present (75 FR 13929; Braun 1998, p. 145; Dinkins *et al.* 2012, p. 600).

Historically, open range laws across western North America allowed domestic livestock to roam freely regardless of land boundaries and the laws held the general public responsible for constructing fences to keep livestock off their property. This style of livestock management continued until the late 19th century when the Homestead Act of 1862 increased the numbers of farmers and ranchers in the West and double-stranded barbed wire was invented making it more practical to fence livestock in rather than fence livestock out (Boundless 2014,; Cook 2015)With the invention of barbed wire, the open range started to become a patchwork of individual parcels marked by barbed fences to restrict livestock movements within and among property boundaries (Boundless 2014; Mosley 2011, p. 13). It was in the mid-20th century, when many open range laws were altered from "fence out" to "fence in" laws, that observations of sage-grouse colliding with fences were first reported (Scott 1942, p. 477). Prior to the invention of barbed wire and the changes in fence laws, sage-grouse would have traveled across the landscape relatively unimpeded by anthropogenic structures. The impact of fences on sage-grouse, however, has not been evaluated in greater depth until more recently.

Today, fences are ubiquitous across the landscape (75 FR 13929) and occur across all MZs. Although specific numbers showing miles of fence lines over time are unavailable, production of barbed wire increased from 4.5 metric tons in 1879 to 210,600 metric tons in 1945 (Jones 2014, p. 150). Fences continue to be used to restrict access to anthropogenic structures (e.g., energy development sites, residential areas, railroads) and to modify livestock movements and grazing patterns, thus fences create or alter disturbance patterns on the landscape for sage-grouse (75 FR 13929; Knick *et al.* 2011, p. 232). Unfortunately, there are no rangewide geospatial datasets available on fence locations or fence density (Poor *et al.* 2014, p. 2). Some datasets have been created locally or regionally to determine impacts to big game species (Poor *et al.* 2014, p. 2) or that have come from limited numerical data from land management agencies. For instance, just over 51,000 km (31,690 mi) of fence were added on BLM-administered lands in the range of sage-grouse to facilitate livestock grazing between 1962 and 1997 (Connelly *et al.* 2000, p. 974) and between 1996 and 2002, more than 1,000 km (621 mi) of fences were constructed each year with densities of 2 km/km^2 or higher in some areas (primarily Montana, Nevada, Oregon, and Wyoming) (Knick *et al.* 2011, p. 224).

A GIS-based tool, known as The Fence Collision Risk Tool (Tool), has been created based on collision data from four areas in central Idaho to identify high risk areas for fence collision (Stevens *et al.* 2013, p. 409; NRSC 2012, p. 1). The Tool uses state wildlife agency lek data current to 2007 and topography information to predict the amount of landscape within 3 km of leks in 10 western States (excluding Colorado) predicted to be high-risk for collisions if fences are present (NRSC 2012, p. 2). However, caution should be used regarding implementation of this Tool: the Tool does not contain information on existing fence locations or fence density so once an area is identified as high risk, ground truthing would need to take place (NRSC 2012, p. 3); and the Tool was developed using collision data from Idaho only; yet sage-grouse fence collisions are known to be highly variable both within and between regions (Stevens *et al.* 2012a, p. 1370; Stevens *et al.* 2012b, p. 1).

Current Impacts

Fences can result in direct mortality and injury to sage-grouse due to collisions (Call and Maser 1985, p. 22; Connelly *et al.* 2004, p. 13-12; Christiansen 2009, p. 1; Beck *et al.* 2006, p. 1070; Stevens 2011, p. 60). Fences that tend to cause problems typically include one or more of the following characteristics: (1) constructed with steel t-posts; (2) are constructed near leks, (3) bisect winter concentration areas, or (4) border riparian areas (Christiansen 2009, p. 2; Stevens *et al.* 2012b, p. 3). Modeling of data from fence locations with known collisions in Idaho suggested that design aspects of the fence, such as the absence of wooden posts and segment widths greater than 4 m (13 ft.), increased the probability of collision (Stevens *et al.* 2012a, p. 1370). Additionally, modeling of data on a broader, rather than a site-specific, scale suggested that collision risk was higher on flat, sloping ground and when fence density was high (Stevens 2011, p. 68; Stevens *et al.* 2012a, p. 1370).

The presence of fences can increase predation risk by creating predator perches and by fragmenting habitat (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; Stevens *et al.* 2012a, p. 1370; Dinkins *et al.* 2014a, p. 637; 75 FR 13929). Sage-grouse avoid areas with potential predator perches (Dinkins *et al.* 2014a, p. 637) and since fence posts can create perching places for avian predators, sage-grouse may choose avoid available habitat adjacent to fences. This can result in fragmentation and loss of functional habitat even though suitable habitat is present (75 FR 13929; Dinkins *et al.* 2012, p. 600; Hovick *et al.* 2014, p. 1680).

Sage-grouse can be killed or injured when they collide with fences (Call and Maser 1985, p. 22; Connelly *et al.* 2004, p. 13-12; Christiansen 2009, p. 1; Beck *et al.* 2006, p. 1070; Stevens 2011, p. 60). Mortality from fences was documented in only one out of 87 fatalities in Nevada (Blomberg *et al.* 2013, p. 351) but 36 carcasses of sage-grouse were found along a 3.2km (2mi) fence within 3 months of its construction in Utah (Call and Maser 1985, p. 22) and 21 incidents of fence collisions were reported in 2003 to the BLM in Wyoming (Connelly *et al.* 2004, p. 13-12). Also in Wyoming, a study confirmed 146 sage-grouse fence strike mortalities over a 31–month period along a 7.6km (4.6mi) stretch of 3-wire BLM range fence (Christiansen 2009, p.1). In Idaho, 86 of 111 fence collisions were sage-grouse (Stevens 2011, p. 60). Of 135 sage-grouse deaths in the Dakotas, none were confirmed as fence collisions (Swanson 2009, cited in SDDFGP 2014, p. 24). Differences in habitat requirements or habitat use may explain some variation in mortality with localized impacts being substantial if fences occur close to leks or in areas of high density. However, Stevens and Dennis (2013, p. 2094) cautioned using uncorrected fence collision data because of possible misinterpretation of the models as a result of lack of comparability of data from different regions or time frames.

It is hypothesized that sage-grouse may avoid fences due to perceived predation risk associated with anthropogenic structures (75 FR 13929; Braun 1998, p. 145; Connelly *et al.* 2004, p. 7-3, Knick *et al.*, p. 232). In a review of 3,003 existing studies analyzing the effect of anthropogenic structures on grouse avoidance behavior or survival, Hovick *et al.* (2014, p. 1680) determined that too few studies existed to examine the specific effect of fences on grouse species and none of the 10 studies focusing on fences were conducted on sage-grouse specifically.

Projected Future impacts

Timescale for projecting this threat

The presence of fences in sage-grouse habitat is likely to persist indefinitely as they are integral to the operation of the livestock grazing industry and of land development in the western U.S. In addition, fences will continue to be used to delineate property boundaries on both public and private lands (e.g., compressor stations, work yards, neighborhoods).

Anticipated changes from present

The 2010 finding stated that fences are ubiquitous across the landscape and are anticipated to remain on the landscape (75 FR13929). Results from collision modeling suggest that increasing fence density increases collisions in sage-grouse breeding areas (Stevens *et al.* 2012a, p. 1377). Thus, the likelihood of future impacts of fences on sage-grouse will increase as the number of miles of fence also increases unless fence marking and other conservation measures are put into place.

We anticipate that the effect on sage-grouse populations through the creation of new raptor perches and predator corridors into sagebrush habitats is similar to that of power lines (Braun 1998, p. 145; Connelly *et al.* 2004, p. 7-3) as discussed previously in the ***Infrastructure*** chapter.

Threat Amelioration

Management actions to minimize the impact of fence collisions on sage-grouse and to deter predator use are to mark fences in high risk areas to improve visibility for sage-grouse with permanent flagging or other suitable devices, especially those located within 2 km (1.2 mi) of occupied leks and in relatively flat areas; remove old fences no longer in use; consider bird migration and movement patterns when planning new fences; avoid placing fences through leks, flight corridors, brood-rearing habitats, or winter concentration areas; place new fences and other livestock management facilities at least 1 km (0.6 mi) from occupied leks; avoid constructing fences with steel t-posts; and construct fences using large wooden posts spaced at intervals greater than 4 m (13 ft.; Christiansen 2009, p. 2; USFWS 2013, p. 52; Stevens *et al.* 2012a, p.1379; Stevens *et al.* 2012b, p. 6).

In Europe, marking fences reduced capercaillie collisions by 64 percent, black grouse by 91percent and red grouse by 49 percent, but it did not completely eliminate collisions (Baines and Andrew 2003, p. 169). Prior to fence marking efforts on fences for lesser prairie-chickens, one collision mortality carcass per mile (1.2 km) was recovered annually but 30 months after fence marking no carcasses were found from a collision along a marked fence (Wolfe *et al.* 2009, p. 142). In sage-grouse, marking fences reduced collisions by 83 percent over unmarked fences in Idaho during the breeding season (Stevens *et al.* 2012b, p. 1) but collisions still occurred at marked fences less than 500 m from large leks suggesting that moving or removing fences may be necessary in some areas if management is to eliminate collision (Stevens *et al.* 2012b, p. 6). In one anecdotal event in Roundup, Montana, more than 40 sage-grouse fence strikes were documented on a short segment of fence in a wintering area more than a mile from a lek on a fence that was marked (Waage 2015, personal communication).

A rangewide management strategy does not exist for fences but the Fence Collision Risk Tool is the start of a strategy to reduce fence collisions and the USFWS (2013, p. 52) provides recommendations for minimizing fence impact on sage-grouse regardless of location. With these two tools, conservation actions can be implemented at the local level, taking into account the topography of the area and local sage-grouse information such as lek densities and areas of preferred use. Overall, NRCS has marked or removed 350 miles of high-risk fence to reduce collisions (NRCS 2015, p. 6). Conservative estimates show that fence-marking prevents 2,600 collisions annually (NRCS 2015, p. 22). However, Stevens *et al.* (2013, p. 413) cautioned against making population level inferences from reduced collision risk because, “We cannot say how many sage-grouse would be added to a population by reducing collisions because we lack demographic data to know whether populations can compensate for mortality via increased productivity.” Population-level impacts of sage-grouse fence collision also likely depend on proportional mortality of male and female sage-grouse, which is currently unknown (Stevens *et al.* 2012a). Moreover, the ability to compensate for collision mortality probably varies spatially, further complicating our ability to predict the number of birds added to a population as a result of fence-marking efforts.

Threat Amelioration Summary

There are practical conservation actions that can be taken to reduce fence collisions with fence marking being the one most thoroughly investigated. Fence marking is effective at reducing collisions but it is unlikely to eradicate collisions completely (Stevens *et al.* 2012b, p. 1) and further information is needed to make population level inferences regarding the impact of reduced collisions (Stevens *et al.* 2013, p. 413). Amelioration methods to reduce the indirect effects of fences on sage-grouse have not been investigated and thus, indirect effects will likely continue (e.g., see ***Predation*** chapter).

Lands currently enrolled in CCAAs have restrictions on building new fences in or near sage-grouse habitat and require relocating or marking existing fences. Approximately 0.17 percent of occupied range in MZ I, 0.78 percent of MZ II, 2.47 percent of MZ IV, and 4.67 percent of MZ V are enrolled in CCAAs in Wyoming and Oregon. Federal lands enrolled in CCAs in Wyoming, Oregon, and Idaho account for 0.04 percent of occupied range in MZ I, 0.21 percent of MZ II, 3.13 percent of MZ IV, and 4.67 percent of MZ V. See the ***Non-regulatory Conservation Efforts*** section and Table 28-7 for approximate acreages and additional information.

Assessment of Potential Threat

Fences can potentially improve localized habitat conditions for sage-grouse by preventing degradation and protecting sensitive areas (e.g., protecting riparian areas from overgrazing enhances brood-rearing habitats) (USFWS 2013, p. 52). More often, however, fences result in direct mortality and injury to sage-grouse due to collisions, and the presence of fences can increase predation risk by creating predator perches and by fragmenting habitat (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; Stevens *et al.* 2012a, p. 1370; Dinkins *et al.* 2014a, p. 637; 75 FR 13929). Biological, topographical, meteorological, and fence design factors can influence collision probabilities for sage-grouse on local scales (75 FR 13929; Christiansen 2009; Stevens *et al.* 2012a, p. 1379; Stevens *et al.* 2012b, p. 6). Although methods exist to reduce sage-grouse collisions with fences, population level repercussions of reduced collisions are not well understood (Stevens *et al.* 2013, p. 413). It is difficult to determine population level effects because we lack demographic data to know whether populations can compensate for mortality via increased productivity, data on proportional mortality of males and females, and data on fence location and density across the species range. Further information is needed to verify that sage-grouse avoid fences due to perceived predation risk and to evaluate the impacts on sage-grouse survival and reproduction.

In our previous finding, a determination on the specific impact of fences was not made. Rather, conclusions regarding fences were lumped into infrastructure along with roads, communication towers, and power lines. The 2010 finding stated that collectively, infrastructure fragments sage-grouse habitat (75 FR 13931), encourages the presence of the common raven (75 FR 13972), and contributes to the destruction, modification, or curtailment of the sage-grouse's habitat (75 FR 13986). In this chapter, fences are highlighted individually because they continue to be identified as a source of mortality to sage-grouse. Further, we expect the presence of fences in sage-grouse habitat is likely to persist indefinitely as they are integral to the operation of the livestock grazing industry and of land development in the western U.S. Since 2010, fences have continued to be a source of mortality and injury to sage-grouse and we expect this to continue, even with threat amelioration measures in place, given the widespread distribution of fences across the range of the species.

CHAPTER 14: GRAZING AND RANGELAND MANAGEMENT

Prior to the introduction of domestic livestock, sagebrush ecosystems were not heavily grazed by native herbivores (Osborne 1953, p. 267; Mack and Thompson 1982, p. 768; Miller *et al.* 1994, pp. 111, 113; Plew and Sundell 2000, p. 132; Grayson 2006, p. 921). Between 1860 and the early 1900s unregulated numbers of cattle, sheep, and horses rapidly increased across the western states, peaking at the turn of the century (Oliphant 1968, p. vii; Young *et al.* 1976, pp. 194–195; Carpenter 1981, p. 106; Donahue 1999, p. 15; Knick *et al.* 2011, p. 220). During this period, excessive overgrazing by domestic livestock, along with severe drought, significantly changed plant communities and soils across the sagebrush ecosystem (Knick *et al.* 2003, pp. 116, 616; Knick *et al.* 2011, p. 220). At low elevations, excessive overgrazing by livestock removed native vegetation and disturbed soils, promoting the establishment of nonnative annual grasses and increasing the frequency of fires in sagebrush habitats (Boyd *et al.* 2014, p. 62). Conversely, at higher elevations, improper grazing reduced fine fuels and decreased fire frequencies, which encouraged the expansion of fire-sensitive native conifers into sagebrush habitats (Boyd *et al.* 2014, p. 62). Although the number of livestock and the intensity of livestock grazing has decreased since its historical peak in the early 1900s (Laycock *et al.* 1996, p. 3), the resulting impact on plants and soils remain commonplace in sagebrush ecosystems (Knick *et al.* 2003, p. 116; Knick *et al.* 2011, pp. 220, 221).

Livestock grazing is now the most widespread land use across the sagebrush ecosystem (Connelly *et al.* 2004, pp. 7–29; Knick *et al.* 2003, p. 616; Knick *et al.* 2011, p. 219; Boyd *et al.* 2014, p. 62). Throughout the range of the sage-grouse, there are 112,796,863 acres of active grazing allotments on BLM lands that occupy 64.9 percent of the sage-grouse's occupied range and 75.8 percent of the breeding distribution (Table 14-X) (Figure 14-1). Many of grazing allotments are managed by the BLM and USFS, although grazing occurs on most land surface ownerships throughout the species' range. Nearly all sagebrush habitats have been grazed at some point during the last 150 years (Knick *et al.* 2003, p. 616; Knick *et al.* 2011, p. 219).

Table 14-1. Acres of grazing allotments authorized by the BLM within the occupied range and breeding distribution of sage grouse, by management zone and rangewide.

	Grazing Allotments Authorized				
	Within Occupied Range		**Intersect: Breeding Distribution**		**Intersect: Population Index**
Management Zone	**Acres**	**%**	**Acres**	**%**	**%**
I	23,095,638	50.1	7,176,770	69.6	tbd
II	27,216,947	73.5	10,005,658	84.0	tbd
III	21,881,456	76.0	6,480,149	76.5	tbd
IV	25,796,576	66.8	8,830,838	76.5	tbd
V	13,945,477	72.1	2,973,187	85.8	tbd
VI	160,381	5.8	50,334	4.6	tbd
VII	700,388	59.3	91,220	56.5	tbd
RANGEWIDE	112,796,863	64.9	35,608,156	75.8	tbd

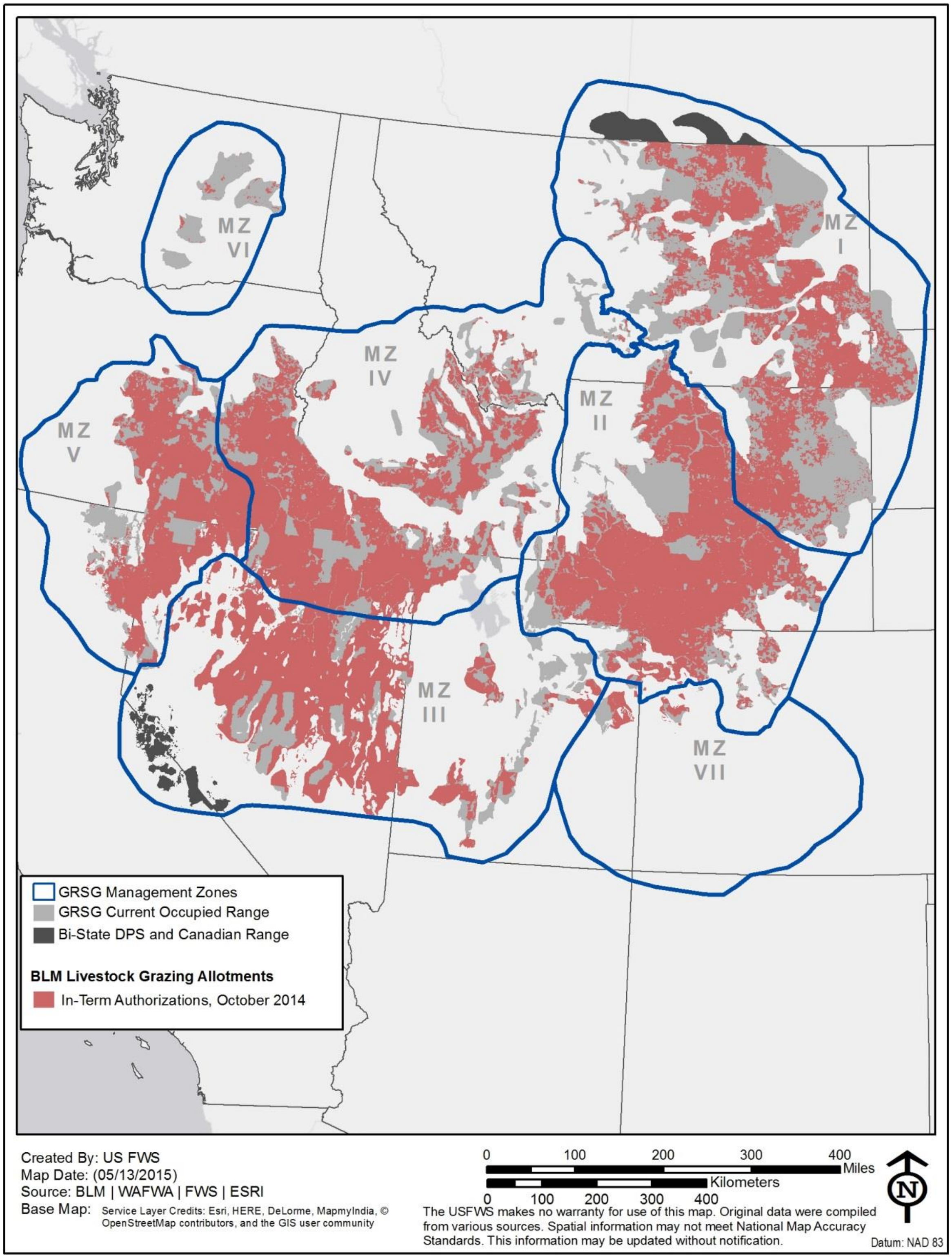

Figure 14-1. Livestock grazing allotments authorized by the BLM as of October, 2014 within the occupied range of greater sage-grouse.

Although the BLM authorized grazing allotments across approximately 64.9 percent of the occupied range of sage grouse (Table 14-1 and Figure 14-1, above), approximately 18.6 percent of the occupied range was actually grazed in 2013, based on fee-collection bills sent to allotment permitees (Table 14-X; Figure 14-3). Therefore, although a large percentage of the occupied range is authorized by the BLM for grazing, the entire lease area may not be grazed at the same time within the same year.

Table 14-2. Acres of grazing pastures and allotments billed by the BLM during the 2013 fee year by management zone and rangewide.

	Grazing Pastures and Allotments Billed[1]				
Management Zone	**Within Occupied Range**		**Intersect: Breeding Distribution**		**Intersect: Population Index**
	Acres	**%**	**Acres**	**%**	**%**
I	3,400,888	7.4	1,254,834	12.2	tbd
II	2,885,529	7.8	1,340,983	11.3	tbd
III	11,263,194	39.1	3,819,719	45.1	tbd
IV	8,813,014	22.8	3,079,283	26.7	tbd
V	5,837,499	30.2	1,251,697	36.1	tbd
VI	24,804	0.9	9,259	0.8	tbd
VII	124,300	10.5	63,525	39.4	tbd
RANGEWIDE	32,349,228	18.6	10,819,300	23.0	tbd

[1] Grazing may have occurred anywhere within the pasture or allotment.

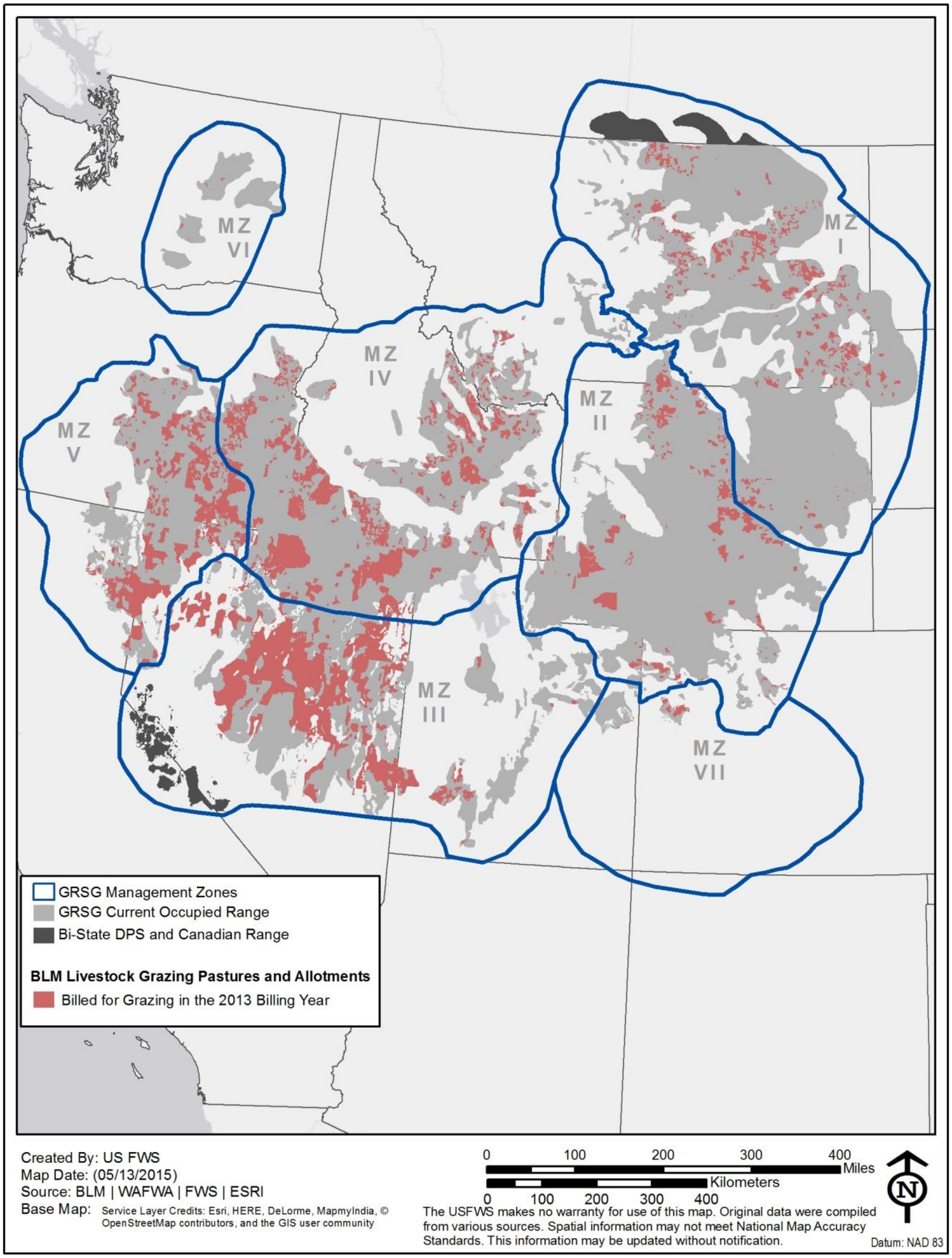

Figure 14-3. BLM grazing pastures and allotments billed in 2013 within the occupied range of greater sage-grouse.

Current Impacts

Grazing can alter the composition of sagebrush plant communities (Boyd *et al.* 2014, p. 62). For example, sustained overgrazing can increase the density of sagebrush while reducing densities of perennial grasses (Boyd *et al.* 2014, p. 62), which degrades the quality of sage-grouse habitats. Alternatively, light to moderate livestock grazing can maintain perennial vegetation that provides important food and cover for sage-grouse (Miller *et al.* 2004, p. X; Boyd *et al.* 2014, p. 63). Grazing's actual influence on the ecosystem depends on the intensity and timing of grazing (Aldridge *et al.* 2008, p. 990; Boyd *et al.* 2014, p. 63) and the local climatic and ecological conditions (Crawford *et al.* 2004, p. X; Boyd *et al.* 2014, p. 63). As a result, drawing inferences regarding the impact of grazing on sagebrush habitats across the range of sage-grouse is difficult.

Livestock grazing directly influences the composition, productivity, and structure of herbaceous plants in sagebrush plant communities (Boyd *et al.* 2014, p. 64), which in turn influences the quality and quantity of food and cover for sage-grouse (Fleischner 1994, pp. 633–635). By reducing protective vegetative cover, livestock grazing may make nesting and brood-rearing habitats less suitable for sage-grouse. Sage-grouse rely on the cover of tall grasses and shrubs to hide from predators, especially during the nesting season, and females will preferentially choose nesting sites based on the height of grasses and shrubs (Hagen *et al.* 2007, p. 46). Grass height is a strong predictor of nest survival and hiding cover can increase nest success, a key vital rate for sage-grouse (Doherty *et al.* 2014, pp. 322–323). Loss of this hiding cover may increase predation during nesting and brood-rearing, subsequently reducing reproductive success rates (Gregg *et al.* 1994, p. 165). Maintaining adequate residual grass height and cover under shrubs minimized the negative effect of grazing on sage-grouse productivity (Boyd *et al.* 2014, p. 64). Livestock grazing may also reduce the cover and height of sagebrush in key wintering habitats (Rasmussen and Griner 1938, p. X), potentially affecting the condition and survival of sage-grouse during the winter when resources are scarce.

Livestock grazing can reduce the food available to sage-grouse (Braun 1987, p. 137; Vallentine 1990, pp. 240–241, 226; Dobkin 1995, p. 18; Connelly and Braun 1997, p. 231; Beck and Mitchell 2000, pp. 998–1,000; Pederson *et al.* 2003, p. 43). If food resources that provide important nutrients to pre-laying females become scarce, the female's overall nutrition can be negatively impacted which may influence nest initiation rates, clutch sizes, and reproductive success rates (Barnett and Crawford 1994, p.117; Coggins 1998, p. 30). A reduction in forbs can also reduce the survival of chicks (Aldridge and Brigham 2002, p. 441; Aldridge and Brigham 2003, p. 30). Livestock grazing may also reduce water infiltration rates, reduce the cover of herbaceous plants, compact soils, and increase soil erosion in mesic, brood-rearing areas (Braun 1998, p. 147; Dobkin *et al.* 1998, p. 213), further affecting the ability of broods to obtain sufficient food resources. Alternatively, some grazing can improve forage conditions for sage-grouse by stimulating the regrowth of forbs (Evans 1986, p. 67).

As livestock graze, they may trample sage-grouse nests and food plants, and females may abandon their nests if livestock approach too closely (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). Nearby livestock frequently force skittish females to flush from their nests (Coates 2008b, p. 462), inadvertently revealing the nest and its eggs to predators, such as ravens (Coates 2007, p.33). Livestock also may trample sagebrush seedlings, which could provide food and cover (Connelly *et al.* 2004, p. 7-31). Trampling by livestock can also reduce or eliminate biological soil crusts, which may promote cheatgrass invasion (Mack and Thompson 1982, p. 764; Young and Allen 1997, p. 531; Masters and Sheley 2001, p. 503; Reisner *et al.* 2013, p. 10; Chambers *et al.* 2014, p. 361). In addition to increasing wildfire risk (Chambers *et al.* 2014, p. 366and references therein), the establishment of invasive species, such as cheatgrass, degrades sagebrush habitats by reducing plant diversity, understory cover and food resources. In some cases livestock grazing may help control invasives and woody plant encroachment (Riggs and Urness 1989, p. 358; Mosley 1996 cited in Connelly *et al.* 2004, p. 7-49; Merritt *et al.* 2001, p. 4; Olsen and Wallander 2001, p. 30), which may improve habitats and may have role in reducing wildfire risk (Boyd *et al.* 2014, p. 68). In some cases sage-grouse may also seek out and use openings in meadows created by cattle grazing (Klebenow 1981, p. 121).

Infrastructure associated with livestock grazing, such as watering structures and fencing, may concentrate disturbance, fragment habitats, kill sage-grouse during collisions, and create perches and access corridors for predators (Call and Maser 1985, p. 3; Connelly *et al.* 2000, p. 974; Connelly *et al.* 2004, p. 1-2). Water developments for livestock, such as springs, tanks, and guzzlers, are common in sage-grouse habitats (Connelly *et al.* 2004, p. 7-35), and influence the distribution of livestock and grazing intensity within a pasture (Boyd *et al.* 2014, p. 65). Congregation of livestock around water developments concentrates grazing and allows for trampling of vegetation around these structures (Braun 1998, p. 147; Knick *et al.*, 2011, p. 230). While these areas may subsequently be unsuitable for sage-grouse, the strategic placement of livestock water developments could protect other habitats by localizing and minimizing the area of impact. There have been documented incidences of sage-grouse drowning in stock tanks which can have substantial localized population level effects (Boyd *et al.* 2014, p. 65), but the rangewide impact is unknown. Water developments may also provide mesic vegetation on which sage-grouse forage. This could provide an important resource in summer habitats (Boyd *et al.* 2014, p. 65) when the availability of succulent plants may be limited.

Diverting water from waterways for livestock can reduce riparian and wet meadow habitats for sage-grouse, which provide key brood-rearing habitats (Schroeder *et al.* 1999, p. X; Connelly *et al.* 2011, p. X; Donnelly 2014, in litt). Water diversions may, therefore, reduce the availability of these habitats, and potentially brood condition and survival. However, water developments could also breed mosquitos that spread the WNv, which is fatal to sage-grouse (Boyd *et al.* 2014, p. 65; see ***Disease*** chapter). The placement of salt or mineral blocks for livestock can also influence livestock grazing distribution and use, but results of studies examining this factor are inconsistent. In arid areas, such as the range of sage-grouse, water developments have a far greater influence on livestock distribution than do salt or mineral blocks (Boyd *et al.* 2014, p. 65and references therein).

Thousands of miles of fences across the sage-grouse range are used to manage domestic livestock (Knick *et al.* 2011, pp. 224–225). Fences cause direct mortality through collision and indirect mortality through the creation of avian predator perch sites, the potential creation of predator corridors along fences (particularly if a road is maintained next to the fence), incursion of invasive plants along the fencing corridor, 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, pp. 1–2; see ***Fence*** chapter).

Extensive rangeland treatment has been conducted to improve conditions for livestock in the sagebrush-steppe region (Connelly *et al.* 2004, p. 7-28; Knick *et al.* 2011, p. X). Sagebrush has been deliberately eliminated and then seeded with nonnative grasses (Connelly *et al.* 2004, p. 7- 28), effectively reducing, and in some cases eliminating, sagebrush and many native grasses and forbs used by the sage-grouse for food and cover (Hull 1974, p. 217; Connelly *et al.* 2004, p. 4-4). Impacts of the planting of non-native monocultures for the benefit of livestock are relative to scale of the planting (Boyd *et al.* 2014, p. 67). By the 1970s, over 2 million ha (5 million ac) of sagebrush are estimated to have been mechanically treated, sprayed with herbicide, or burned in an effort to remove sagebrush and increase herbaceous forage and grasses for livestock (Crawford *et al.* 2004, p. 12). The BLM treated over 1,800,000 ha (4,447,897 ac) from 1940 to 1994 (Miller and Eddleman 2000, p. 20). All sagebrush habitats used by sage-grouse have been treated in some way to reduce shrub cover since European settlement in western North America (Braun 1998, p. 146). Reduction in sage-grouse habitat quality and likely numbers in the 1970s were associated with extensive rangeland treatments to increase forage for domestic livestock (Crawford *et al.* 2004, p. 12). Negative impacts of range treatments for domestic livestock to breeding sage-grouse (Connelly *et al.* 2000a, p. 972), nesting success rates, brood carrying capacity (Klebenow 1970, p. 399) and winter cover and food (Pyrah 1972 and Higby 1969 cited in Connelly *et al.* 2000, p. 973) have been documented. Sagebrush height, and grass and forb communities rarely return to pre-treatment conditions or to the extent they provide sage-grouse habitat, years (up to 30) after initial treatment (Hess and Beck 2012, pp. 91–92; Boyd *et al.* 2014, p. 66). The type and extent sage-grouse response to range treatments depends on the extent to which forbs and sagebrush are killed.

Some rangeland treatments can be beneficial for sage-grouse habitats. Small treatments interspersed with non-treated sagebrush habitats did not affect sage-grouse use, presumably due to minimal effects on food or cover (Braun 1998, p. 147). Application of herbicides to reduce sagebrush cover may enhance some brood-rearing habitats by increasing the coverage of herbaceous plant foods (Autenrieth 1981, p. 65; Boyd *et al.* 2014, p. 66 and references therein). Mechanical treatments, if carefully designed and executed, can be beneficial to sage-grouse by improving herbaceous cover, forb production, and sagebrush re-sprouting (Braun 1998, p. 147), but this may only be true at higher elevations (Boyd *et al.* 2014, p. 66). Small chemical treatments may not impact sage-grouse if intact sagebrush remains nearby (Braun 1998, p. 147).

The success of restoring or rehabilitating 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 influence perennial grass response than other treatments (Wambolt and Payne 1986, p. 318), although prescribed grazing of nonnative perennial grasses may help promote restoration of sagebrush (Boyd *et al.* 2014, p. 67). At least one author has suggested modifying grazing management, including removal of grazing in some areas, to allow for habitat restoration (Pyke 2011, p. 537). Active restoration is required where the native understory is reduced (Pyke 2011, p. 539). If an area has soil loss or invasives, returning the native plant community may be impossible (Daubenmire 1970, p. 82; Knick *et al.* 2011, p. 232; Pyke 2011, p. 539).

Livestock grazing on BLM-administered lands is managed through limitations on number of animal unit months (AUM), and length and dates of grazing. Permitted AUMs represent potential maximum use based on land conditions and trend, whereas actual use will vary due to economics, non-use due to forage or drought conditions, and unreported trespass (Knick and Connelly 2011, p. 221). Land condition is a consideration in establishing grazing strategies for individual allotments and the BLM follows defined standards and guidelines for determining the health of individual allotments (Knick and

Connelly 2011, p. 222). An important objective of the BLM in managing livestock grazing is to maintain residual cover of herbaceous vegetation to reduce predation during nesting and to maintain the integrity of riparian vegetation and other wetlands (BLM 2011, p. 14). Unfortunately, individual allotments are not assessed on a regular basis due to limitations in budget and staffing (cite), and therefore, permits can be renewed without a review of whether or not the allotment meets the necessary standards and guidelines (Figure 14-2). For example, in Nevada there are 550 grazing allotments managed by the BLM, but the BLM has only evaluated 36 percent of these to see if they meet land health standards. Of the 36 percent of allotments that have been evaluated in Nevada, only 45(or 23 percent) meet land health standards (BLM DEIS, p. 472). Similarly, the BLM has evaluated 61 percent of the 155 grazing allotments that it manages in northeastern California, and 73 percent of these allotments meet land health standards (BLM DEIS, p. 470). BLM must consider many factors when establishing allotment restrictions, and sage-grouse habitat is not always considered if the allotment falls outside of PHMA. Therefore, not all allotments on BLM-administered lands are managed or evaluated for sage-grouse conservation.

Of the allotments evaluated by the BLM, 5.8 percent did not meet habitat land health standards due to grazing within the occupied range of sage-grouse (Table 14-3; Figure 14-3). Approximately 7.9 did not meet land health standards due to grazing within the breeding distribution of sage-grouse (Table 14-3; Figure 14-3).

Table 14-3. Acres of allotments evaluated by the BLM between 1998 and 2012 that did not meet land health standards due to grazing, by management zone and rangewide.

	Allotments Not Meeting Habitat Land Health Standards - Grazing as a Causal Factor[1]				
Management Zone	**Within Occupied Range**		**Intersect: Breeding Distribution**		**Intersect: Population Index**
	Acres	%	Acres	%	%
I	338,496	0.7	140,304	1.4	tbd
II	705,551	1.9	394,283	3.3	tbd
III	4,338,253	15.1	1,534,250	18.1	tbd
IV	3,834,539	9.9	1,323,466	11.5	tbd
V	878,625	4.5	336,887	9.7	tbd
VI	NA	NA	NA	NA	NA
VII	NA	NA	NA	NA	NA
RANGEWIDE	10,095,464	5.8	3,729,190	7.9	tbd

[1] Data was based on land health assessments from 1998-2012. Each state, or resource advisory council area within a state, has a habitat quality Land Health Standard that focuses on threatened and endangered and special status species habitat. Sage-grouse might be the only special status species, or it might be one of several T&E or special status species within an evaluated allotment.

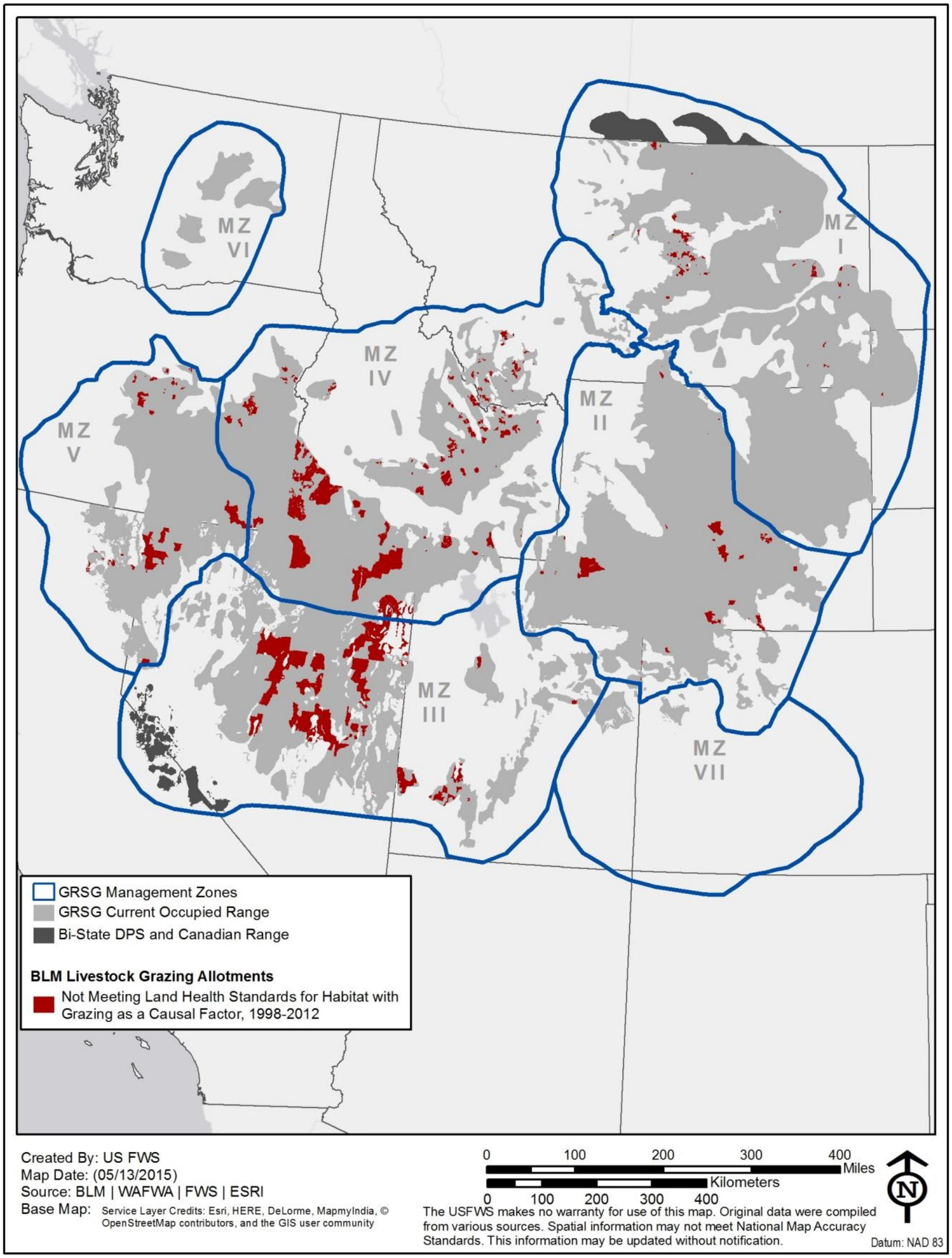

Figure 14-3. BLM livestock grazing allotments within the occupied range of greater sage-grouse, which did not meet land health standards for habitat between 1998–2012, with grazing was identified as a casual factor.

Grazing by Wild Ungulates

Wild, native, ungulates (hoofed mammals), such as elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*), and pronghorn antelope (*Antilocapra americana*) share the sagebrush ecosystem with sage-grouse (Miller *et al.* 1994, p. 111) and feed on the same grasses, forbs, and shrubs (Kufeld 1973, p. 106–107; Kufeld *et al.* 1973 cited in Wallmo and Regelin 1981, pp. 387–396 and 389–396; Allen *et al.* 1984, p. 1; Vallentine 1990, pp. 235, 236; Wambolt and Sherwood 1999, p. 225). Concentrated grazing by native ungulates may reduce vegetation available to sage-grouse for food and cover. Elk and deer may concentrate and overgraze near small-scale, supplemental feeding and watering stations (Doman and Rasmussen 1944, p. 319; Smith 2001, pp. 179–181). Additionally, native ungulates may graze heavily on sagebrush during the winter, when food is scarce, and overgrazing can kill sagebrush and reduce shrub cover in specific areas (Wambolt 1996, p. 502; Wambolt and Hoffman 2004, p. 195). However, unlike domestic livestock, wild, native ungulates roam freely, spreading potential impacts diffusely across the landscape or concentrating it in specific areas. Therefore, there is no evidence that grazing by native ungulates impacts sage-grouse population levels.

Timescale for Projecting this Threat

We have not identified any information indicating that either domestic livestock or wild ungulate grazing on public or private lands will cease in the future. While the intensity and species grazed will likely be fluid on a local scale, we cannot predict how these changes will impact sage-grouse at the population level or higher, if at all. Therefore, the time-scale for projecting this threat is that it will occur indefinitely into the foreseeable future based on current information.

Threat Amelioration

Conservation Efforts Database Projects

Through the CED, the Service collected information relating to conservation actions that were completed, in progress, or planned. Our partners reported more than 800 completed projects, representing over 7.7 million ha (nearly 19 million ac), or 10.9 percent of the occupied range, that address grazing practices. Of these, 745 projects and more than 7 million ha (18 million ac), or 10.4 percent of the occupied range, address grazing and range management. Numerous projects are listed more than one MZ in the CED, but the total acres for each are not allocated among MZ in the CED. We have not allocated them here; instead we have included these acres in the sum for each MZ listed by the data providers (Appendix C).

Candidate Conservation Agreements with Assurrances and Candidate Conservation Agreements

Lands currently enrolled in CCAAs reduce grazing impacts through implementation of appropriate grazing management plans (appropriate timing, location, duration, frequency, types of livestock). Approximately 0.17 percent of occupied range in MZ I, 0.78 percent of MZ II, 2.47 percent of MZ IV, and 4.67 percent of MZ V are enrolled in CCAAs in Wyoming and Oregon. Federal lands enrolled in CCAs in Wyoming, Oregon, and Idaho account for 0.04 percent of occupied range in MZ I, 0.21 percent of MZ II, 3.13 percent of MZ IV, and 4.67 percent of MZ V. See the ***Non-regulatory Conservation Efforts*** section and Table 28-7 for approximate acreages and additional information.

State Plans

State plans in Idaho and Montana include measures to reduce the impact of overgrazing on sage-grouse. Idaho's plan features a suite of regulatory conservation measures designed to reduce impacts from improper grazing on Idaho State lands (Idaho Department of Lands 2015, pp. 34–37). Idaho's plan incorporates guidelines to help ensure that restoration areas meet seasonal habitat requirements (Idaho Department of Lands 2015, p. 22. Although these conservation measures would apply only to Idaho State Lands, they are largely surrounded by Federal lands, often with no clear delineation, so conservation measures that address overgrazing on the adjoining Federal lands will likely also occur on the Idaho State lands. Therefore, the regulatory components of Idaho's state plan effectively reduce impacts associated with overgrazing on Idaho State lands.

With the Governor's mandate and the State Land Board's approval, Montana's state plan would direct the State to develop lease evaluation criteria for State Trust grazing lands that maintain and improve sage-grouse habitat in core and connectivity areas on State lands in Montana (State of Montana 2014, pp. 7, 17). The State would also develop a corrective action plan for grazing leases on State Trust lands that fail to meet the evaluation criteria (State of Montana 2014, p. 7). However, the State has not developed or approved these evaluation criteria or the corrective action plan, with full implementation tentatively expected by 2016. Montana's plan also creates and encourages voluntary incentives to conserve sagebrush habitats on private and state lands in core and general habitat areas (State of Montana 2014, pp. 7, 20, 26, 27). Once approved and implemented, the evaluation criteria and corrective action plan would be regulatory and would likely effectively reduce impacts associated with overgrazing in core and connectivity areas on State Trust lands in Montana. A summary of state regulations and conservation plans addressing grazing, and other threats is in the Regulatory Mechanisms chapter (pp.X).

BLM Resource Management Plans and USFS Land and Resource Management Plans

The BLM and USFS plans include management of grazing for sage-grouse habitat objectives, as consistent with site-specific guidelines or ecological site descriptions. Management of livestock will benefit or not impact sage-grouse through evaluation of numbers and distribution of livestock, consideration of drought, consideration of closing or changing allotments as available, managing riparian habitat for sage-grouse, and only authorizing water developments if they are beneficial or there is no adverse impact to sage-grouse. Additionally, structural range improvements will be managed to benefit or not adversely affect sage-grouse by restricting locations of ranch facilities (e.g., fences, windmills, and corrals) around leks, marking or removing fences, and controlling invasive plants. In Wyoming, the plans mimic the Wyoming Executive Order. For additional details, see the ***Regulatory Mechanisms*** section.

Other Conservation Efforts (e.g., Data Call, SGI)

In 2010, NRCS launched SGI to voluntarily reduce threats facing sage-grouse on private lands. To date, SGI has assisted private landowners enhance rangeland health inside PACs by enrolling 986, 479 ha (2,437, 645 ac) in grazing systems, re-vegetating 19,473 ha (48,120 ac) former rangeland with sagebrush and native perennial bunchgrasses, controlling invasives on 6,276 ha (15,509 ac), and restoring over 70 ha (179 ac) of wet meadow (NRCS 2015, p. 6). Of the almost 1 million hectares (over two million acres) enrolled in grazing systems, 76 percent are clustered within five populations (MZ I: Powder River Basin, Yellowstone Watershed, and the Dakotas; MZ II: Wyoming Basin; MZ IV:Snake/Salmon/Beaverhead) (NRCS 2015, p. 7). In addition over 74 percent of the newly seeded acres are concentrated in five populations (MZ I: Dakotas, Yellowstone Watershed; MZ II: Northwest Colorado; MZ IV: Northern Great Basin, Box Elder) (NRCS 2015, p. 7).

Threat Amelioration Summary

Since 2010, conservation actions have addressed impacts to sage-grouse across approximately 7 million ha (18 million ac) of the occupied range. These grazing and range-management projects cover approximately 10.4 percent of the occupied range, of which more than 64.9 percent are authorized grazing allotments. Partners have also completed CCAAs and CCAs to reduce impacts from grazing. State conservation plans that address grazing are largely voluntary, except potentially in Idaho and Montana in the future if their state plans are approved and implemented. The BLM and USFS plans direct grazing management to meet sage-grouse habitat objectives that are consistent with site-specific guidelines or ecological site descriptions.

Assessment of Potential Threat

The relationships between livestock grazing and sage-grouse population levels are not well understood (Braun 1987, p. 137; Connelly and Braun 1997, p. 231), and there are no studies that directly evaluate the effects of livestock grazing on sage-grouse habitat (Boyd *et al.* 2014, p. 64). Impacts are often contextual relative to scale (i.e., localized severe impacts may not have larger population level impacts), and indirect impacts (e.g., increase in invasive plants) are likely more problematic than direct impacts (e.g., nest trampling, food competition; Beck and Mitchell 2000, p. 997). Researchers have documented both positive and negative effects of livestock grazing on sage-grouse and their habitats (Beck and Mitchell 2000, p. 997; Davies *et al.* 2011; Pyke 2011, p. 537; Boyd *et al.* 2014, p. X; Chambers *et al.* 2014 pp. 369–370). Over the last 150 years, livestock have grazed nearly all sage-grouse habitats throughout the species range, confounding any evaluation of potential impacts, especially at the large landscape scales that are important to sage-grouse (Knick *et al.* 2011, p. 232). Improperly managed grazing will continue to degrade sagebrush habitats important to sage-grouse, but in many areas across the specie's range, well-managed grazing practices are compatible with sagebrush systems (Boyd *et al.* 2014, p. 60; Chambers *et al.* 2014, p. 369) and can improve habitat conditions for sage-grouse. None of the individual components discussed above (loss of cover, competition for food, etc.) have been demonstrated to have population level impacts to sage-grouse, although they have undoubtedly had localized effects. Range management treatments are the exception, where negative population responses have been recorded, although a rangewide impact has not been documented. Given the inconclusive nature of the scientific literature we cannot determine an overall impact of domestic livestock grazing on sage-grouse persistence. However, maintaining grazing activities compatible with local conditions on large landscapes may be preferable to the loss of those landscapes through habitat fragmentation caused by urbanization or other factors (Boyd *et al.* 2014, p. 67). We are also unable to determine if there is a change in the impact of grazing from our 2010 warranted determination.

CHAPTER 15: FREE-ROAMING EQUIDS

Free-roaming equids (wild horses (*Equus caballus*) and burros (*E. asinus*)) have utilized sagebrush and other communities across the West since they were brought to North America about the16th century. Additional equids escaped captivity or were released (Wagner 1983, p. 116; Beever 2003, p. 887; Beever and Aldridge 2011, p. 278; Garrott and Oli 2013, p. 847). Today, equids continue to stray from both private, public, and land under other management authorities onto Federal lands.

Approximately 49,209 free-roaming equids (about 40,815 horses and 8,394 burros) currently inhabit BLM-administered rangelands in 10 western States (including 2 states outside the range of the sage-grouse) (BLM 2015, p. 1). On USFS-managed rangelands in 7 western States (including 2 states outside the range of the sage-grouse), there are an additional 7,447 free-roaming equids (Frolli 2015b, pers. comm.). Using BLM and USFS data for 2013, equids (assuming a ratio of 1 horse AUM to 1 cow AUM (cow/calf pair)) consume approximately 679,872 AUMs annually, as compared to over 7 million AUMs for domestic livestock within the range of sage-grouse (Beever and Aldridge 2011). The BLM and USFS manage these free-roaming equids in equid management areas. These equid management areas overlap with about 12 percent (8,225,231 ha; 20,324,988 ac) of the current sage-grouse range, primarily in Oregon, Nevada and Wyoming (MZ's II, III, IV, and V; Table 15-1; Figure 15-1).

As free-roaming equid populations reproduce without adequate population control, they can expand their range outside of the designated Federal equid management areas. The extent to which BLM- and USFS-managed free-roaming equids use land outside of designated management areas is difficult to quantify, but may be considerable. This is compounded as BLM and USFS are not the only entities (e.g., many Native American Tribes, the Nevada Department of Agriculture, the Service, and the NPS) managing equids that may utilize Federal lands (Sheperd and Frolli 2015, pers. comm.). It should be noted that equids are being completely removed from some Service and NPS units (Connelly *et al.* 2004, p. 7-36). Across the West, Native American Tribes are estimated to manage over 200,000 free-roaming equids (Sheperd and Frolli 2015, pers. comm.). However, about 100,000 of the Native American-managed equids are managed by the Navajos in Arizona and New Mexico (Shepherd and Frolli 2015, pers. comm.) and therefore, do not overlap with the current occupied sage-grouse range. The remaining approximately 100,000 free-roaming equids occur on Tribal lands within or near the current range of the sage-grouse. These lands typically are not fenced and an unknown number of these equids use adjacent Federal lands (USFS 2015, p. 1). Furthermore, there are an unknown number of stray (a stray domestic animal of unknown ownership) equids, both from the Tribes and the public that may also use Federal lands (Shepherd and Frolli 2015, pers. comm.). While equids are actively managed by Federal agencies on federally-managed lands, ongoing challenges with maintaining populations at delineated management levels persist.

Current Impacts

Free-roaming equids effects on sage-grouse can occur directly, indirectly, and via feedback loops. Direct effects include disturbance of lekking behavior, trampling of nests or young, and loss of food resources (Beever and Aldridge 2011, pp. 281–282). Indirect effects include degradation and destruction of sage-grouse habitats, changes to the structure and composition of vegetation, loss of prey base, reduced escape cover, and other energetic and nutritional effects on sage-grouse (Beever and Aldridge 2011, p. 277).

The local effects of ungulate grazing depend on a host of abiotic and biotic factors (e.g., elevation, season, soil composition, plant productivity, and composition). Also, significant biological and behavioral differences influence the impact of equids as compared to domestic livestock grazing on sagebrush ecosystems (Beever 2003, pp. 888–890) and as compared to wild ungulates. Equids are generalists, but grasses comprise the majority of their diet throughout the year (McInnis and Vavra 1987, p. 61). Due to physiological differences, an equid 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). Unlike domestic cattle and other wild ungulates, equids can crop vegetation closer to the ground, potentially limiting or delaying recovery of plants (Menard *et al*. 2002, p. 127). Equids tend to move to higher elevations in late spring until early fall, which may increase the interactions between equids and sage-grouse, as sage-grouse often move to higher elevation communities to more mesic habitats with forbs throughout the summer (Beever and Aldridge 2011, pp. 285–286). Conversely, equids tend to spend less time at water, and range farther from water sources than cattle (Beever and Aldridge 2011, p. 286), which can segregate them from sage-grouse.

Testing for impacts of free-roaming equids at landscape scales important to sage-grouse is confounded by the fact that almost all sage-grouse habitat has at one time been grazed, and thus no non-grazed areas currently exist with which to compare (Knick *et al.* 2011, p. 232). The loss and fragmentation of sagebrush habitat due to free-roaming equid grazing cannot be quantified or spatially analyzed due to lack of data collection.

Results of Impact

Preliminary research looking at differences in sage-grouse nesting success and survival on sites with various grazing regimes (i.e., no grazing, grazing by equids only, grazing by both equids and cattle) suggest that nest success is three times higher at sites without grazing (Jaster and Sedinger 2013, pp. 7, 11, 30); however, this result is from only one year of data collection and is not statistically significant. Free-roaming equids could negatively impact important meadow and spring brood-rearing habitats that provide forbs and insects for chick survival (Crawford *et al*. 2004, p. 11; Connelly *et al*. 2004, p. 7-37). Davies *et al*. (2014, pp. 9–11) found a two-fold increase in sagebrush density at sites with no equid grazers, suggesting that equid grazers may limit sagebrush recruitment, which in turn could negatively impact sage-grouse. These equid grazed sites also had lower plant diversity, greater soil penetration resistance, and lower soil aggregate stability than ungrazed areas (Beever and Herrick 2006, pp. 108–109; Davies *et al*. 2014, pp. 10–11). Lek persistence, nest success, chick survival, or other aspects of fitness and survival could also be affected by free-roaming equid grazers; all of which could ultimately affect the viability of some sage-grouse populations.

Sage-grouse need grass and shrubcover for protection from predators, particularly during nesting season (Connelly *et al*. 2000, pp. 970–971). A meta-analysis of sage-grouse nesting habitat data indicated female sage-grouse will preferentially choose nesting sites based on grass and shrub cover (Hagen *et al*. 2007, p. 46). A comparison of areas in the Great Basin region with and without equid grazing showed 1.9 to 2.9 times more grass cover and higher grass density in areas without equid grazing. Additionally, sites with equid grazing had less shrub cover and more fragmented shrub canopies as equids can trample, rub against, and consume shrubs (Plumb *et al*. 1984, p. 132; Beever *et al*. 2003, pp. 119–120; Beever *et al*. 2008, p. 180). Sites with equid grazing typically showed less plant diversity, altered soil characteristics, and 1.6 to 2.6 times greater abundance of cheatgrass (Beever *et al*. 2008, pp. 180–181).

Impacts from free-roaming equids on sagebrush ecosystems can increase the energetic costs and stress levels of sage-grouse by limiting habitat, precluding a sage-grouse from nesting, causing the sage-grouse to locate alternative suitable habitat, increasing predation risks to a sage-grouse nesting in a less favorable location, and/or decreasing food availability, both insects and vegetation. These impacts combined indicate that free-roaming equids have the potential to result in an overall decrease in the quality and quantity of sage-grouse habitat in areas where grazing by free-roaming equids occurs within the range of the sage-grouse.

Location and Extent

It is difficult to assess the overall magnitude of the impact of free-roaming equids on the landscape in general, or on sage-grouse habitat in particular. Furthermore, whether the impacts of equids and cattle grazing are synergistic or simply additive is currently unknown (Beever and Aldridge 2011, p. 286). 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).

Management of herd size by Federal agencies is an ongoing challenge as free-roaming equids reproduce rapidly, in most areas they have no natural predators, and management is expensive. The BLM is restricted in their management options due to budgetary levels and an annual appropriation rider that restricts the sale of equids without limitation and the euthanasia of healthy equids (Shepherd and Frolli 2015, p. 4; see ***Regulatory Mechanisms*** section). Additionally, free-roaming equid management is frequently litigated, which limits the timeliness of management actions and the budgets of the Federal agencies.

Table 15-1: Percent of sage-grouse current range impacted by free-roaming equids by Management Zone**.**

Management Zone	Total Acres of Occupied Sage-grouse Range	Acres Impacted by Free-roaming Equids	Total Ha of Occupied Sage-grouse Range	Ha Impacted by Free-Roaming Equids	Percent of Occupied Sage-grouse Range Impacted by Free-roaming Equids
I	48,359,844	0	19,570,535	0	0%
II	37,115,827	4,928,427	15,020,242	1,994,464	13.28%
III	28,803,339	8,780,092	11,656,298	3,553,177	30.48%
MZ IV	38,213,133	2,081,854	15,464,306	842,496	5.45%
V	19,277,972	4,526,080	7,801,518	1,831,639	23.58%
MZ VI	2,757,910	0	1,116,086	0	0%
VII	1,180,428	8,535	477,702	3,454	0.72%
Total	**175,708,452**	**20,324,988**	**71,106,688**	**8,225,231**	**11.57%**

Over half of the total free-roaming equids that are managed by the BLM and USFS occur in Nevada (BLM 2015, p. 1; Table 15-2). MZs III and V (Southern Great Basin and Northern Great Basin) have the two highest percentages of current sage-grouse range impacted by free-roaming equids, 30.5 and 23.6 percent, respectively (Table X-1 and Figure X-1). Additionally in MZ II, the Wyoming Basin, free-roaming equids potentially impact sage-grouse on 13.3 percent of the current range of the sage-grouse. Rangewide, free-roaming equids managed by the BLM and the USFS directly impact nearly 12 percent of the sage-grouse's current range (Table 15-2 and Figure 15-1). This estimate does not account for the distribution of equids managed by entities other than the BLM and the USFS. Therefore, the extent to which equids impact sage-grouse outside BLM- and FS-administered lands is difficult to quantify, but may be considerable.

Table 15-2: Total BLM- and USFS-managed equids by State as of March 1, 2014; Maximum BLM- and USFS-allowable appropriate management levels (AML; the number of free-roaming equids that the Federal agencies determine can exist in balance with other public rangeland species.

State	BLM-managed Horses	USFS-managed Horses	BLM-managed Burros	USFS-managed Burros	Total BLM/FS-managed Equids	Max BLM-allowed AML	Max USFS-allowed AML	Max BLM/USFS-allowed AML
AZ	333	0	4,411	133	4,877	1,676	35	1,711
CA	4,086	2,768	1,922	61	8,837	2,184	767	2,951
CO	1,205	0	0	0	1,205	812	0	812
ID	668	0	0	0	668	617	0	617
MT	160	160	0	0	320	120	120	240
NV	23,347	2,505	1,688	714	28,254	12,796	879	13,675
NM	146	564	0	0	710	83	200	283
OR	3,120	350	60	0	3,530	2,715	200	2,915
UT	3,979	193	313	0	4,485	1,956	52	2,008
WY	3,771	0	0	0	3,771	3,725	0	3,725
Total	**40,815**	**6,540**	**8,394**	**908**	**56,657**	**26,684**	**2,253**	**28,937**

For the Federally-managed free-roaming equids that we can account for, the estimated current population is nearly double the amount that the BLM and USFS have determined can exist in balance with other public land resources and uses (BLM 2015, p. 1; Table 14-2). Free-roaming equids reproduce rapidly and \can have rates of increase averaging 15 to 20 percent annually (NRS 1980, p. 3; Eberhardt *et al*. 1982, p. 374; BLM 2015, p. 1). Thus, the population of free-roaming equids can double every four years. Using a slightly more conservative estimate of populations doubling every 5 years (due to factors such as density-dependent feedback mechanisms, gathers, and other fertility control methods) in 10 years (2025) the free-roaming equid population managed by the BLM and the USFS would be approximately 226,600 animals. At that time, free-roaming equids would exceed the appropriate management level (AML; the number of free-roaming equids that the Federal agencies determine can exist in balance with other public rangeland species, resources, and uses in a given area, typically given as a range that allows for population growth over a 4 or 5 year period) by 852 percent. Based on this understanding, we anticipate future impacts caused by free-roaming equids to increase. However, we recognize that changes in management direction, if realized, could influence the degree of impact caused by equids.

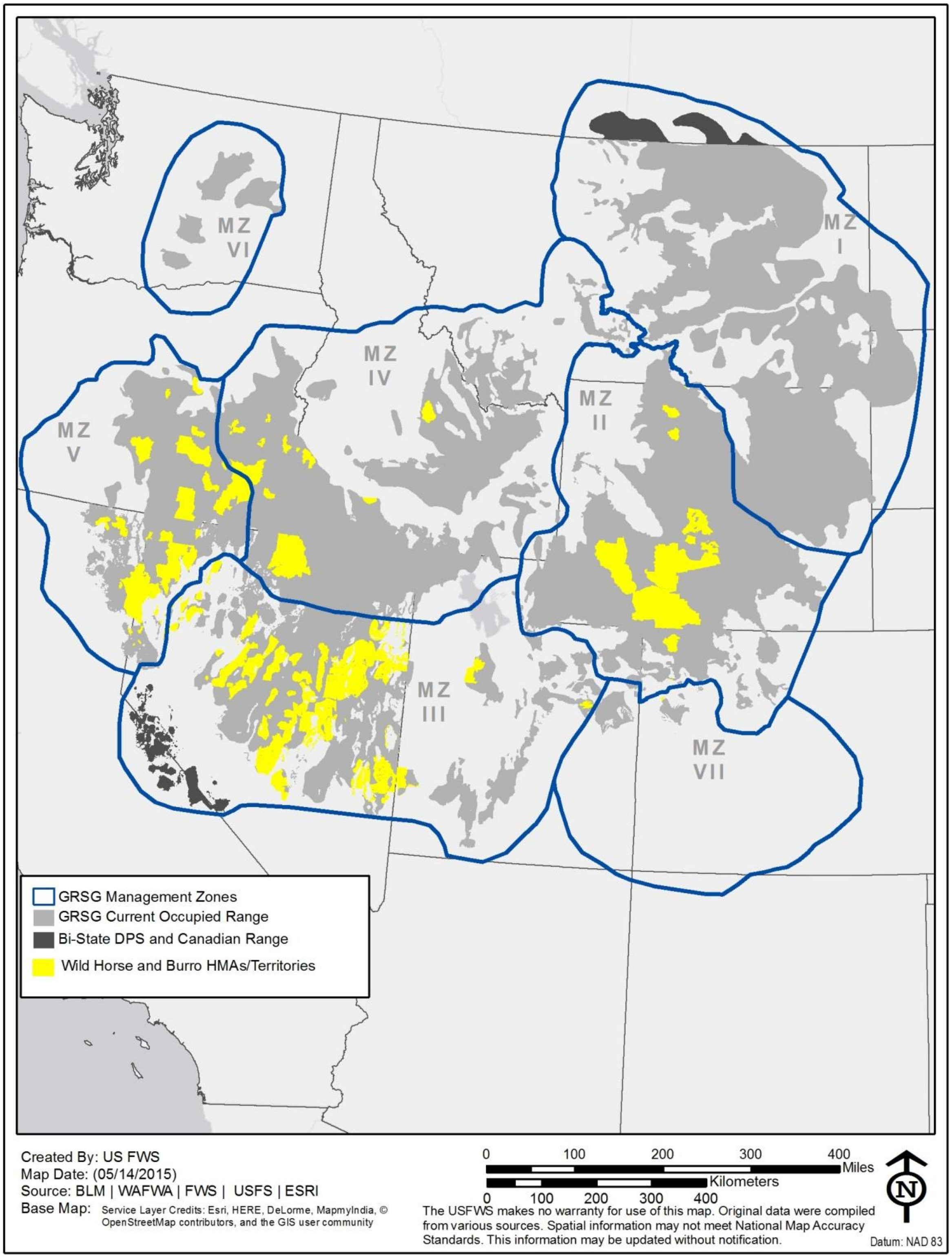

Figure 15-1. Free-roaming Equid Management Areas areas managed by BLM and USFS for free-roaming equids with the current greater sage-grouse range.

Projected Future Impacts (Timescale, Likelihood of Future Impacts and Anticipated Changes from Present)

The Wild Free-Roaming Horses and Burros Act of 1971 (Public Law 92-195), as amended, protects free-roaming equids on public lands. This law charges the BLM and USFS with managing these animals to achieve a thriving ecological balance with the land. Therefore, we expect that free-roaming equids will be present and have an effect on sagebrush ecosystems and sage-grouse where they overlap for at least the next 15 to 20 years. Additionally, without changes to management actions, free-roaming equid populations will increase, expand their range, and affect additional areas within the range of sage-grouse.

The BLM and USFS manage free-roaming equids by conducting surveys, round-ups, administering fertility control drugs, sex ratio management, and adoptions. Table 15-3 provides information on the BLM's management actions from 2009 through 2015. In the absence of changes to the equid management abilities of the BLM and the USFS, we expect free-roaming equids will continue to increase in numbers and have the potential to impact sagebrush ecosystems and sage-grouse where they overlap in range. As free-roaming equid numbers increase, they are likely to expand their range. This would cause a greater increase in impacts to sagebrush ecosystems and sage-grouse.

Table 15-3. BLM data, free-roaming equids gathered, administered fertility control, and adoptions 2009 through 2015.

Year	Gathers	Fertility Control Administered	Adoptions
2009	6,306	0	2,208
2010	7,207	429	2,369
2011	8,426	791	2,028
2012	8,032	952	1,988
2013	3,815	332	1,973
2014	992	40	1,030
2015	2,157 (planned)	629 (estimated)	209 (first 3 months)

Threat Amelioration

Conservation Efforts Database Projects

Through the Conservation Efforts Database (CED), the Service collected information relating to conservation actions that were completed, in progress, or planned. Two completed projects addressing free-roaming equids in MZ V were entered in the CED, representing a total of 2,957 horses removed.

Candidate Conservation Agreements with Assurances and Candidate Conservation Agreements

In addition to the conservation efforts described above, lands currently enrolled in CCAAs reduce equid impacts through implementation of appropriate grazing management plans (e.g., appropriate timing, location, duration, frequency, types of livestock). Approximately 0.17 percent of occupied range in MZ I, 0.78 percent of MZ II, 2.47 percent of MZ IV, and 4.67 percent of MZ V are enrolled in

CCAAs in Wyoming and Oregon. Federal lands enrolled in CCAs in Wyoming, Oregon, and Idaho account for 0.04 percent of occupied range in MZ I, 0.21 percent of MZ II, 3.13 percent of MZ IV, and 4.67 percent of MZ V. See the ***Non-regulatory Conservation Efforts*** section and Table 28-7 for approximate acreages and additional information.

State Plans

Nevada's plan guides the BLM to reduce AMLs in habitats degraded at least partially by wild horses and burros and to consider excluding, removing, or reducing free-roaming equids from burned, riparian, and mesic sage-grouse habitats (State of Nevada 2014, pp. 77–79). The plan also guides the BLM to provide water sources to disperse free-roaming equids from heavily impacted habitats, reduce the numbers of wild horses, work with partners to develop control techniques, monitor populations, and to meet established AMLs within five years (State of Nevada 2015, pp. 79–80). Although they apply to all lands within the State of Nevada, the components of Nevada's state plan that address free-roaming equids are not regulatory mechanisms and rely on the BLM to implement them. Therefore, Nevada's plan does not effectively reduce impacts associated with free-roaming equids at this time. A summary of state regulations and conservation plans addressing free-roaming equids, and other threats is in the Regulatory Mechanisms chapter (pp.X).

BLM Resource Management Plans and USFS Land and Resource Management Plans

The BLM and USFS plans address free-roaming equids by prioritizing areas for monitoring and if necessary, gathers of equids. Additionally, supplemental water stations will be placed to disperse equids and removal or exclusion of equids following emergencies (e.g., fire and drought) will be considered. Specifically, the LUPs will include the following management actions:

- Manage HMAs in sage-grouse habitat within established AML ranges to achieve and maintain sage-grouse habitat objectives.
- Complete rangeland health assessments for HMAs containing sage-grouse habitat using an interdisciplinary team of specialists (e.g., range, wildlife, and riparian). The priorities for conducting assessments are:
    1. HMAs containing SFA;
    2. HMAs containing PHMA;
    3. HMAs containing only GHMA;
    4. HMAs containing sagebrush habitat outside of PHMA, Important Habitat Management Areas (IHMA), and GHMA mapped habitat;
    5. HMAs without sage-grouse habitat.

- Prioritize gathers and population growth suppression techniques in HMAs in sage-grouse habitat, unless removals are necessary in other areas to address higher priority environmental issues, including herd health impacts. Place higher priority on Herd Areas not allocated as HMAs and occupied by wild horses and burros in SFAs followed by PHMA, as these areas are to be managed for zero wild horses and burros.

- In SFAs and PHMA outside of SFA, assess and adjust AMLs through the NEPA process within HMAs when wild horses or burros are identified as a significant causal factor in not meeting land health standards, even if current AML is not being exceeded

.

- In SFAs and PHMA outside of SFA, monitor the effects of wild horse and burro use in relation to sage-grouse seasonal habitat objectives on an annual basis to help determine future management actions.

- Develop or amend herd management area plans (HMAPs) to incorporate sage-grouse habitat objectives and management considerations for all HMAs within sage-grouse habitat, with emphasis placed on SFAs and other PHMAs.

- Consider removals or exclusion of wild horse and burros during or immediately following emergency situations (e.g., fire, floods, and drought) to facilitate meeting sage-grouse habitat objectives where HMAs overlap with sage-grouse habitat.

- When conducting NEPA analysis for wild horse and burro management activities, water developments, or other rangeland improvements for wild horses, address the direct and indirect effects to sage-grouse populations and habitat. Implement any water developments or rangeland improvements using the criteria identified for domestic livestock.

- Coordinate with professionals from other federal and state agencies, researchers at universities, and others to utilize and evaluate new management tools (e.g., population growth suppression, inventory techniques, and telemetry) for implementing the wild horse and burro program.

Threat Amelioration Summary

Some equids have been gathered and taken off the landscape. These actions have helped to ameliorate localized impacts to sagebrush and sage-grouse in Nevada and California. There have also been gathers in other locations by the BLM (Table 15-3). Projects to protect important brood-rearing habitat have occurred in many locations. However, without a broader look at the impacts on the larger landscapes of these locations, it is difficult to assess the effectiveness of these actions. Fencing a riparian area in one location could cause the free-roaming equids to utilize and impact other important riparian areas. Additionally, we received information on several conservation plans that have been completed or are in progress. However, the information we received through the CED does not make it clear whether these plans have actions to alleviate impacts of free-roaming equids or if those actions would be effective.

Assessment of Potential Threat

In our 2010 finding, we reported that there were approximately 36,000 free-roaming equids occurring in 10 western States (including 2 states outside the range of sage-grouse), occupying approximately 12 percent of the range of sage-grouse. These figures largely only reported the free-roaming equids managed by and occurring on BLM-administered lands. The BLM manages approximately 90 percent of the free-roaming equid population (NAS 2013, p. 15; Table 15-2).

End-of-year counts for 2013 show that free-roaming equid numbers on BLM-administered lands have increased to approximately 49,000 animals across 10 western States (BLM 2015, p. 1; Table 15-1). Additionally, there are over 7,000 free-roaming equids on land managed by the USFS (USFS 2015, p. 1; Table 15-1). The number of free-roaming equids on public lands rose rapidly after the passage of the Wild Free-Roaming Horse and Burros Act of 1971 (Public Law 92-195). This increase in animals was cited as a contributing to the overgrazing of rangelands (GAO 2008, p.2; Beever and Aldridge, pp. 280–281). The number of free-roaming equids on public lands has been over AML for more than 15 years (BLM 2014c, p. 1).

Additionally, we are aware of other entities (e.g., other Federal agencies, State agencies, Native American Tribes) that manage other private stock, feral equids, and stray animals that may trespass onto public lands and cause additional impacts within the range of the sage-grouse (USFS 2015, p. 1; Shepherd and Frolli 2015, pp. 2–3). Therefore, free-roaming equids may impact sage-grouse over a greater extent that the aforementioned 12 percent. The extent to which free-roaming equids use land outside Federally-administered lands is difficult to quantify, but may be considerable.

CHAPTER 16: URBAN AND EXURBAN DEVELOPMENT

Historically, low densities of Native Americans limited human impact on the landscape but settlement by Euro-Americans had a much greater influence on sagebrush habitat (Connelly *et al.* 2004, p. 7-24). Impacts from European settlement began in the southwestern portion of the sage-grouse range (MZ III) as early as the 1600s and was widespread in the northern portion of the range by the mid-1800s (Schroeder *et al.* 2004, pp. 371–372). Today, urban and exurban development are part of the human footprint on the landscape along with other anthropogenic features, such as roads and power lines (Leu *et al.* 2008, p 1119; Bar-Massada *et al.* 2014, p. 429). Urban areas are densely developed residential, commercial, industrial, and other built-up areas (U.S. Census Bureau 2012, p. 1) and typically have a housing density of more than one unit per 0.4 ha (more than one unit per ac) (Brown *et al.* 2005, p. 1853). Urban development eliminates sage-grouse habitat (Connelly *et al.* 2004, p. 7-25; Knick *et al.* 2011, p. 217). Exurban development includes both development at the fringe of urban areas and rural residential development; it is the fastest growing land use in the U.S. (Hansen *et al.* 2005, p. 1893–1894; Theobald 2005, p. 1). Exurban development typically has a housing density of one unit per 0.4–16 ha (1–40 ac) (Brown *et al.* 2005, p. 1853). Like urban development, exurban development modifies, fragments, or eliminates sage-grouse habitat (Connelly *et al.* 2004, p. 7-26).

Urban development eliminates sage-grouse habitat through the removal of vegetation and subsequent construction of buildings and associated infrastructure, resulting in an inhospitable environment that lacks the food sources and shelter necessary for the species' survival (Knick *et al.* 2011, p. 217). Exurban development follows a similar process. However, the intensity of exurban development is less than urban development. In contrast to urban areas, exurban areas may continue to provide some sagebrush habitat, but it is typically less suitable due to associated disturbances (Connelly *et al.* 2004, p. 7-26). Both urban and exurban development can result in an increase in associated infrastructure, fences, predation from pets and novel predators typically associated with humans (e.g., skunks, fox), invasive plants, and recreation; all of which can further impact the species (see details in respective Chapters on these topics). Noise associated with urban and exurban development may also affect lekking activity and other sage-grouse behavior; however, little information is currently available that assesses this impact relative to urban activities (Blickley *et al.* 2012, p. 470).

Sage-grouse avoid human development for nesting and brood-rearing (Aldridge and Boyce 2007, p. 508). Sage-grouse extirpation is most likely in areas having a human population density of at least four persons per 100 ha (four persons per 0.01 km^2 or 247 ac) in 1950, suggesting that habitat stressors were well established by that time (Aldridge *et al.* 2008, pp. 983 and 991). Approximately 99 percent of active leks are in landscapes with less than 3 percent developed lands; inactive leks have more than 25 times the development and human density of active leks (Wisdom *et al.* 2011, p. 462; Knick *et al.* 2013, p. 6).

Location and Extent

The location of early human settlements was based on resource availability; later development was often minimized by large amounts of public land (Knick *et al.* 2011, pp. 212 and 217). Most urban development is at the edge of the sage-grouse range (Connelly *et al.* 2004, p. 7-25; Figure 16-1), which may reflect either the lack of desirable resources for early urban development, or the early loss of sage-grouse habitat. Major urban areas include the Columbia River Valley in Washington (MZ VI), the

Snake River Valley in Idaho (MZ IV), and the Bear River Valley in Utah (MZ II) (Connelly *et al.* 2004, p. 7-25). Urbanized areas directly impact 320,123 ha (791,040 ac))—approximately 0.56 percent of the species' range (Manier *et al.* 2013, p. 31; Table 15-1). Indirect impacts of urban areas, based on the spatial foraging scale of avian predators attracted to human habitation, such as ravens (6.9 km; 4.3 mi), influence approximately 5.7 percent of BLM-designated priority habitats throughout the sage-grouse range (Manier *et al.* 2013, p. 31).

Exurban development is scattered throughout the sage-grouse range (Connelly *et al.* 2004, p. 7-25; Knick *et al.* 2011, p. 212; Table 16-1; Figure 16-1). In 2000, exurban development in the conterminous (mainland) U.S. occupied nearly 15 times the area of urban development (Brown *et al.* 2005, pp. 1851, 1854). Since, population data only consider primary residences, exurban development in rural areas, (especially areas affected by seasonal and recreational use) is likely underestimated (Brown *et al.* 2005, p. 1852). Urban and exurban development are largely limited to private land (Knick *et al.* 2011, p. 217).

Table 16-1. The extent of direct impact from urban and exurban development within the current occupied greater sage-grouse range (adapted from Theobald 2014, entire).

Management Zone	Occupied Range	Urban Development[1] and Percent of Occupied Range	Exurban Development[1] and Percent of Occupied Range
I	19,585,736 ha (48,359,844 ac)	9,970 ha (24,618 ac) 0.05 %	43,809 ha (108,170 ac) 0.22 %
II	15,031,909 ha (37,115,827 ac)	12,002 ha (29,635 ac) 0.08 %	99,227 ha (245,006 ac) 0.67 %
III	11,665,352 ha (28,803,339 ac)	4,359 ha (10,762 ac) 0.04 %	56,277 ha (138,956 ac) 0.48 %
IV	15,476,318 ha (38,213,133 ac)	2,834 ha/6,998 ac 0.02 %	26,920 ha (66,468 ac) 0.17 %
V	7,807,579 ha (19,277,972 ac)	7,174 ha (17,714 ac) 0.09 %	35,684 ha (88,109 ac) 0.46 %
VI	1,116,954 ha (2,757,910 ac)	691 ha (1,705 ac) 0.06 %	7,647 ha (18,881 ac) 0.68 %
VI	478,073 ha (1,180,428 ac)	3 ha (8 ac) <0.01 %	66 ha (162 ac) 0.01 %
Total	71,161,922 ha (175,708,453 ac)	37,033 ha (91,440 ac) 0.05 %	269,629 ha (665,751 ac) 0.38 %

[1] Based on United States Census Bureau data from 2010.

Table 16-2. The extent of direct disturbance footprints of urban and exurban development within the current occupied range, modeled breeding habitat distribution, and population index.

Management Zone	Urban and Exurban Development[1] Direct Disturbance Footprint	Within Occupied Range		Intersect: Breeding Distribution		Intersect: Population Index
	Urban Class	**Acres**	**%**	**Acres**	**%**	**%**
I	Urban (up to 1 ac)	13,058	0.03	299	0.00	tbd
	Exurban (1 - 40 ac)	112,692	0.24	2,983	0.03	tbd
	Urban Other	10,960	0.02	357	0.00	tbd
II	Urban (up to 1 ac)	14,114	0.04	343	0.00	tbd
	Exurban (1 - 40 ac)	237,371	0.64	22,827	0.19	tbd
	Urban Other	14,371	0.04	456	0.00	tbd
III	Urban (up to 1 ac)	5,275	0.02	856	0.01	tbd
	Exurban (1 - 40 ac)	138,956	0.48	33,757	0.40	tbd
	Urban Other	5,487	0.02	834	0.01	tbd
IV	Urban (up to 1 ac)	1,719	0.00	736	0.01	tbd
	Exurban (1 - 40 ac)	65,578	0.17	9,544	0.08	tbd
	Urban Other	5,295	0.01	1,148	0.01	tbd
V	Urban (up to 1 ac)	10,982	0.06	0	0.00	tbd
	Exurban (1 - 40 ac)	88,109	0.46	1,603	0.05	tbd
	Urban Other	6,732	0.03	0	0.00	tbd
VI	Urban (up to 1 ac)	1,065	0.04	47	0.00	tbd
	Exurban (1 - 40 ac)	18,881	0.68	368	0.03	tbd
	Urban Other	640	0.02	53	0.00	tbd
VII	Urban (up to 1 ac)	6	0.00	0	0.00	tbd
	Exurban (1 - 40 ac)	162	0.01	0	0.00	tbd
	Urban Other	2	0.00	0	0.00	tbd
Range wide [2]		**751,453**	**0.004**	**76,212**	**0.002**	

[1] Urban Residential (up t0 1 ac), Exurban Residential (1 - 40 ac), and Urban Other

[2] All range wide calculations will not include Bi-State population or the Canadian portion of the range.

Table 16-3. The extent of the indirect area of influence related to urban and exurban development within the current occupied range, modeled breeding habitat distribution, and population index. Areas derived using foraging distances of common synanthropic predators such as ravens (reference Manier et al. 2013, p.158 and others).

	Urban and Exurban Development[1] Indirect Area of Influence [3]				
Management Zone	**Within Occupied Range**		**Intersect: Breeding Distribution**		**Intersect: Population Index**
	Acres	**%**	**Acres**	**%**	**%**
I	4,335,812	9.4	352,966	3.4	tbd
II	6,429,994	17.4	1,111,211	9.3	tbd
III [2]	2,667,817	9.3	803,257	9.5	tbd
IV	5,703,315	14.8	1,122,423	9.7	tbd
V	1,705,838	8.8	71,708	2.1	tbd
VI	630,275	22.9	98,141	8.9	tbd
VII	47,341	4.0	3,327	2.1	tbd
Range wide [2]	**21,520,392**	**0.1**	**3,563,034**	**0.1**	tbd

[1] Urban Residential (up to 1 ac), Exurban Residential (1 to 40 ac), and Urban Other

[2] All range wide calculations will not include Bi-State population or the Canadian portion of the range.

[3] 3.0-km buffer to quantify indirect area of disturbance related to increased predator (corvid) densities near urban/suburban areas (Bui et al. 2010).

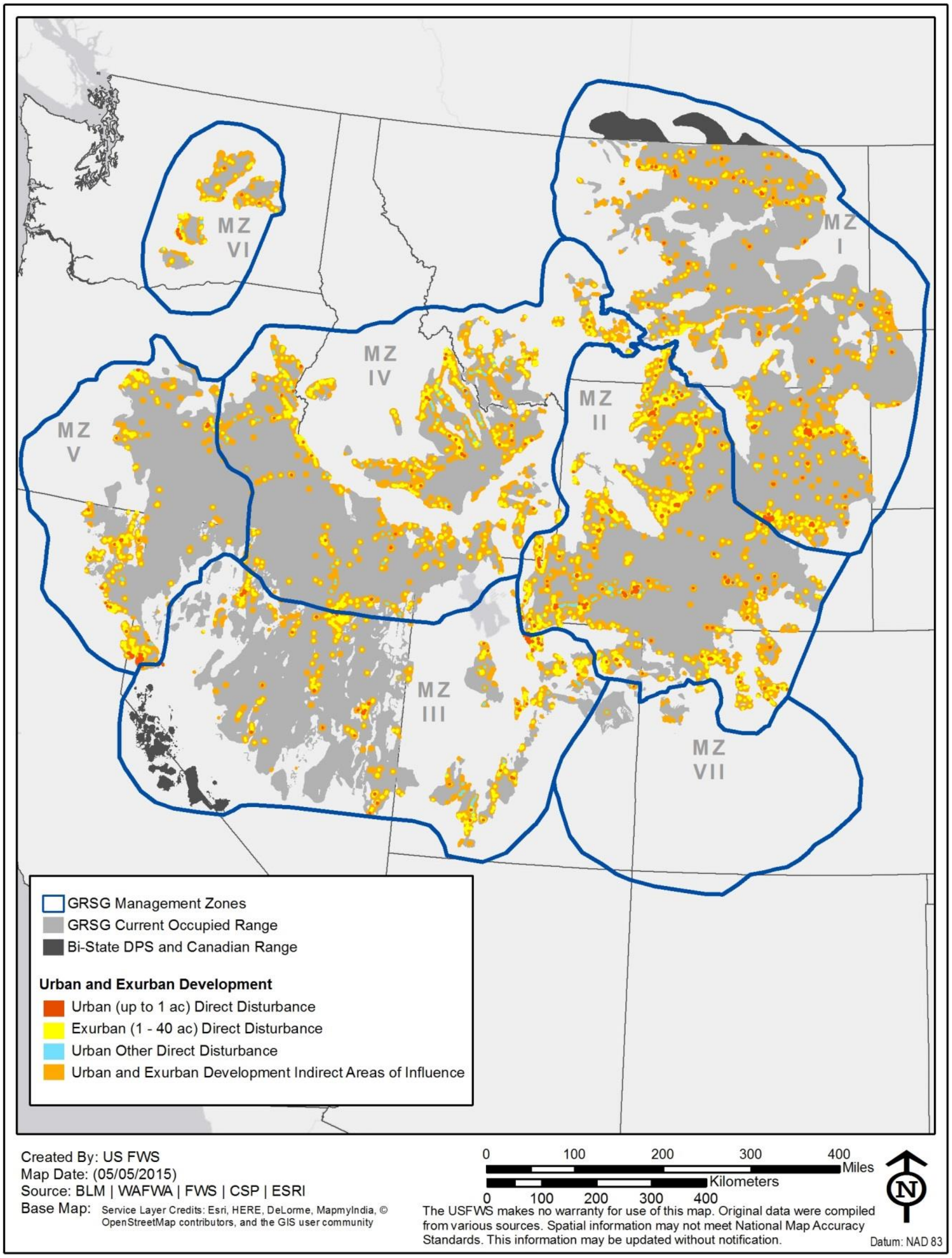

Figure 16-1. Urban and exurban development within the current sage-grouse range. The category of Urban Other in the map key refers to non-residential urban areas including commercial, industrial, and other built-up areas.

Projected Future Impacts (Timescale, Likelihood of Future Impacts and Anticipated Changes from Present)

Habitat modification, fragmentation, and elimination due to urban and exurban development that already occurred in the sage-grouse range are permanent. Additional impacts from future development are likely for some sage-grouse populations and will be permanent (see following section). Consequently, we anticipate that urban and exurban development will contribute to the present and threatened destruction (i.e., direct habitat loss), modification (i.e., compounded effects from associated infrastructure, fences, predation, invasive plants, recreation, and energy development), and curtailment (i.e., fragmentation) of sage-grouse habitat and range indefinitely.

Based on recent trends and projections regarding human population growth and associated urban and exurban development, there is a likelihood of increasing impacts to sage-grouse from this factor. Urban densities throughout the conterminous U.S. doubled in extent from 1950 to 2000; exurban densities experienced a five-fold increase (Brown *et al.* 2005, pp. 1855–1856). Exurban development is the fastest growing land use in the U.S. (Hansen *et al.* 2005, p. 1893). In the Great Basin (MZs III, IV, and V), the human population increased 69 percent from 1990 to 2004 (Torregrosa and Devoe 2008, p. 10). The national projected rate of human population increase from 2000 to 2030 is 29 percent; the projected increases for States that are partially within the Great Basin during the same timeframe are 114 percent in Nevada, 56 percent in Utah, 52 percent in Idaho, 41 percent in Oregon, and 37 percent in California (Torregrosa and Devoe 2008, p. 10). This may result in continued or accelerated ex-urban development in these states.

Human populations increased in size and spatial extent over the past century, particularly in the western portion of the sagebrush biome (Stiver *et al.* 2006, Appendix C-2; Torregrosa and Devoe 2008, p. 10). If current projections of human population expansion in the West continue, the human footprint from development and resultant impacts will also continue to increase, leading to additional habitat modification, fragmentation, and elimination. The highest areas of risk to sage-grouse are along the southeastern, southwestern and southern portions of the range (MZs II, III, V), along and south of the Snake River (MZ IV), and in the Columbia Basin (MZ VI; USFWS 2013, pp. 16-29).

Threat Amelioration

Urban development permanently eliminates sage-grouse habitat, with little or no opportunities for restoration. Exurban development modifies, fragments, or eliminates sage-grouse habitat, depending on the type and extent of development. Avoiding or minimizing additional incursion of urban and exurban development into sage-grouse habitats will require identifying habitats most at risk to development, and developing and implementing land policies to acquire, maintain, or enhance habitat, as well as promoting ecologically sustainable private lands and ranches in sage-grouse habitat (Stiver *et al.* 2006, Appendix C-2).

Voluntary conservation efforts related to ranch management practices may address some impacts from exurban development related to construction and siting of buildings. Candidate Conservation Agreements with Assurances provide assurances to private landowners that if agreed-upon conservation measures are undertaken by the landowner, no further requirements will be made of the landowner if, in the future, the species is listed under the Endangered Species Act. Candidate

Conservation Agreements with Assurances often include avoiding subdivision of rangeland, new building construction, or other new associated infrastructure as potential conservation measures. Approximately 0.17 percent of occupied range in MZ I, 0.78 percent of MZ II, 2.47 percent of MZ IV, and 4.67 percent of MZ V are enrolled in CCAAs in Wyoming and Oregon. Federal lands enrolled in CCAs in Wyoming, Oregon, and Idaho account for 0.04 percent of occupied range in MZ I, 0.21 percent of MZ II, 3.13 percent of MZ IV, and 4.67 percent of MZ V. See the ***Non-regulatory Conservation Efforts*** section and Table 28-7 for approximate acreages and additional information. Conservation easements allow private landowners to enter into a voluntary agreement with a land trust (e.g., The Nature Conservancy), the NRCS, or other organizations or agencies that maintain the land in private ownership with development restrictions that are typically permanent. Conservation easements can permanently protect sagebrush habitat from subdivision while providing compensation to landowners.

A total of 498 projects addressing the threat of urbanization were entered in the CED as "completed" by data providers. These projects totaled more than 404,686 ha (1,000,000 ac) rangewide (Appendix D). Of the projects deemed completed by the project proponents the Service reviewed projects in MZs II, III, IV, and V (Table 16-4). In addition to these conservation efforts, the NRCS estimates that since the Sage Grouse Initiative was begun in 2010, approximately 183,013 ha (451,884 ac) have been enrolled in conservation easements in the sage-grouse range (NRCS 2015, p. 6). This habitat is permanently protected from development.

Table 16-4. Summary of completed and effective projects evaluated by the Service that address urbanization. Some of the projects addressed two threats, or spanned more than one MZ. These are indicated separately and with footnotes. The acres for several projects were reported for multiple MZs (in boldface below); this number of acres is reflected only once in the table total.

Management Zone	Conservation Effort	ha (ac)
II	unique acres (MZ & threat) [1]	175,903 (434,666)
	same acres & MZ, > 1 threat [2]	29,135 (71,995)
	same acres & >MZ, > 1 threats [3]	**206,794 (511,000)**
III	unique acres (MZ & threat) [1]	0
	same acres & MZ, > 1 threat [2]	2,753 (6,802)
	same acres & >MZ, > 1 threats [3]	2,313 (5,715)
IV	unique acres (MZ & threat) [1]	0
	same acres & MZ, > 1 threat [2]	0
	same acres & >MZ, > 1 threats [3]	**206,794 (511,000)**
V	unique acres (MZ & threat) [1]	0
	same acres & MZ, > 1 threat [2]	0
	same acres & >MZ, > 1 threats [3]	0
TOTAL*		146,898 (1,030,178)

[1] projects in one MZ addressing one threat
[2] projects in one MZ addressing more than one threat
[3] projects crossing more than one MZ addressing more than one threat

If enacted, Montana's state plan would regulate habitat loss due to urbanization on Montana State lands and on private lands if a project needs an authorization from the state. Montana's plan would use seasonal, timing, and noise restrictions, disturbance caps, lek buffers, and other conservation measures to reduce the threat of urbanization (State of Montana 2014, pp. 13–21). If a development project will disturb sage-grouse on any lands in the State, Nevada's state plan requires that project proponents consult with the State's Sagebrush Ecosystem Technical Team (SETT) to avoid, minimize, or mitigate potential impacts (State of Nevada 2014, p. 100). However, the BLM would be responsible for enforcing this consultation process on the majority of land in Nevada, but this process has yet to be implemented and it is not an existing regulatory mechanism. A summary of state regulations and conservation plans addressing urbanization, and other threats is in the Regulatory Mechanisms chapter (pp.X).

Lands in BLM and USFS ownership are not directly impacted by urbanization. The BLM and USFS plans address urbanization through conservation measures associated through land retention, disposal, and acquisition by BLM and USFS. Lands classified as PHMA and GHMA for sage-grouse will be retained in federal management, which would prevent urbanization. Exceptions to this include: (1) the agency can demonstrate that disposal of the lands will provide a net conservation gain to the sage-grouse; or (2) the agency can demonstrate that the disposal of the lands will have no direct or indirect adverse impact on conservation of the sage-grouse. Restrictions on infrastructure (see ***Infrastructure*** chapter) would also reduce risk of urbanization. For additional details, see the ***Regulatory Mechanisms*** section.

Threat Summary

The 2010 12-month finding for the sage-grouse concluded that growing human populations are increasing the impacts to sage-grouse habitat from development, particularly from exurban development and the associated indirect effects. Urban and exurban development continue to impact sagebrush habitat at many locations scattered throughout the sage-grouse range due to a rapidly expanding human population (see Figures 16-1 and 16-2). If current projections of human population growth in the western U.S. continue, ranch and agricultural land that provide sage-grouse habitat will decrease due to conversion to exurban development (Leu *et al.* 2008, p. 1130). Impacts from urban and exurban development may occur at the individual, PAC, and/ or population level depending on development location. Compounded effects from associated factors, such as infrastructure, fences, predation, invasives, and recreation may further impact sage-grouse habitat. We anticipate that impacts from urban and exurban development will continue to affect sage-grouse, particularly in areas projected for increasing human population growth. However, despite the permanence of impacts, past urban and exurban development has only impacted 0.4 percent of the current range. Therefore, given the very small footprint of this type of development we do not believe urban and exurban development is a threat to sage-grouse at a MZ or rangewide scale.

CHAPTER 17: RECREATION

A variety of recreational activities occur across the range of sage-grouse , including hiking, camping, fishing, horseback riding, mountain biking, OHV (e.g., all-terrain vehicles, motorbikes, snowmobiles) use, and recreational hunting (for other wildlife species) may occur in sage-grouse habitat. Other non-consumptive activities, such as bird watching, lek visitation, general wildlife viewing, and wildlife photography use sage-grouse as the primary subject. Recreational hunting of sage-grouse (consumptive use) is discussed in Chapter 20 and is therefore not included in this chapter.

Human use of sage-grouse and sage-grouse habitat for recreational purposes can degrade habitat and/or influence sage-grouse behavior. The intensity of threats associated with recreational activities varies based on the behavior of people utilizing the area and the location, type, frequency, timing, and magnitude of the activity. However, recreational activities are often low impact and concentrated to specific recreational areas. Therefore, the current assessment is that recreation threats do not result in local or rangewide declines of sage-grouse.

Recreational activities surged in popularity during the second half of the 19th century, coinciding with the western expansion of human populations in the U.S. (Ibrahim and Cordes, 2008, p. 9). Historical recreational activities within sage-grouse habitat included bird watching, hiking, camping, fishing, horseback riding, and recreational hunting (Ibrahim and Cordes 2008, pp. 9–10).

Current sources of this stressor include all of the historical sources, many of which continue to increase in popularity (Cordell *et al.* 1995, p. 37; Cordell *et al.* 2008, p. 9; Ibrahim and Cordes 2008, p. 14). The introduction and increasing popularity of OHVs use, shed antler and horn searching, wildlife viewing, and wildlife photography has occurred throughout the species range (Ouren *et al.* 2007, p. 2; NDOW 2014, p. 1; Knight 2009, p. 167). Improved access to recreational lands and equipment, growing awareness and attention related to the status of sage-grouse (Storch 2007, p. 13), and the continuing influx of people into the western U.S. (Leu and Hanser 2011, p. 255) currently influence the impacts associated with recreational activities within the range of the sage-grouse.

Current Impacts

The primary mechanisms for recreation threats are habitat degradation, habitat loss and fragmentation, and disturbance of sage-grouse. Where recreation occurs in conjunction with sage-grouse habitat, recreational activities may decrease sage-grouse mating, nesting, and feeding through habitat loss (Call and Maser 1985, p. 19). Disturbance may increase stress on birds, displacing sage-grouse to less optimal habitats (Knick *et al.* 2011, p. 219). Recreational activities can degrade habitat by increasing garbage and pet waste (Boyle and Samson 1985, pp.110–111; Lenth *et al.* 2008, p. 223). These activities can introduce non-native or invasive species, including sage-grouse predators, into sage-grouse habitat (Boyle and Samson 1985, pp. 110–111; Knick *et al.* 2011 p. 219). Recreational activities that crush, trample, or remove vegetation (e.g., off-trail hiking, horseback riding, hunting, and OHV use) can change vegetation structure, reduce or eliminate sagebrush canopy cover through repeated trips in an area (Payne *et al.* 1983, p. 329), increase the spread of invasive plants, increase soil sediment and decrease soil infiltration rates through compaction (Eckert *et al.* 1979, p. 395). Risk of wildfire may increase through recreation participants' cooking, smoking, shooting, or vehicle's exhaust pipe/catalytic converters (NWCG 1999, pp. 6–7). Trails, camping facilities, roads, and areas of human activity may cause habitat fragmentation (Ouren *et al.* 2007, p. 16; Knick *et al.* 2011, p. 219).

Recreational activities within sage-grouse habitat may contribute to reduced fitness (the ability to survive and reproduce). Noise and movement associated with OHVs, pets, and humans may disrupt sage-grouse behavior or movement patterns by causing physiological stress and interfering with auditory cues and intraspecific communication (Holloran 2005, p. 56; Barber *et al.* 2010, p. 184, Blickley and Patricelli 2010, pp. 278–281, Knick *et al.* 2011, p. 219; Blickley and Patricelli 2012, pp. 32–33; Blickley *et al.* 2012a, pp. 467–470, Blickley *et al.* 2012b, p. 7, Patricelli *et al.* 2013, p. 242). Human use, garbage, and associated domestic dogs (*Canis familiaris*; hereafter dog) may attract and maintain an increased density of sage-grouse predators or increase the rate of sage-grouse predation by dogs (Boyle and Samson 1985, pp. 110–111, Lenth *et al.* 2008, p. 223; Knick *et al.* 2011 p. 219; Young *et al.* 2011, pp. 126–127). Humans and accompanying animals may crush or destroy eggs. Vehicle collisions (including OHVs) with sage-grouse can result in direct mortality (Connelly *et al.* 2000, p. 228; Wiechman 2013, p. 12) but is likely a relatively small percentage of overall mortality in sage-grouse. Although there may be direct impacts to sage-grouse, it is likely that these may impact sage-grouse at an individual level rather than population level.

Overall, a relatively small number of leks in each State receive regular viewing during the breeding season and most States report no known impacts from this use (Drilling 2014, pers. comm.; Gardner 2014, pers. comm.; Espinosa 2014, pers. comm.; Kremner 2014, pers. comm.; Robinson 2014, pers. comm.; Runia 2014, pers. comm.; Schroeder 2014, pers. comm.; Wightman 2014, pers. comm.). Anecdotal evidence exists of negative impacts from viewing to individual leks near urban areas in Oregon and Nevada are subject to frequent disturbance from visitors, although the majority of leks in the States do not receive much recreational viewing (Budeau 2014, pers. comm.; Espinosa 2014, pers. comm.).

We have not located any published literature concerning measured effects of recreational activities on sage-grouse, but can infer potential impacts from studies on related grouse species. Male sharp-tailed grouse were displaced from leks due to human presence, resulting in loss of reproductive opportunity during the disturbance period (Baydack and Hein 1987, p. 537). Female sharp-tailed grouse were observed at undisturbed leks while absent from disturbed leks during the same time period (Baydack and Hein 1987, p. 537). Immature sharp-tailed grouse were disturbed by dog training activities resulting in decreased brood survival (Hicks 1992, p. 110). Recreational activities may negatively impact survival rates of black grouse at winter feeding areas (Warren et *al.* 2009, p. 186). Skiing and snowshoeing are sources of human disturbance to capercaillie and black grouse (Menoni and Magnani 1998, pp. 4–7; Suchant and Roth 1998, pp. 13–16; Zeitler and Glanzer 1998, pp. 8–11; Thiel *et al.* 2007, pp. 1790–1791; Thiel et *al.* 2011, p. 131). While individual birds were shown to be displaced or disturbed from recreational activities, frequently these impacts were localized and did not appear population-wide.

Additionally, sage-grouse are impacted by other activities that may have similar mechanisms to recreation, such as increasing human presence and noise. Sage-grouse avoidance of activities associated with energy field development (Holloran 2005, pp. 43, 53, 58; Doherty *et al.* 2008, p. 194; Hess and Beck 2012, p. 1632) suggest sage-grouse are likely disturbed by any persistent human presence. Additionally, the density of humans in 1950 was the best predictor of extirpation of sage-grouse (Aldridge et *al.* 2008, pp. 987–988), suggesting sage-grouse have been extirpated in all counties reaching a human population density of 25 people/km2 (65 people/mi2). However, this analysis considered all impacts of human presence and did not separate recreational activities from other associated activities and infrastructure (Aldridge *et al.* 2008, p. 988). Ecosystems with low biological productivity (such as sagebrush) may have reduced resiliency and therefore may be disproportionally impacted by increasing human densities (Leu *et al.* 2008, p. 1133). However, impacts from energy development and areas with high human densities likely have more frequent or longer duration of human presence and noise compared to recreational activities.

Location and Extent

Recreational activities occur across the range of the species (42 of the 48 sage-grouse populations; UFWS 2013, pp. 16–29), but are of limited severity and typically concentrated in designated areas for recreational activities (e.g., trails and campgrounds). Of these 42 populations, recreation threats were widespread in 31 populations and localized in 11 populations (UFWS 2013, pp. 16–29), though intensity and duration have not been quantified. Areas near human population centers have more recreational use than areas farther from high human densities; however, most areas may be accessed by OHVs, snowmobiles, and hiking trails. Federal, State, and private lands that are closed to the public may have fewer impacts from recreation compared to open Federal and State lands, though noise from recreation activities outside of closed areas may cause disturbance for long distances. Use of OHVs was identified as a threat in portions of the BLM's Prineville and Vale Districts (Hagen 2011, pp. 197–198). Participation in recreational activities associated with sagebrush acreage on BLM-administered lands accounted for approximately 13.8 million visitor days in 2013, with one visitor day representing an aggregate of 12 visitor hours at a site or area (ECONorthwest 2014, p. 12). Sagebrush ecosystems within BLM-administered lands in Idaho and Montana had the most recreational visits, with over 2.5 million visitor days in each state (ECONorthwest 2014, p. 13). However, the majority (72 percent, 36,689,673 of 50,534,000) of recreational visits to BLM-administered lands occurred in areas not containing sagebrush, indicating that sage-grouse habitat may be impacted less frequently by recreation than other habitat types.

Table 17-1: The number of recreational visits to BLM lands by State in 2013 (ECONorthwest 2014, p. 13).

State	Total Visits	Total Visits in BLM Sagebrush Regions	Total Regional Visits Scaled by % Sagebrush
California	8,706,000	1,426,544	648,699
Colorado	6,963,000	5,185,041	1,220,282
Idaho	5,536,000	4,105,056	2,853,006
Montana	5,215,000	4,932,743	2,506,253
Nevada	6,185,000	3,854,694	1,975,786
North Dakota	Included in MT Total	729	200
Oregon	8,170,000	2,080,321	1,493,792
South Dakota	Included in MT Total	44,611	5,104
Utah	6,844,000	5,322,927	997,848
Washington	Included in OR Total	479,034	230,948

State	Total Visits	Total Visits in BLM Sagebrush Regions	Total Regional Visits Scaled by % Sagebrush
Wyoming	2,915,000	2,914,533	1,912,439
Total	50,534,000	30,346,233	13,844,327

Projected Future Impacts (Timescale, Likelihood of Future Impacts and Anticipated Changes from Present)

The timescale for projecting recreation is not defined. Given the limited data about recreational activities occurring in sage-grouse habitat, it is difficult to accurately predict future impacts on sage-grouse. However, based on historical and current trends, recreational activities will continue on the landscape indefinitely.

Recreational activities may increase over time given the increases in human populations. Recreational impacts from bird watching and lek visitation is dependent on public interest in the species. Listing of a species can increase public interest and ecotourism (tourism of natural areas) of a species (Brown and Shogren 1998, p. 12), thereby increasing impacts from recreational activities.

Recreational use of OHVs is one of the fastest-growing outdoor activities. In the western U.S., greater than 27 percent of the human population used OHVs for recreational activities between 1999 and 2004 (Knick et *al.* 2011, p. 217). Off-highway vehicle use was a primary factor listed for 13 percent of species either listed under the Endangered Species Act or proposed for listing (Knick *et al.* 2011, p. 219).

Given the continuing influx of people into the western U.S. (Leu and Hanser 2011, p. 255), which is contributed to, in part, by access to recreational opportunities on public lands, we anticipate effects from recreational activities will continue to increase for the foreseeable future.

We assume that recreational activities will continue throughout the range of the sage-grouse. If human populations continue to increase throughout the western U.S., areas now considered remote for recreational activities may become more accessible and have higher recreational use. While the types, localities, and amount of recreational activities may shift in the future, we currently do not believe that impacts would decrease from current levels.

Threat Amelioration

To reduce potential impacts of lek viewing on sage-grouse, several States have implemented measures to protect most leks while allowing recreational viewing to continue. The Wyoming Game and Fish Department (WGFD) provide the public with directions to 16 leks and guidelines to minimize viewing disturbance (WGFD year unknown, pp. 1–4). Leks included in the brochure are close to roads and already subject to some level of disturbance (Christiansen 2014, pers. comm.); presumably, focusing attention on these areas reduces pressure on relatively undisturbed leks. Most States discourage viewing of sage-grouse during breeding season and do not provide lek locations to the general public (Budeau 2014, pers. comm.; Robinson 2014, pers. comm.; Schroeder 2014, pers. comm.; Wightman 2014, pers. comm.). Washington and Wyoming have wildlife harassment laws that could apply to disruptions of lek activities from recreational viewing (Christensen 2014, pers. comm.; Schroeder 2014, pers. comm.).

Conservation options to reduce recreation threats include closing important sage-grouse areas to OHV use and avoiding development of recreational facilities (e.g., new roads, trails, and campgrounds) in sage-grouse habitats (UFWS 2013, pp. 49–50). Executive Order 11644 (1972, 37 FR 2877) requires public land management agencies to develop regulations and designate areas where OHV use is permitted. The BLM issued IM 2012-043 to provide conservation policies to sage-grouse, including evaluation of existing use of travel activities and their effects on sage-grouse, potential seasonal restrictions, closure and reclamation of unauthorized travel routes, and limitation and enforcement of travel use to existing trails/roads and seasons (BLM 2011, p. 10). Lands managed by BLM are categorized as "open," "limited," or "closed" to the OHV use. Limitations can include limiting use to existing routes, limiting use to designated routes, or limiting use seasonally (Ouren *et al.* 2007, p. 53). To the Service's knowledge, X areas (X percent of BLM land) within sage-grouse habitat are closed for recreational use.

Conservation Efforts Database Projects

Through the Conservation Efforts Database (CED), we collected information relating to conservation actions for the sage-grouse that are completed, in progress, or planned. Thirteen projects addressing recreation, representing 114,121 ha (282,000 ac) were entered in the CED as "completed" (Appendix D). Of this total number of acres, 101,171 ha (250,000 ac) represent one large project in Montana that spans three MZs. In addition to these conservation efforts, lands currently enrolled in CCAAs restrict human activities within sage-grouse habitat during lekking and nesting seasons. Approximately 0.17 percent of occupied range in MZ I, 0.78 percent of MZ II, 2.47 percent of MZ IV, and 4.67 percent of MZ V are enrolled in CCAAs in Wyoming and Oregon. Federal lands enrolled in CCAs in Wyoming, Oregon, and Idaho account for 0.04 percent of occupied range in MZ I, 0.21 percent of MZ II, 3.13 percent of MZ IV, and 4.67 percent of MZ V. See the ***Non-regulatory Conservation Efforts*** section and Table 28-7 for approximate acreages and additional information.

State Plans

State plans in Idaho, Utah, and Montana address impacts to sage-grouse from recreation. Utah's state plan uses a management and mitigation protocol to reduce impacts from recreation and recommends restricting the use of OHVs to identified trails and roads in nesting and wintering habitats (State of Utah 2013, p. XX). Utah's state plan also promotes local counties to enforce travel management plans that consider impacts to sage-grouse (State of Utah 2013, p. 17). The Utah Governor's Executive Order direct state agencies to coordinate to ensure that recreational activities or recreational facilities within the Sage-Grouse Management Areas (SGMAs) comply with Utah's state conservation plan (State of Utah 2015, p. XX). However, actions on private lands are voluntary under Utah's state plan. Montana's plan does not address recreation directly; however, if enacted, Montana's state plan would include conservation measures, such as required mitigation sequencing, seasonal and noise restrictions, lek buffers, and surface restrictions in core and connectivity habitats, to reduce impacts from recreation facilities on state lands and private lands where state authorization is required (State of Montana 2014, pp. 4, 13–21). Idaho's State plan includes conservation measures for travel management that could help reduce impacts associated with recreation on Idaho State lands (Idaho Department of Lands 2015,

p. 37). A summary of state regulations and conservation plans addressing recreation, and other threats is in the Regulatory Mechanisms chapter (pp.X).

BLM Resource Management Plans and USFS Land and Resource Management Plans

Impacts from recreational activities are addressed in BLM and USFS plans through exclusion of new recreational facilities in PHMA (unless the development would have a net conservation gain to sage-grouse habitat or if development is required for visitor health and safety). Travel will be limited to existing routes and trails and evaluated in Travel Management Plans that would emphasize neutral or net positive impacts on sage-grouse. Trails and educational programs will be developed to reduce recreational impacts. Any residual impacts will require seasonal and timing restrictions, lek buffers, and mitigation, and will also be subject to disturbance caps (see ***Regulatory Mechanisms*** section).

In PHMA and GHMA, temporary closures will be considered in accordance with 43 CFR subpart 8364 (Closures and Restrictions); 43 CFR subpart 8351 (Designated National Area); 43 CFR subpart 6302 (Use of Wilderness Areas, Prohibited Acts, and Penalties); 43 CFR subpart 8341 (Conditions of Use). Temporary closure or restriction orders under these authorities are enacted at the discretion of the authorized officer to resolve management conflicts and protect persons, property, and public lands and resources. Where an authorized officer determines that OHVs are causing or will cause considerable adverse effects upon soil, vegetation, wildlife, wildlife habitat, cultural resources, historical resources, threatened or endangered species, wilderness suitability, other authorized uses, or other resources, the affected areas shall be immediately closed to the type(s) of vehicle causing the adverse effect until the adverse effects are eliminated and measures implemented to prevent recurrence (43 CFR 8341.2) A closure or restriction order should be considered only after other management strategies and alternatives have been explored. The duration of temporary closure or restriction orders should be limited to 24 months or less; however, certain situations may require longer closures and/or iterative temporary closures. This may include closure of routes or areas.

Threat Summary

The 2010 finding determination stated that there was no evidence that recreation threats were resulting in local or rangewide declines of sage-grouse. Since then, no additional evidence has been found that shows a substantial change in recreational threats. Therefore, the current assessment is that recreation does not result in local or rangewide declines of sage-grouse.

CHAPTER 18: CLIMATE CHANGE

The terms "climate" and "climate change" are defined by the Intergovernmental Panel on Climate Change (IPCC). "Climate" refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (Stocker *et al.* 2013, p. 1450). The term "climate change" refers to a change in the mean or variability of one or more measures of climate (e.g., temperature or precipitation) that persists for an extended period, usually decades or longer, whether the change is due to natural variability, human activity, or both (Stocker *et al.* 2013, p. 1450). Various changes in climate can have direct or indirect effects on plant and animal species. These effects may be positive, neutral, or negative, direct or indirect, and they may change over time, depending on the species and other relevant considerations, such as the effects of interactions of climate with other variables (e.g., habitat fragmentation) (IPCC 2007, pp. 8–14, 18–19).

Current Impacts

Increasing ambient temperature and annual frost-free season, and other indicators of climate change, are occurring within the range of sage-grouse (e.g., Mote *et al.* 2005, p. 46; Abatzoglou and Kolden 2011, p. 474; Abatzoglou *et al.* 2014, entire). Documented changes include decreasing snow-pack (Mote *et al.* 2005, p. 46; Mote 2006, p. 6219); increased frequency of heavy precipitation events (U.S. Global Change Research Program 2014, p. 8); increased fire frequency, increased size and duration of fires, longer fire seasons (Westerling *et al.* 2006, p. 941–943; Abatzoglou and Kolden 2011, pp. 474–475), and increasing annual frost-free period and annual precipitation, especially in the spring in MZs IV, V, and VI (Abatzoglou *et al.* 2014, pp. 2132–2133). These, and other effects of climate change, (e.g., incidence and severity of drought, timing and amount of precipitation) are anticipated to affect the distribution and quality of sagebrush habitat, seasonal availability of resources, and disease incidence. Sage-grouse vital rates are influenced by climate-mediated resources such as the timing and amount of new vegetation and insect production in the spring (Blomberg *et al.* 2012, p. 12; Guttery *et al.* 2013 pp. 8–9), and some evidence exists that other grouse species (e.g., red grouse [*Lagopus lagopus scotica*]) are responding to increasing ambient temperature (Fletcher *et al.*, pp. 460–462). In the past 20 years, first-egg dates have occurred earlier in relation to increasing spring temperature, clutches are larger, and chick survival is greater in red grouse in Scotland (Fletcher *et al.*, pp. 460–462). However, current impacts of increasing temperature or other aspects of climate change on sage-grouse vital rates or populations are unknown.

Timescale for Projecting Impacts from Climate Change

Our assessment of climate change impacts to sage-grouse, based on the influence of climate on sage-grouse habitat and on other stressors, is limited to a timeframe of 30 to 50 years from the present. This timeframe is comprehensible from a management and conservation perspective, and one used in many published studies (e.g., Abatzoglou and Kolden 2011, p. 473; Schrag *et al.* 2011, p. 5; Dominguez *et al.* 2012, pp. 3–4; Still and Richardson 2015, p. 32). Furthermore, most emissions scenarios diverge by mid-century (IPCC 2013, pp. 19–21), making projections past that time subject to increasingly different assumptions. The overall increase in ambient temperature and the likely northward shift of conditions suitable for sagebrush can be projected to the end of the century (with a high level of agreement among multiple global circulation models [GCMs]; Schlaepfer *et al.* 2015, pp. 6–7). However, the synergistic effects of climate change interactions with impacts to sage-grouse habitat such as wildfire and invasives are more complex and are projected in the literature as far as mid-century (Abatzoglou and Kolden 2011, p. 473;). However, current trends in the climate system—increasing temperature, increasing duration and intensity of drought, decreasing snow-pack, increasing heavy precipitation events and other extreme weather—are likely to continue through the 21st century (IPCC 2013, p. 7).

Likelihood of Future Impacts

Increases in global and regional ambient temperature are projected out to the end of the 21st century with medium to high confidence (Abatzoglou and Kolden 2011, p. 474; IPCC 2013, p. 19). Under current trends in carbon emissions, global mean surface temperature is likely to increase (relative to 1986–2005) by 0.3°C to 0.7°C (0.54°F to 1.26°F) between 2016 and 2035, and increase by 2.6°C to 4.8°C (4.7°F to 8.6°F) between 2081 and 2100 (IPCC 2013, p. 20).[3] Despite variable projected changes in precipitation and increases in some areas (Trenberth 2010, p. 15; IPCC 2013, p. 22), moderate to extreme increases in the duration and/or severity of droughts are likely by mid-century (Strezepek *et al.* 2010, pp. 4–6; IPCC 2013, p.7; Ault *et al.* 2014, p. 7540–7545; Touma *et al.* in press, pp. 5–6; Cook *et al.* 2015, pp. 1–2). Regional increases in frequency of heat extremes, and heavy precipitation events and decrease in snow-pack also are likely by mid-century (IPCC 2013, pp. 20, 25, 27; U.S. Global Change Research Program 2014, pp. 7, 8). As annual average temperature increases, increasing hot extremes and decreasing cold extremes, on daily and seasonal timescales, are certain (IPCC 2013, p. 20).

Projected warming in the interior western U.S. and the range of sage-grouse is similar in scale to global projections. Annual temperature across the interior West is likely to rise relative to the period 1971 to 2000 by an average of 2.5°C to 3.0°C (4.5°F to 5.4°F) by 30 to 50 years from now, and the annual frost-free period is likely to increase by 25 to 40 days (Abatzoglou and Kolden 2011, p. 474). The influence of climate change on spatial and temporal pattern in precipitation across the range is more complex, and model results differ in detail (Diffenbaugh *et al.* 2005, p. 15776; Cayan *et al.* 2008, p. S28; Dominguez *et al.* 2012, pp. 5–-6;). Although projected changes in precipitation include high geographic and

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[3] These values are based on models using the carbon emissions scenario, or representative concentration pathway (RCP) 8.5, which reflects the status quo: continued growth in global population and gross domestic product, and greenhouse gas emissions similar to current levels (van Vuuren 2011, pp.16–20; Fuss *et al.* 2014, entire). Representative concentration pathways 2.6, 4.5, and 6.5 posit lower levels of total carbon emissions than RCP 8.5, and result in lower total increase in global surface temperature (Fuss *et al.* 2014, p. 851; Stocker *et al.* 2014, p. 129); however, we have elected to cite figures based on climate projections using RCP 8.5, the status-quo scenario, because they involve the least uncertainty: (1) RCPs 2.6, 4.5, and 6.5 are reliant on significant decreases in the rate of human population growth (van Vuuren 2011, pp.16-20), but the global population growth rate is not projected to decrease significantly in the 21st century (Gerland *et al.* 2014, entire). (2) Currently, global CO_2 emissions continue to track or exceed RCP 8.5 (Peters *et al.* 2013, pp. 4–5; Le Quéré *et al.* 2014, pp. 253–254), and these increases are likely to continue until potential new international climate agreements are negotiated, ratified, and implemented by nations around the world (Peters *et al.* 2013, pp. 5–6; Friedlingstein *et al.* 2014, p. 713). (3) Finally, unlike the other RCPs, 8.5 does not rely significantly on commitments to carbon capture and storage. This mitigation strategy has yet to be deployed on a large scale and faces considerable uncertainty owing to biophysical, technical, and social challenges (Fuss *et al.* 2014, p. 852). Our approach (focusing on projections using RCP 8.5) is used in many other current climate-change studies and analyses (for examples relevant to the range of sage-grouse and to our status review, see Diffenbaugh *et al.* 2013; NOAA 2014, p. 53888; Cook *et al.* 2015; Schlaepfer *et al.* 2015; Touma *et al.*, in press).

interannual variability, the likely general pattern by mid-century is increased winter precipitation in the northern part of the interior West and an increase in the likelihood of wet winters (MZs I, II, IV, V, and VI), decreased winter precipitation and wet winters in the southern part of the range, south of 37º south latitude (the southern edges of MZs III and VII), and a 20 to 50 percent increase in the frequency of precipitation falling as rain rather than snow throughout the Great Basin (Abatzoglou and Kolden 2011, p. 474;). Despite projected increases in average annual precipitation in much of the range of sage-grouse, rising temperature leads to a high likelihood of increases in hydrological droughts (i.e., drought defined by low water supply, rather than by low precipitation)across the West by mid-century (Strzepek *et al.* 2010, pp. 4–6). Likelihood in these instances describes a high level of agreement in projections among multiple global circulation models (Strzepek *et al* 2010, p. 3; Abatzoglou and Kolden 2011, p. 473; USGS 2014, p. 5).

Mechanisms

Changes to climate, including increased ambient temperature and drought frequency, changes in the seasonality, amount, and distribution of precipitation, and increase in atmospheric carbon available to plants are anticipated to substantively alter distributions of individual species and biotic communities (Bachelet *et al.* 2001, pp. 173–174; Shafer *et al.* 2001, pp. 208–210; Rehfeldt *et al.* 2006, p. 1141; reviewed in Friggens *et al.* 2012, entire). Direct impacts of climate on individual birds are unknown for most species, including sage-grouse (Galardi *et al.* 2012, p. 3), but climate influences the distribution and quality of sage-grouse habitat and resources by mediating conditions favorable for individual plant species and conditions for disturbance factors such as wildfire (Miller *et al.* 2011, pp. 174–179). Aspects of sage-grouse habitat that are strongly influenced by climate, and thus most likely to be affected by climate change, include: the distribution and quality of sagebrush habitat and/or the availability of seasonal resources, such as native herbaceous plants and insects, that influence sage-grouse vital rates and ultimately population growth rates (Schrag *et al.* 2011, pp. 7–8; Blomberg *et al.* 2012, p. 12; Fletcher *et al.* 2013, p. 461; Guttery *et al.* 2013, pp. 8–9; Schlaepfer *et al.* 2015, entire; Still and Richardson 2015, entire); conditions that (a) facilitate the establishment of invasive plants such as cheatgrass, which increases wildfire risk, and (b) exacerbate the positive feedback process between cheatgrass and wildfire (D'Antonio and Vitousek 1992, pp. 63-87; Westerling *et al.* 2006, entire; Abatzoglou and Kolden 2011, pp. 474–475; Miller *et al.* 2011, p. 183; Balch *et al.* 2013, p. 180–182; Chambers *et al.* 2014, pp. 367–368); and conditions that influence disease incidence (Christiansen and Tate 2011, pp. 119, 126; Schrag *et al.* 2011 pp. 8–9, 12).

Anticipated Impacts, Location, and Extent

Western North America is identified as a "hotspot" of regional climate change under a range of future emissions scenarios (Diffenbaugh *et al.* 2008, pp. 3–4; Diffenbaugh and Georgi 2012, p. 819). Some degree of uncertainty is inherent in these and other projections of future change; however, climate change will likely affect the entire range of sage-grouse, and the severity of impacts and interaction with other limiting factors will vary by MZ.

By mid-century, conditions suitable for sagebrush will likely be lost in the southernmost parts of the range of sage-grouse (southern portions of MZs III and VII) (Schlaepfer *et al.* 2015, p. 4), with potential adverse impacts to peripheral populations of sage-grouse in those areas. The natural distribution of sagebrush reflects seed germination, seedling survival, and the likelihood of sagebrush regeneration following disturbance such as fire or drought, and these processes are driven by soil-water availability (Schlaepfer *et al.* 2014, p. 74; Schlaepfer *et al.* 2015, pp. 7–8). Soil water conditions are influenced by the amount and seasonality of precipitation and by temperature, with spring precipitation and melting snowpack being the chief influences of peak soil water availability (Bradford *et al.* 2014, p. 595). Decreasing snow-pack and earlier spring melt with increasing ambient temperature is projected to lead to increased evaporation and transpiration in sagebrush habitat and a lengthening summer period of dry soil conditions (Bradford *et al.* 2014, p. 599). These conditions are projected to be most pronounced along the southern edge of the current distribution of sagebrush (MZs III and VII), and particularly at low elevations (Schlaepfer *et al.* 2015, p. 13; Still and Richardson 2015, p. 33). As climate conditions suitable for sagebrush shift northward, the likely result is low probability of sagebrush regeneration in the south (Nielson *et al.* 2005, p. 155; Schlaepfer *et al.* 2012, p. 377; Schlaepfer *et al.* 2015, pp. 4, 8). In these areas, increasing temperature and an increasing number of frost-free days are likely to favor northward and upslope shifts in frost-sensitive woodland vegetation into areas currently suitable for sagebrush (Nielson *et al.* 2005, pp. 153–155; Comer *et al.* 2012, p. 142; reviewed in Friggens *et al.* 2012, pp. 8–11; Rehfeldt 2012, p. 126) at a projected rate of 12 percent of sagebrush habitat displaced per 1°C (1.8 °F) increase in temperature (Nielson *et al.* 2005, p. 154). Given a projected increase in temperature of several degrees Celsius by mid-century in MZs III and VII, this could mean the displacement of a substantial proportion of sagebrush by other types of vegetation (Miller *et al.* 2011, p. 179). North of the current extent of sagebrush distribution (along the "leading edge," e.g., north of MZs I and VI), projected changes in temperature and precipitation will alter soil-water storage patterns and likely to produce conditions more suitable for sagebrush than at present. But other factors in those areas, such as extensive agriculture, existing grasslands, and improved conditions for invasive plants, including cheatgrass, could complicate an actual range-shift to the north in sagebrush (Schlaepfer *et al.* 2012, pp. 379–380; Schlaepfer *et al.* 2015, p. 13).

[PLACEHOLDER: SAGEBRUSH CONDITIONS & SAGE-GROUSE GIS OVERLAYS; FIGURES 17-X, 17-Y, 17-Z]

In addition to these future patterns of trailing-edge loss and leading-edge gain in climate conditions suitable for sagebrush, sagebrush habitat currently faces climate-mediated stressors such as fire and encroachment by nonnative annual grasses and woody species. Combined, these stressors could have additive, adverse impacts to sagebrush habitat (Bradford *et al.* 2014, p. 599; Chambers *et al.* 2014, entire). , By mid-century sagebrush cover within the Great Basin and Columbia Basin (MZs III, IV, V, and VI) is likely to be fragmented and reduced overall by cheatgrass and conifer encroachment (Nielson *et al.* 2005, p. 155–157; Chambers and Pellant 2008, pp. 30–32; Bradley 2010, pp. 203–205; Chambers *et al.* 2014, pp. 365–368; Schlaepfer *et al.* 2015, p. 13; Still and Richardson 2015, p. 33). Low elevation sites within the Great Basin (MZs III, IV, and V) will be susceptible to fragmentation by and conversion to xeric or novel vegetation, such as desert scrub communities (Friggens *et al.* 2012, pp. 9–10). Overall, by mid-century the potential loss and fragmentation of sagebrush habitat caused by climate change, especially in the southern portions of the range (MZs III and VII) and low-elevation portions of the Great Basin (MZs III, IV, and V) could in turn exacerbate impacts to sage-grouse populations or other stressors and sources of fragmentation (e.g., agriculture, infrastructure, wildfire, invasives) and increase the risk of population decline and extirpation (Johnson *et al.* 2011, pp. 447–450; Miller *et al.* 2011, pp. 183–184; Wisdom *et al.* 2011, pp. 465–468).

Plant growth (which in turn drives insect production) during the brief growing season in semi-arid sagebrush-steppe ecosystems is reliant on seasonal soil moisture conditions, which is determined by climate (temperature, precipitation, snow-pack) (Waide *et al.* 1999, pp 269–271; Wenninger and Inouye 2008, pp. 27–29; Miller *et al.* 2011, pp. 171–172; Blomberg *et al.* 2012, p. 12; Bradford *et al.* 2014, 595–599). In particular, herbaceous vegetation and invertebrates are seasonally important resources for sage-grouse and their young (Klebenow and Gray 1968, pp. 81–82; Barnett and Crawford 1994, pp. 115–116; Gregg and Crawford 2009, pp. 908–909). Availability of these resources varies interannually and is correlated with chick growth and prefledging survival (e.g., in the northern Great Basin; Huwer *et al.* 2008, p. 1624–1625; Gregg and Crawford 2009, pp. 907–908). For example, in the Great Basin and the southern Rockies (study sites in Nevada and Utah, respectively; MZ III), reproductive success, post-fledging survival, and recruitment were positively associated with rainfall, and survival was negatively associated with high temperature and drought (Blomberg *et al.* 2012 p. 9; Guttery *et al.* 2013, pp. 5–7; Blomberg *et al.* 2014, p. 8). These patterns are likely attributable to the effects of temperature and precipitation on resource availability (Blomberg *et al.* 2012, pp. 12–14; Blomberg *et al.* 2013, pp. 153–154, Guttery *et al.* pp. 8–9). Conditions that result in decreased soil moisture during the growing season, such as projected increases in temperature and drought and decrease in snow-pack in the western U.S. (Abatzoglou and Kolden 2011, p. 474; IPCC 2013, p. 20, 25; Cook *et al.* 2015, pp. 5–6) could result in decreased availability of these important food resources, and concomitant negative consequences for sage-grouse survival and recruitment (e.g., projections for the lesser prairie-chicken; Grisham *et al.* 2013, pp. 7–8). . In contrast, changes in seasonality, such as earlier onset of warm temperatures in the spring, can directly affect avian phenology. For example, red grouse in Scotland adjusted their nesting to coincide with earlier warming in the spring and had larger clutch sizes and greater chick survival (Fletcher *et al.* 2013, pp. 460–462).

Climate change directly affects fire risk, independent of exacerbation by cheatgrass invasion. Since the 1980s, the frequency of wildfires has increased as direct result of increased temperature, earlier spring warming, and diminishing snow-pack, all of which contribute to overall drying of vegetation, especially in arid and semi-arid regions, such as the Great Basin (Westerling *et al.* 2006, entire). Projections for hotter and, in the southern parts of MZ II and VII, drier climate conditions will result in worsening of these trends (Brown *et al.* 2004, pp. 382–383; Neilson *et al.* 2005, p. 150; Westerling *et al.* 2006, p. 943; Chambers and Pellant 2008, p. 31; Climate Change Impacts in the United States 2014, pp. 463–486). Therefore, beyond the potential shifts in sagebrush and other vegetation communities induced by alterations in temperature and precipitation regimes, increases in CO2 concentrations represent a threat to the extant sagebrush biome and an indirect threat to sage-grouse through habitat degradation and loss (Miller *et al.* 2011, p. 179). Climate change also can heighten interactions among existing impacts if these are not ameliorated (Chambers *et al.* 2014, p. 368). Increasing temperature coupled with increased winter and spring precipitation, for example, is likely to exacerbate cheatgrass invasion and wildfire in sagebrush habitats—stressors that results in habitat fragmentation, particularly in the Great Basin (MZs III, IV, and V) (Balch *et al.* 2014, p. 182). Warmer winters, earlier spring melt, and increased concentrations of atmospheric CO2 are likely to favor cheatgrass and other invasives, exacerbating the fire-invasives feedback loop, especially in the Great Basin (Chambers *et al.* 2014, pp. 367–368).

Threat Amelioration

Many conservation actions have been planned or undertaken to address those current stressors to sage-grouse and their habitat that are most influenced by climate change, such as wildfire, invasive plants, and conifer encroachment. For details of these activities, see the corresponding chapters of this report. Successful actions manage these stressors can improve the resilience of sage-grouse in the face of changing climate. Ultimately, ameliorating the impacts of climate change to sage-grouse involves addressing the proximate threats described in this species report to improve the resilience of the species and its sagebrush habitat under changing environmental conditions and safeguard the species' adaptive potential by conserving its distribution, connectivity among populations, and genetic variation.

Threat Amelioration Summary

In our 2010 finding, we considered climate change to play a potentially important indirect role in intensifying some of the current significant impacts to sage-grouse (USFWS 2010, p. 47). Since then, new climate-change analyses and regionally downscaled climate data have projected future conditions with increased confidence, including rangewide increase in temperature; increasing precipitation in the north, decreasing precipitation in the south, and a shift to more winter and spring precipitation, less precipitation falling as snow, and increased likelihood of long, severe droughts (e.g., Strzepek *et al.* 2010; Abatzoglou 2011; Abatzoglou and Kolden 2011; IPCC 2013; U.S. Global Change Research Program 2014; Cook *et al.* 2015;). Climate and climate change impacts to conditions suitable for sagebrush have been investigated in greater detail (e.g., Schlaepfer *et al.* 2012, Bradford *et al.* 2014; Schlaepfer *et al.* 2014, 2015; Still and Richardson 2015), as well as climate impacts to wildfire, invasives, and West Nile virus in the west (Bradley 2009, 2010; Abatzoglou and Kolden 2011; Chambers *et al.* 2014; Schrag *et al.* 2011; Balch *et al.* 2015). Additionally, the relationships between climate variables and seasonally important food resources for sage-grouse have been documented in some areas (e.g., Blomberg *et al.* 2012, 2013, 2014; Guttery *et al.* 2014).

Although current climate change effects are documented in North America, including the western U.S. (Abatzoglou 2011; IPCC 2013; Abatzoglou *et al.* 2014; U.S. Global Change Research Program 2014; Balch *et al.* 2015), current impacts of climate change to sage-grouse have not been documented. Nonetheless, by the mid-21st century, climate change is reasonably certain to result in the loss of sagebrush habitat from MZs III, VII, and the southern portions of II and V, and possibly from low-elevation areas farther north. Changes in the timing and amount of precipitation are likely to have adverse impacts to the availability of spring and early summer food resources for sage-grouse broods, with potential negative consequences for survival and recruitment, at least in the central Nevada Great Basin and Utah Rocky Mountains where studies of these relationships have been conducted (e.g., Blomberg *et al.* 2012, entire; Guttery *et al.* 2013, entire; Blomberg *et al.* 2014, entire). Increased winter and spring precipitation, especially in MZs I, II, IV, V, and VI, is likely to benefit growth of cheatgrass and other invasives, which can increase the potential for wildfires and displace herbaceous vegetation and insect production in drought years. An earlier and longer frost-free season will facilitate encroachment by woody vegetation which, along with increased biomass of invasive annual grasses, also results in increased fuel loads and fire risk, especially under conditions of hotter, drier summers. Increasing temperature is likely to benefit mosquito reproduction and replication of West Nile virus, and increase the risk of its transmission to sage-grouse rangewide where other necessary conditions coincide (i.e., suitable breeding habitat for mosquitos and areas such as mesic habitats where sage-grouse tend to congregate when temperature peaks in the summer).

New studies have not altered our fundamental understanding of how climate change is likely to affect sage-grouse and their habitat; rather, these studies have improved the detail of that understanding and our confidence in the likelihood that these changes to sage-grouse habitat will likely occur by mid-century. However, the response of sage-grouse to these habitat changes, and the impacts to sage-grouse populations or to the species, remain difficult to predict. Based on the new science, we conclude that climate change is likely to exacerbate other major stressors to sage-grouse and their habitat. Regulatory mechanisms and conservation efforts that ameliorate the risk of wildfire and the invasion of sagebrush habitat by native conifers and by nonnative annual grasses—stressors mediated substantially by climate—may also ameliorate the impacts of climate change to sage-grouse habitat.

CHAPTER 19: DROUGHT

Drought, the shortage of precipitation over an extended period of time (NDMC 2015), is a natural, periodic occurrence throughout the range of the sage-grouse. Drought can be measured by the imbalance between water supply and water demand, taking duration, intensity, size of the area affected, and impacts into consideration (Peterson *et al.* 2013, p. 827). Large-scale drought lasting a decade, similar to the 1930s Dust Bowl drought, has occurred once or twice per century on average (Woodhouse and Overpeck 1998, p. 2706; Ault *et al.* 2014, p. 7529) and periodic drought regularly influences sagebrush ecosystems (Miller *et al.* 2011, p. 145). Megadroughts (droughts lasting multiple decades) occurred throughout the western U.S. in the 13th and 16thh centuries according to tree-ring reconstructions (Woodhouse and Overpeck 1998, p. 2699). Throughout the 20th century, drought duration has increased in the interior western U.S. (Andreadis and Lettenmaier 2006, p. 1; Miller *et al.* 2011, p. 145). Recently, drought has occurred with varying severity in portions of the sage-grouse range (USDM 2015).

Current Impacts

Infrequent, severe drought and fluctuating soil moisture may cause local reduction or elimination of sagebrush important for sage-grouse (Connelly *et al.* 2004, p. 5-11). Recolonization of these areas by native species may be slow and uneven, increasing opportunities for invasive plant growth and establishment (Chambers *et al.* 2007, p. 141). Decreases in moisture during drought reduce vegetation cover important for sage-grouse nesting (Milton *et al.* 1994, p. 75; Connelly *et al.* 2004, p. 7-18) by decreasing plant survival and growth. Reduction of sagebrush abundance can also be exacerbated by defoliation of sagebrush by insects during drought (Connelly *et al.* 2004, p. 5-11). Loss of vegetation cover may result in increased soil erosion and subsequent reduced soil depths, decreased water infiltration, and reduced water storage capacity, compounding the effects of water shortages and subsequently result in additional loss of vegetative cover (Miller *et al.* 2011, p. 174).

Drought also impacts insect abundance within sage-grouse habitat. Insects, important in sage-grouse brood survival, may decrease due to the shortage of water or insect habitat (Fischer *et al.* 1996, p. 197). Mosquitoes, carriers of WNv infections, may increase in abundance during a drought, as previously running water may become stagnant, providing additional mosquito breeding habitat (Walker and Naugle 2011, p. 131). Sage-grouse are impacted by drought through decreased habitat, food sources, and increased risk of disease transmission.

Drought impacts to sage-grouse habitat relate to adult survival, nesting success, and chick survival. Structural composition of plants vital for sustaining sage-grouse nesting success, including plant height and percent plant cover, may be impacted during drought (Hanf *et al.* 1994, p. 41). Vegetation providing the appropriate height and canopy cover for nesting cover is essential for successful nesting (Doherty *et al.* 2014, p. 323) and therefore important for chick production. Structural changes in vegetation attributed to reduction of herbaceous cover may result in declining sage-grouse populations due to increased nest predation (Braun 1998, p. 149; Moynahan *et al.* 2007, p. 1781; Guttery *et al.* 2013, p. 8). Female sage-grouse re-nesting rates may be lower during drought conditions due to poor nutrition as a result of drought impacts on vegetation used as food (Hanf *et al.* 1994, p. 23). As chick survival rates are key for sage-grouse population growth (Guttery *et al.* 2013, p. 2), decreases in insects and forbs important for sage-grouse chick survival (Johnson and Boyce 1990, p. 91, Crawford *et al.* 2004, p. 6) during drought (Fischer *et al.* 1996, p. 197) may negatively impact sage-grouse populations. Spring precipitation has a positive relationship with sage-grouse productivity, as years with below-average spring moisture result in less vegetation growth, an important dietary component for chicks (Aldridge and Bridgham 2003, p. 31). Winter drought has been positively associated with reduced chick survival, possibly due to the impact of winter drought on plant production during the following summer when brood habitat quality is important for chick survival (Guttery *et al.* 2013, p. 8). Additionally, drought during winter may affect female nutrition and therefore resource provisioning during egg formation (Guttery *et al.* 2013, p. 8). Adult females are capable of surviving drought conditions, however, concurrent impacts during drought conditions lead to higher mortality of adult females (Moynahan *et al.* 2006, p. 1536).

Correlational information from the 1930s linked the decline in sage-grouse populations to periods of drought (Patterson 1952, p. 33; Braun 1998, p. 139). Drought conditions in the late 1980s and early 1990s also coincided with a period when sage-grouse populations were at historically low levels (Connelly and Braun 1997, p. 8). Experimental data found that from 1950 to 2003, the frequency of droughts had a weak negative effect on sage-grouse persistence, with extirpation most likely in areas having three or more severe droughts per decade (Aldridge *et al.* 2008, pp. 983, 992). Populations on the periphery of a species' range may be extirpated during periods of severe and prolonged drought (Wisdom *et al.* 2011, p. 468).

Location and Extent

Drought has been documented through much of the interior western U.S. in the 20th century (Miller *et al.* 2011, p. 145). Abnormally dry (when going into drought, defined as short-term dryness slowing planting, growth of crops or pastures; when coming out of drought, defined as the occurrence of some lingering water deficits, pastures and crops not fully recovered) to exceptional long-term (defined as exceptional and widespread crop/pasture losses; shortages of water in reservoirs, streams, and wells creating water emergencies) drought conditions currently exist in portions of the sage-grouse range (USDM 2015, Figure 19-1). Many portions of the sage-grouse range show drier conditions from 1991-2012 compared to the first half of the 20th century, even though major droughts occurred during the 1930s and 1950s (Walsh *et al.* 2014, p.32; Figure 19-2).

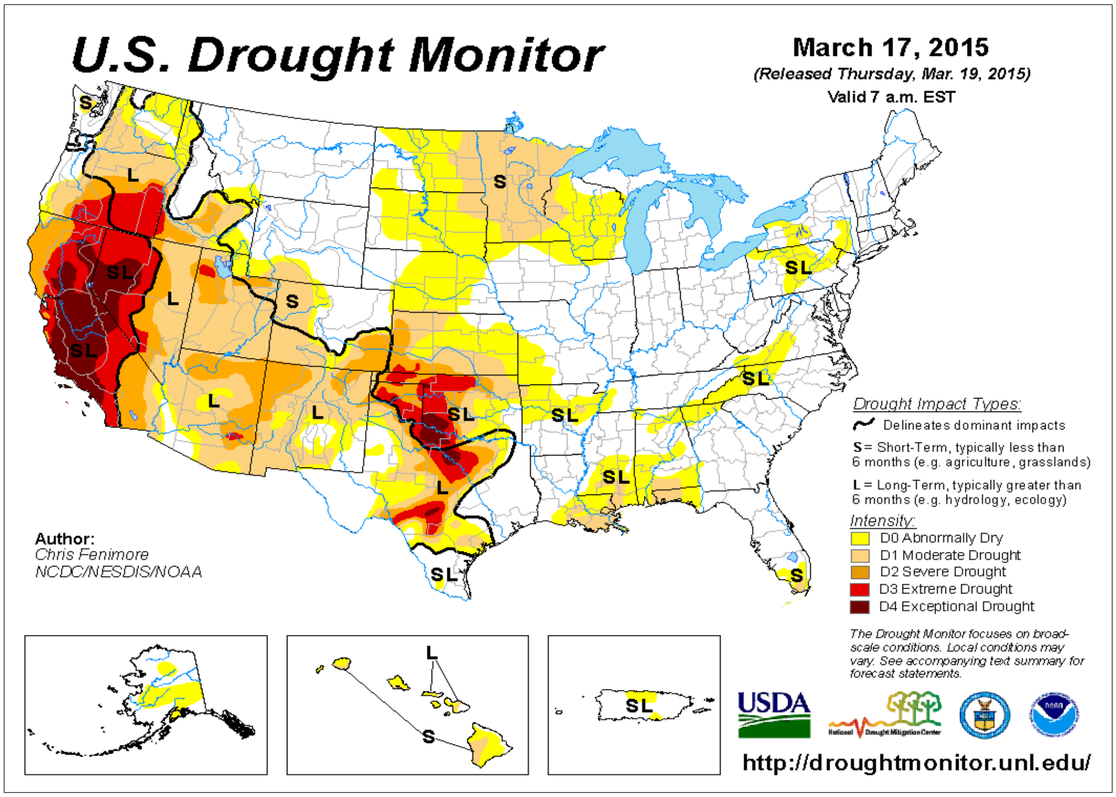

Figure 19-1: Drought conditions in United States as of January 27, 2015 (USDM 2015).

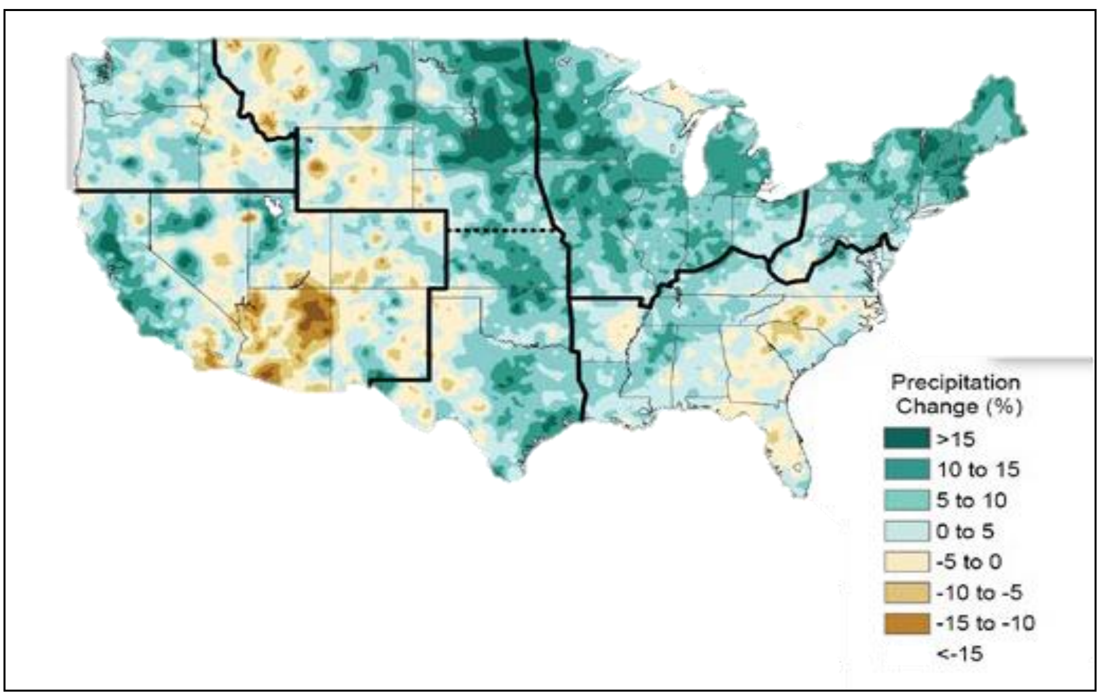

Figure 19-2: The colors on the map show annual total precipitation changes for 1991 to 2012 compared to the 1901 to 1960 average, and show wetter conditions in most areas. This increase in precipitation reflects the major droughts in the 1930s and 1950s that made the early half of the record drier. (from Walsh *et al.* 2014, p. 32; adapted from Peterson *et al.* 2013).

Table 19-1: List of impacts associated with drought by management zone.

Management Zone	Timing of Impacts (Season)	Immediacy of Impacts	Severity of Impacts	Extent of Impacts	Resource or Life stage impacted
I	Current	Drought conditions occurring	Normal conditions, Abnormally dry conditions	Only occurring in very SE portion of MZ; less than 25% of MZ impacted	Potentially all life stages in areas with drought
II	Current	Drought conditions occurring	Normal conditions, abnormally dry, moderate drought, and severe drought conditions	Drought conditions occurring only within southern portion of MZ; less than 50% of MZ impacted	Potentially all life stages in areas with drought
III	Current	Drought conditions occurring	Moderate drought, severe drought, extreme drought, and exceptional drought conditions	Entire MZ currently impacted. Western portions of the MZ have more severe drought conditions.	Potentially all life stages in areas with drought
IV	Current	Drought conditions occurring	Normal conditions, abnormally dry, moderate drought, severe drought, and extreme drought conditions	Over 50% of MZ impacted; Western portions of MZ have more severe drought conditions.	Potentially all life stages in areas with drought
V	Current	Drought conditions occurring	Moderate drought, severe drought, extreme drought, and exceptional drought conditions	Entire MZ currently impacted. Southern portions of MZ have more severe drought conditions.	Potentially all life stages in areas with drought
VI	Current	Drought conditions occurring	Normal conditions, abnormally dry, and moderate drought conditions	Over 75% of MZ impacted; Southern portions of MZ have more severe drought conditions	Potentially all life stages in areas with drought
VII	Current	Drought conditions occurring	Normal conditions, abnormally dry, moderate drought, and severe drought conditions	Over 75% of MZ impacted; Southern and western portions of MZ have more severe drought conditions.	Potentially all life stages in areas with drought

Projected Future Impacts (Timescale, Likelihood of Future Impacts and Anticipated Changes from Present)

Drought is a natural occurrence that gas impacted the entire range of the sage-grouse in the past (1930s, late 1980s to early 1990s) and will likely continue to impact the entire range in indefinitely. The risk of decade-scale drought occurring within the southern MZs within the sage-grouse range (MZ III, V, VII, and portions of MZ II and IV) this century is estimated between 20 and 70 percent, while the probability of a multidecadal drought is between 10 and 20 percent depending on the impacts of climate change (Ault *et al.* 2014, p. 7541–7542). The probability of decade-scale drought in the northern MZs (MZ I,VI, and portions of MZ II and IV) is between 10 and 50 percent, with lower risk of mutidecadal megadrought risk (between 0 to 10 percent) (Ault *et al.* 2014, p. 7541–7542). Based on precipitation and temperature projections, drought frequencies are expected to increase across the country, especially in the Rocky Mountain and southwestern states, including all sage-grouse MZs (Strzepek *et al.* 2010, p. 1).

Arid regions where sage-grouse occur are likely to become hotter and drier by the end of the 21st century due to climate change (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; Walsh *et al.* 2014, p. 34; Cook *et al.* 2015, p. 6). The southern portions of the range (MZ I, VI, and portions of MZ II and IV) are likely to have increased risk and higher severity of drought, though the entire range will likely be impacted (Cook *et al.* 2015, p. 6). Drought models for late 21st century indicate that drought and changes in precipitation may be seasonal, with higher than normal amounts of precipitation occurring in the northern portion of the range during the spring, fall, and winter, with reduced precipitation occurring over the southern portion of the range in the spring and the majority of the range in summer (Figure 19-3) (Walsh *et al.* 2014, p. 34). Additionally, despite projected increases in precipitation in much of the range of the sage-grouse, rising temperatures associated with climate change are projected to lead to a high likelihood of increases in hydrological drought (i.e., drought defined by low water supply, rather than by low precipitation) across the west by the middle of the 21st century (Strzepeck *et al.* 2010, pp. 4–6).

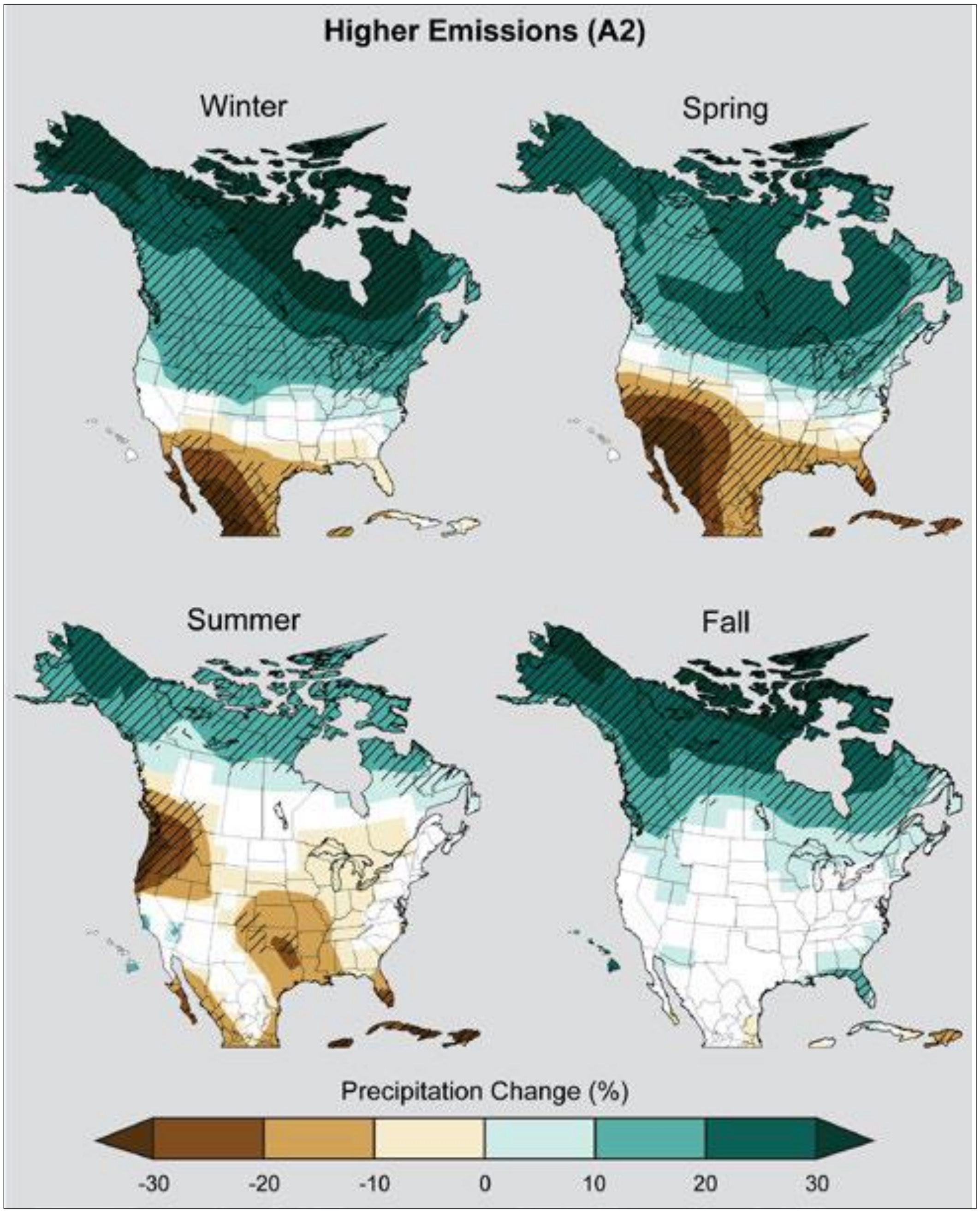

Figure 19-3: Projected change in seasonal precipitation for 2071 to 2099 (compared to 1970 to 1999) under an emissions scenario that assumes continued increases in emissions (A2). Hatched areas indicate that the projected changes are significant and consistent among models. White areas indicate that the changes are not projected to be larger than could be expected from natural variability. (from Walsh *et al.* 2014, p. 34/ NOAA NCDC / CICS-NC).

Table 19-2: Projected change in seasonal precipitation for 2071 to 2099 (compared to 1970 to1999) under an emissions scenario that assumes continued increases in emissions (from Walsh *et al.* 2014, p. 34/ NOAA NCDC / CICS-NC).

	Spring			**Summer**			**Fall**			**Winter**		
Management Zone	Change in Precipitation	Severity	Extent	Change in Precipitation	Severity	Extent	Change in Precipitation	Severity	Extent	Change in Precipitation	Severity	Extent
I	Wetter	>0-30% wetter	Majority of MZ in 10-20%	No Change	N/A	N/A	No Change	N/A	N/A	Wetter	10-2-% wetter	entire MZ
II	S portion drier	>0-20% drier	Majority of southern half of MZ in 0-10%	Drier	>0-10% drier	Majority of MZ in 0-10%	No Change	N/A	N/A	Wetter	10-20% wetter	entire MZ
	N portion wetter	>0-20% wetter	Majority of northern half of MZ in 0-10%									
III	Drier	>0-30% drier	Approximately half of the MZ in 10-20% drier, half in 20-30%	Drier	>0-20% drier	Northern portion of MZ in 10-20%	Wetter	>0-10% wetter	North-central portion of MZ only.	Wetter	no change - 20 % wetter	Only very N portion of MZ has change
IV	S portion drier	>0-10% drier	Southern third of MZ drier	Drier	>0-30% drier	Western portions of MZ in 20-30%	Wetter	>0-10% wetter	Majority of MZ	Wetter	10-20% wetter	entire MZ
	N portion wetter	>0-20% wetter	Northern two-thirds of MZ wetter, very N portion 10-20%									
V	Drier	>0-20% drier	Southern two-thirds of MZ drier, very S portion 10-20%	Drier	10->30% drier	Western portions of MZ in 20-30%	Wetter	>0-10% wetter	Only very E portion of MZ	Wetter	>0-20% wetter	NE portion of MZ in 10-20%
VI	Wetter	>0-20% wetter	Entire MZ	Drier	20->30% drier	Western portions of MZ in >30%	Wetter	>0-20% wetter	Very N portion of MZ within 10-20%	Wetter	10-20% wetter	entire MZ
VII	Drier	10-30% drier	Entire MZ	Drier	0-10% drier	Some areas with no change	No Change	N/A	N/A	Wetter	>0-20% wetter	N and E portions wetter

Threat Amelioration

Active conservation is occurring related to compounding factors that may be associated with drought, such as implementation of proper grazing practices, but no conservation measures that directly influence the potential risk or impacts associated with drought were provided in our CED,

Threat Summary

Drought has been a periodic and natural part of the sagebrush-steppe ecosystem that has been implicated in short-term population fluctuations however, persistent population declines have mostly been attributed to human-caused changes in sagebrush habitats (Braun 1998, pp. 10, 12). Sage-grouse population numbers have been shown to fluctuate in correlation to drought conditions, but data is lacking to indicate whether drought contribute to overall long-term declines in sage-grouse populations. Presently, drought is impacting individuals and some populations. Drought impacts on the sage-grouse may be exacerbated when combined with other habitat impacts (e.g., habitat modification from grazing and development) that reduce cover and food and may increase in frequency and duration due to climate change. Future drought predictions indicate that impacts will continue and may intensify, particularly for the southern portion of the sage-grouse range, potentially resulting in MZ level impacts.

Overutilization

CHAPTER 20: RECREATIONAL HUNTING

Sage-grouse are not used for any commercial purpose, but recreational hunting of sage-grouse is a long-standing recreational pursuit and still occurs at varying levels throughout almost all of the species' range. Sage-grouse have not been commercially harvested for many decades; therefore, commercial hunting no longer impacts the species.

In the U.S., a limited amount of sage-grouse hunting mortality occurs on tribal lands (Cleveland and Seo 2014, pers. comm.; Hnilicka 2014, pers. comm.). The majority of hunting mortality occurs during the State-managed sage-grouse hunting seasons in the fall, which are discussed below. State-managed falconry hunting also occurs throughout most of the range, but is dispersed and limited. In 2010, the Service determined that the impacts of falconry hunting are likely negligible (75 FR 13910, p. 13965). We have no new information to indicate that determination should be changed. Illegal harvest (poaching) also occurs, but the Service determined in 2010 that the impacts from poaching are likely negligible (75 FR 13910, p. 13965) and we have no new information to indicate that determination should be changed. Given the lack of new information about falconry and poaching and the continued absence of a commercial harvest, we will not discuss those activities further.

Sage-grouse have been hunted by humans before and throughout recorded history. Some of the earliest evidence of hunting of sage-grouse comes from excavations of hearths used by prehistoric humans located at Bonneville Estates Rockshelter in northeastern Nevada. Sage-grouse bones showing evidence of tool cut marks and charring were radiocarbon dated at over 10,000 years old (Hockett 2007, p. 211). Native American tribes have historically hunted sage-grouse for sustenance, for their feathers and for cultural reasons (BLM 2013 EIS, pp. 142–144).

During the late 1800s and early 1900s, the sage-grouse was heavily exploited by both commercial and sport hunters (Patterson 1952, pp. 30–33; Autenrieth 1981, pp. 3–11). Prior to the 1900s, sage-grouse were hunted year-round with no bag limit, which resulted in significant population declines (Patterson 1952, p. 30; Connelly *et al.* 2004, p. 9-1; Reese and Connelly 2011, p. 103). Whereas declines in the latter parts of the 1900s are considered primarily to be the result of loss of habitat quality and quantity, declines in the 1920s and 1930s are attributed, at least in part, to over hunting (Patterson 1952, pp. 30–33; Connelly and Braun 1997, p. 2). State wildlife agencies were sufficiently concerned with the observed declines in the 1920s and 1930s that many closed their hunting seasons and others significantly reduced bag limits and season lengths as a precautionary measure (Patterson 1952, pp. 30–33; Autenrieth 1981, p. 10). By the 1950s, populations were considered recovered and recreational hunting was again allowed throughout the range (Patterson 1952, p. 242; Autenrieth 1981, p.11).

Since the resumption of recreational hunting in the 1950s, sage-grouse hunting mortality has varied. In the 1960s, hunting mortality across the range was estimated to have exceeded 120,000 individuals annually for 7 of 10 years. Hunting mortality reached a peak in the 1970s, with estimates being above 200,000 individuals in 9 of 10 years (Table 20-1). During the 1980s, hunting mortality was estimated to have exceeded 130,000 individuals in 9 of 10 years. The hunting mortality was estimated above 100,000 annually during the early 1990s but in 1994 dropped below 100,000 for the first time in decades. Hunting mortality decreased significantly in the 2000s with an average annual mortality estimate of 31, 373 birds (Table 20-1). From 1968 to 2013, the time period with the most complete records, the majority of estimated sage-grouse hunting mortality has occurred in Wyoming (32 percent), Idaho (28 percent), and Montana (16 percent; USFWS 2015).

Table 20-1: Estimated rangewide greater sage-grouse hunting mortality by decade (USFWS 2014, unpublished data). Estimates of hunting mortality prior to the 1960s are incomplete or unreliable for most States.

Decade	Average	Maximum	Minimum	Total
1960s	151,481	265,589	118,263	1,514,811
1970s	232,258	323,555	196,874	2,322,581
1980s	164,661	237,451	105,689	1,646,610
1990s	90,967	166,034	48,044	909,674
2000s	31,373	43,540	20,680	313,731
2010-2013	20,725	27,786	13,603	82,899

Hunting mortality has shown a steady decline over recent decades as States have modified season length, geographical scope, and harvest regulations in response to declining sage-grouse populations and an increased understanding of sage-grouse biology. In 2014, sage-grouse hunting took place in 8 of the 11 States where sage-grouse occur. Sage-grouse are listed as a threatened species in Washington (Stinson *et al.* 2004, p. 1) and hunting has been closed since 1988. Sage-grouse have not been hunted in Saskatchewan since 1938 and Alberta closed the season in 1996 (Aldridge and Brigham 2003, p. 25). In 1998, sage-grouse were designated as endangered in Canada and hunting is prohibited (Connelly *et al.* 2004, p. 6-3). North Dakota closed its hunting season in 2008 due to low lek count numbers and it has remained closed. South Dakota closed its hunting season in 2013 due to low lek count numbers; it also remained closed in 2014. Montana Fish and Wildlife Commission closed all or parts of 32 counties to sage-grouse hunting in 2014 and shortened the hunting season from two months to one.

Current Impacts

Direct mortality is the primary mechanism for impacts to sage-grouse from recreational hunting. Poor shot placement also results in an undetermined amount of delayed mortality (crippling loss) either as a direct result of the injury or because injuries make individuals more susceptible to predation. Birds injured by hunters are seldom retrieved or reported, making estimates on these types of crippling losses difficult to obtain or monitor (Watson 2007, p.3; Caudill 2011, p. 10). One recent radio-telemetry study estimated crippling losses from sage-grouse hunting on Parker Mountain in south-central Utah to be as high as 6.8 percent, but these estimates are based on a very small sample size (Caudill *et al.* 2014, p. 814).

In addition to direct mortality and injury, levels of disturbance increase with the increased human activity (e.g., vehicles, dogs, gunshot noise) in areas open to hunting. Females and young of year birds will aggregate in wet areas (such as riparian corridors or wet meadows) in the fall due to the presence of green vegetation and associated insects. Due to the concentration of birds in these areas, hunters have greater success but the result is to bias hunting mortality towards females and young. In one unreplicated study however, the presence of hunters seemingly resulted in avoidance of these areas during the hunting season (Zunino 1987, p. 26; Reese and Connelly 2011, p. 109). If this displacement, which could affect late summer foraging, is common the timeframe is limited to the hunting season (2 to

30 days depending on the State). It is unknown if disturbance of this type and relatively short duration has any measurable negative impacts on sage-grouse.

Sage-grouse hunting is regulated by State wildlife agencies and managed with the goal of maintaining a sustainable harvest. Managing for sustainable harvest is traditionally based on the concept of compensatory and additive mortality (Connelly 2005, p. 7). The validity of hunting as a form of compensatory mortality for upland game birds, including sage-grouse, has been questioned in recent years (Connelly 2005, p. 7; Gibson *et al.* 2011, p. 313; Reese and Connelly 2011, p. 101). Sage-grouse possess several life history characteristics (e.g. long-lived, low reproductive rates) which violate the assumptions of compensatory hunting hypothesis, making the potential for additive hunting mortality high. Additionally, while high mortality during notably severe winters has been reported (Moynahan *et al.* 2006, p. 1536; Anthony and Willis 2008, p. 544), sage-grouse typically experience low overwintering mortality (Connelly *et al.* 2000b, p. 22; Wik 2002, p. 40; Sika 2006, p. 80; Caudill *et al.* 2014, p. 812), meaning that in a typical year, the majority of individuals should successfully overwinter and join the breeding population in the spring (Wik 2002, p. 36). This suggests there is little potential for compensatory hunting mortality as birds lost to hunting likely would have otherwise survived to breed (Gibson *et al.* 2011, p. 309). Various studies have attempted to determine whether hunting mortality in sage-grouse is compensatory or additive (Crawford 1982; Crawford and Lutz 1985; Braun 1987; Zunino 1987; Gibson 1998; Johnson and Braun 1999; Connelly *et al.* 2003; Sedinger *et al.* 2010; Gibson *et al.* 2011; Reese and Connelly 2011). Results have been contradictory. For example, Braun (1987, p. 139) found that harvest levels of 7 to 11 percent had no effect on subsequent spring breeding populations. Johnson and Braun (1999, p.83) determined that overwinter mortality correlated with harvest intensity in North Park, Colorado, and hypothesized that hunting mortalities may be additive. In Montana, Moynahan *et al.* (2006, p. 1536) found that survival was lower in an area that allowed hunting compared to another area where hunting was closed, but noted that the effect could not be attributed hunting alone. Sedinger *et al.*(2011, p. 324–325) examined variation in survival of sage-grouse in Nevada and California and concluded that even if harvest was an additive source of mortality, other sources of mortality were more important in determining annual survival. They are likely the result of differing methods, study design, an absence of experimental data, and differing effects of hunting mortality due to a relationship between hunting mortality and habitat quality.

Female survival is a key element driving sage-grouse population growth (Taylor *et al.* 2012, p. 336), yet hunting can be biased towards females (adults and juveniles). For example, hunting was responsible for 42 percent of adult female mortality and for only 15 percent of adult male mortality in Idaho (Connelly *et al.* 2000b, p. 228). A recent examination of 60,132 wings collected in Colorado and Oregon over the periods, 1973–1998, and 1993–2013, respectively (Braun *et al.* 2015, p. 2) also showed the harvest was female-biased. However, because it is not clear how well these data correlate with actual population structure, this information alone cannot be used to definitively determine the percentage of the female population that experiences annual hunting mortality. The degree and impact of potentially selective hunting of females has not been examined in sage-grouse, but could have measureable and likely negative impacts on the populations.

The levels of hunting mortality (expressed as a percent of the estimated fall population) suggested as compensatory (sustainable) for sage-grouse vary from 10 percent (Connelly *et al.* 2000a, p. 976) to 30 percent (Autenreith 1981, p. 77). State wildlife agencies currently attempt to keep hunting mortality below 10 percent of the estimated fall population, based on recommendations by Connelly *et al.* (2000a,

p. 976). However, the level of hunting mortality has not been experimentally tested with regard to its impacts on sage-grouse populations. There is a growing body of evidence that suggests sage-grouse populations in relatively poor habitats (i.e., isolated, fragmented, closer to urban centers) have a limited ability to withstand levels of hunting mortality that would have little or no impacts on populations in higher quality habitats (i.e., contiguous, relatively mesic habitats) (Gibson 1998, p. 15; Connelly *et al.* 2003, pp. 256–257; Reese and Connelly 2011, p. 109). For example, research conducted in Idaho showed that sage-grouse populations experiencing relatively higher levels of hunting mortality had slower population growth rates than populations experiencing light or no hunting mortality (Connelly *et al.* 2003, pp. 256–257). The effect was particularly pronounced in xeric habitats near human populations, suggesting the impact of hunting on sage-grouse, to some extent, depends on habitat quality.

The continued lack of rigorous experimental data makes a decisive determination about the impacts of hunting mortality on sage-grouse population dynamics at a rangewide scale difficult. Hunting mortality is likely neither totally additive nor totally compensatory but falls somewhere in between (Robertson and Rosenberg 1988, cited in Christiansen 2010, p. 6). For sage-grouse at a rangewide scale the ability of populations to withstand specific levels of hunting mortality likely varies both spatially and temporally depending on a number of factors, including population size and habitat quality and quantity. Adaptive management of recreational hunting offers the best approach to dealing with the uncertainty related to the impacts of hunting.

Location and Extent

In 2014, recreational hunting of sage-grouse took place in 8 of the 11 States where sage-grouse occur. States with the largest sage-grouse populations historically and currently have the highest average percentage of hunting mortality (Table 2). From 2010 to 2013, the majority (93 percent) of reported hunting mortality occurred in Wyoming, Idaho, Montana, and Nevada (in portions of Management Zones I, II, III, and IV). Rangewide hunting mortality has steadily declined over the decades. Average annual hunting mortality this decade is 34 percent lower than the previous decade (Table 1). An examination of possession limits in areas open to hunting in 1995 versus 2013 shows a marked decrease in potential hunting pressure (Figure 20-1). Possession limits do not necessarily correlate directly with hunting mortality and are being considered here only as a proxy of potential hunting pressure.

Table 20-2: Average percent of total rangewide harvest by State in recent decades (Service 2015).

Decade	WY	ID	MT	NV	UT	CO	OR	CA	ND	SD	WA
1960s	35	23	27*	4	5	2*	3	**	**	**	1
1970s	27	30	19	8	8	5	1	**	**	0.01*	0.44
1980s	40	23	14	6	9	8	0.08	0.08*	0.02	closed	0.18
1990s	28	32	12	10	10	7	1	0.33	0.02	closed	closed
2000s	36	23	15	15	4	3	3	0.46	0.05	0.05	closed
2010-2013	44	13	14	21	3	2	3	0.09*	closed	0.04	closed

* Limited data available
** No data available

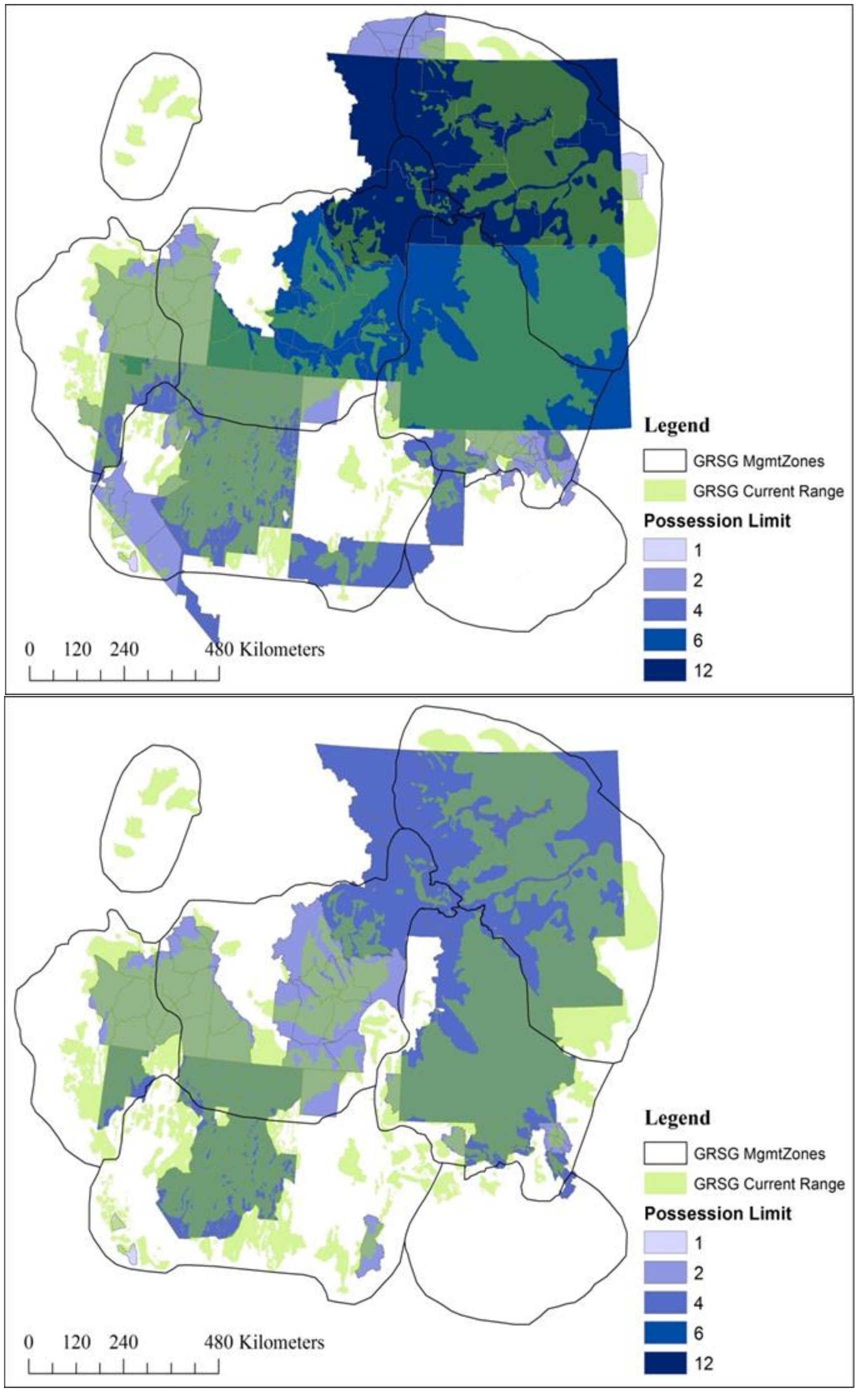

Figure 20-1. Possession limits for State managed sage-grouse hunting seasons in 1995 and 2013.

Large portions of Montana were closed to hunting in 2014, which is not captured in Figure 20-1. It is important to note that not all populations experience the same degree of hunting pressure and some populations may receive little to no hunting pressure. Mortality is not distributed uniformly throughout any of the MZs, but is dependent State management, land ownership, and accessibility of the area. Public lands in close proximity to urban centers and roads likely receive greater hunting pressure than more remote areas. Populations on private lands may experience very limited to no hunting pressure at all. Hunters must obtain landowner permission to hunt on private lands; permission may be very limited or denied entirely. If permission is granted, hunters are still required at a minimum to follow State regulated season limits. The percent of private lands in the occupied sage-grouse range is substantial and varies by MZ (Table 20-3). We do not have quantitative information on the number of landowners that allow public hunting access.

Table 20-3. Private land ownership in occupied range of greater sage-grouse.

Management Zone (MZ)	Acres	Hectares	Percent of MZ
I	31,631,870	12,800,964	69
II	13,817,812	5,591,870	37
III	3,795,323	1,535,913	13
IV	11,563,874	4,679,734	30
V	3,370,259	1,363,895	17
VI	1,720,767	696,370	62
VII	291,453	117,947	25

Sage-grouse hunting is regulated by State wildlife agencies. Hunting seasons are reviewed annually at which time States can adjust harvest management based on updated population information and adaptive management criteria established in state wildlife management plans (e.g. the recent closure of hunting in portions Montana where the population fell below established thresholds [Wightman 2014, pers. comm]). Emergency closures also occur in response to low lek counts, significant habitat impacts between season setting and the start of hunting, or other concerns (e.g., projected wildfire probability, West Nile virus) (e.g., Bohne 2003, pp.1¬10). As knowledge of the potential impacts of recreational hunting has increased, States have adopted more conservative hunting seasons and an adaptive management approach at the population level.

Projected Future Impacts

Timescale for Projecting Impacts from Hunting

Because States make adjustments annually, it is difficult to make accurate predictions about specific levels of hunting mortality into the future. However, given the downward trend in hunting mortality reported over the last several decades, we anticipate mortality rates will continue at levels similar to or lower than current levels.

Likelihood of Future Impacts

States are unlikely to end sage-grouse hunting for several reasons: (1) States have a long cultural tradition of recreational hunting of sage-grouse; (2) States are confident that current adaptive management strategies are adequate to avoid additive hunting mortality that can result in population level declines in sage-grouse; (3) States recognize the value of population information gained through hunter surveys and wing collection barrels and contend that the information would be more difficult and expensive to obtain by other methods; and (4) License fees provide revenue for State management and conservation of sage-grouse. There is a degree of political uncertainty about the continuation of recreational hunting due to wide-ranging public views on the role of hunting for a candidate species (e.g., Christiansen 2010, p. 14; Frost 2010; Brean 2014; Darling 2014; Moore 2014; Smith 2014; South Dakota Game, Fish, and Parks 2014). Despite this discussion we anticipate that recreational hunting will likely continue in those states with current hunting seasons and at present or reduced levels throughout the range of sage-grouse. An increase in the number of sage-grouse hunters in Utah after our 2010 finding was attributed in part to the desire to obtain a "trophy species" (Guttery et al. in press, p. 5). We have no data from the rest of the range suggesting this is occurring elsewhere.

Threat Amelioration

All States with sage-grouse hunting seasons have adopted an adaptive management approach to sage-grouse hunting. Information on population size, trends, and structure along with knowledge of current local habitat conditions is used to make any adjustments to the hunting season necessary to reduce the potential for additive mortality. Seasonal adjustments take the form of changes to the number of permits issued, changes to the season length or bag limit, or total closure of the hunting season.

All of the States where hunting sage-grouse is legal manage harvests on a regional or population scale rather than applying State-wide limits. Bag limits and season lengths are relatively conservative compared to prior decades (Connelly 2005, p. 9; Gardner 2008, pers. comm.; Service 2014, unpublished data). Emergency closures, changes in permits numbers, and implementation of more conservative hunting seasons have been used for populations in decline or in areas experiencing other issues of potential concern (Budeau 2014, pers. comm.; Christiansen 2014, pers. comm.; Espinosa 2014, pers. comm.; Griffin 2014, pers. comm.; Moser 2014b, pers. comm.; Robinson 2014, pers. comm.; Wightman 2014, pers. comm.).

The current management strategy employed by the States is more conservative than management approaches taken in past decades. Rangewide, hunting seasons are more conservative than in the past which has resulted in a significant reduction in sage-grouse hunting mortality across all sex and age classes (Service 2014, unpublished data). Many States have reported estimated hunting mortality to be lower than the 10 percent mortality cap recommended by Connelly *et al.* (2000a; p. 976) (Christiansen 2010, p. 12; Budeau 2014, pers. comm.).

Threat Summary

States have adopted an adaptive management approach that is structured to allow for a timely reduction or cessation of hunting pressure on populations in decline. Adaptive management requires that States maintain detailed knowledge of population size and dynamics. To date, changes in the management of sage-grouse hunting have resulted in a significant reduction in sage-grouse hunting mortality rangewide. As a result of the flexibility in managing harvest, recreational hunting at current levels likely does not pose a significant threat to the species.

CHAPTER 21: SCIENTIFIC AND EDUCATIONAL PURPOSES

Scientific Research and Monitoring

Sage-grouse are the subject of many scientific research studies and monitoring efforts. We are aware of over 50 studies ongoing or completed since 2010. Eight of the 11 western States where sage-grouse currently occur and Alberta, Canada reported some type of field studies that included the capture, handling, and subsequent banding, or banding and radio-tagging of sage-grouse. These activities have the potential to negatively impact sage-grouse directly and indirectly.

In 2005, the overall direct mortality rate due to the capture, handling, and/or radio-tagging process was calculated at approximately 2.7 percent of the birds captured (68 mortalities of 2,491 captured). In 2010 a survey of researchers indicated there was little change in direct handling mortality since 2005. Since 2010, direct mortality from capture and handling remains low. For example, Idaho reported 14 capture-related mortalities among 1,606 birds (0.8 percent) trapped and radio-collared from 2010 to 2014.

Researchers have long been aware of potential indirect impacts (e.g., altered behavior, reduced survival) from radio transmitters and various marking methods on wildlife. Changes in technology have likely reduced but not eliminated this potential for sage-grouse. Early transmitters used on sage-grouse were relatively heavy (5 percent or more of a bird's body mass) and during the 1970s to the early 1980s were attached using backpack harness that was later shown to increase the vulnerability of birds to predation (Amstrup 1980, p. 214; Connelly *et al.* 2003, p. 32). The methods now most commonly used to mark and track adult and juvenile sage-grouse include metal legs bands and battery-powered radio transmitters attached around the bird's neck by a necklace usually made of plastic-coated cable. Necklace radio transmitters can have negative impacts to individuals when not attached properly, potentially resulting in suffocation or starvation (citation, p. X). Impacts to males are likely different than those for females because males perform elaborate mating displays that involve the swelling of neck and breast tissues (Gibson *et al.* 2013, p. 773). Based these results, Wyoming no longer permits necklace collaring of male sage-grouse (WYGD 2015, p. 253). Lek attendance of females with necklace radio transmitters does not appear to be affected (Walsh *et al.* 2004, p. 63). Additionally, radio collars do not appear to alter flushing behavior of sage-grouse, which could increase vulnerability to predation (Frye *et al.* 2014, p. 436).

Solar-powered, global positioning system (GPS) satellite transmitters, a more recently developed technology, are now being used on sage-grouse with increasing frequency. The use of GPS transmitters provides information on bird locations multiple times per day and reduces the logistical problems and potential disturbance associated with tracking birds. These transmitters cannot be attached on the neck, but instead are positioned on the rump of the bird and secured with a leg-loop harness. Because of their similarity to backpack-style transmitters used in the past, there are questions about their impact on sage-grouse (CDOW 2013, p. 48).

Despite the potential for negative impacts to individuals from handling and marking, information gained through these methods has directly benefited the species. Information on the location and characteristics of seasonal habitats essential for sage-grouse persistence continues to be collected and used to inform conservation plans for sage-grouse. State conducted annual leks counts provide invaluable information on population status, trends, and population response to disturbance. In recognition of the importance of research to sage-grouse conservation, the COT Report identified the following as an important conservation objective: Prioritize, fund, and implement research to address existing uncertainties (USFWS 2013, p. X).

Translocations

Sage-grouse have been translocated in multiple U.S. States and several Canadian Provinces (Reese and Connelly 1997, p. 235; Alberta Environment and Sustainable Resource Development 2013, p. viii). Over 7,200 birds were translocated between 1933 and 1990 (Reese and Connelly 1997, pp. 235–238). Only 5 percent of the translocation efforts documented by Reese and Connelly (1997, p. 240) were considered successful in producing sustained, resident populations at the translocation sites. From 2003 to 2005, 137 adult female sage-grouse were translocated to Strawberry Valley, Utah and had a 60 percent annual survival rate (Baxter *et al.* 2006, p. 182).

Since 2004, translocation efforts moving sage-grouse to the Washington State have occurred to increase the genetic diversity of the geographically isolated Columbia Basin populations (MZ VI). Since 2006, 155 sage-grouse (from Nevada, Oregon, and Wyoming) were translocated to the Yakima Nation in an effort to reestablish birds to a portion of historical range (Yakima Nation 2015). In addition, a sage-grouse augmentation project from 2004 to 2007 introduced 62 sage-grouse from Oregon and Nevada into the Yakima Training Center population (White 2013, p. 9), with an additional 10 females translocated from southern Idaho in 2014 (Schroeder *et al.* 2014, p. 8). In 2008, Washington Department of Fish and Wildlife (WDFW), in cooperation with the BLM, initiated a project to reintroduce sage-grouse to the Swanson Lakes Wildlife Area in Lincoln County, Washington. While there has been some mortality, and annual mortality for translocated birds are higher than for resident birds (WDFW 2014, pp. 17, 21), translocated birds have now established a lek and successful nests have been documented. The population, however, is still too small to be considered viable and future translocations are planned.

As of 2012, 38 female and 3 male sage-grouse have been translocated from a genetically similar population in Montana to Alberta, Canada (Alberta Environment and Sustainable Resource Development 2013, p. viii). Monitoring of the translocated birds using telemetry is underway, however, the average mortality rate of translocated sage-grouse over 3 years (from 2011 – 2013) was 36.2 percent (Alberta Environment and Sustainable Resource Development 2014, p. 6). This project is in direct response to the steep population decline. Translocation is considered an emergency measure to attempt to prevent extirpation of sage-grouse in Alberta (Alberta Environment and Sustainable Resource Development 2013, p. viii). Future translocations are planned, however Montana is currently unable to supply birds due as population numbers there have fallen below adaptive management threshold values (Wightman 2015 pers. comm).

Given the low numbers of birds that have been used for translocation over many decades and taken from multiple trapping locations, it is unlikely that the removals from source populations have contributed to sage-grouse declines, while the limited success of translocations also has likely had nominal impact on rangewide population trends. Translocations in MZ VI and Canada, however, may be critical for population persistence.

Use for Educational Purposes

Lek viewing occasionally occurs for educational purposes. Lek viewing is limited and does not likely have any measurable rangewide impact on sage-grouse (see ***Recreation*** chapter).

Disease and Predation

CHAPTER 22: DISEASE

Sage-grouse are host to numerous parasites and pathogens (Thorne *et al.* 1982, p. 338; Connelly *et al.* 2004, pp. 10-4 to 10-8; Christiansen and Tate 2011, pp. 114, 115–118). Some of these organisms have played, or may play, a role in population dynamics, mate selection, or juvenile survival (e.g., Honess and Post 1968, p. 12; Boyce 1990, entire; Deibert and Boyce 1997; Dunbar *et al.* 2003, p. 207). The presence of parasites or pathogens is not synonymous with the presence of disease, population-limiting impacts, or population-level threats (Connelly *et al.* 2004, p. 10-3; Christiansen and Tate 2011, p. 114). To date, most parasites and pathogens found in sage-grouse are not known to cause significant, chronic mortality or other adverse impacts to sage-grouse populations (reviewed in Christiansen and Tate 2011, pp. 114, 119–125). Systematic surveys of disease prevalence and specific study of individual parasites and infectious diseases in sage-grouse are lacking, so potential population-level impacts of disease and the role of disease in population decline are poorly known (Connelly *et al.* 2004, p. 10-3; Peterson 2004, p. 46; Christiansen and Tate 2011, pp. 114 and 126; Manier *et al.* 2013, p. 111).

In the early-to-mid 20th century, two diseases had documented population-level effects on sage-grouse: coccidiosis caused by protozoans in the genus *Eimeria*, and tularemia transmitted by ticks in genus *Haemaphysalis*. We do not consider coccidiosis or tularemia to be current threats to sage-grouse. Both of these diseases have been limited to geographically isolated, localized incidents; moreover, no coccidiosis-related mortality in sage-grouse has been recorded since the early 1960s, and the single outbreak of tularemia occurred in Montana in 1932 (Parker *et al.* 1932, p. 480; Scott 1940, entire; Honess and Post 1968, p. 20; Connelly *et al.* 2004, p. 10-4; Christiansen and Tate, 2011, pp. 119, 120. We only know of one disease, West Nile virus (WNv; *Flavivirus* spp.) that currently causes population-level impacts to the species (Christiansen and Tate 2011, p. 122), albeit on a localized scale (Naugle et al. 2004, p. 711; Walker et al. 2004, p. 4 Walker and Naugle 2011, p. 139). The first sage-grouse mortalities from WNv were documented in 2003 (Naugle *et al.* 2004, p. 705). Similar to some other North American bird species (Komar *et al.* 2003, pp. 314–315; McLean 2006, p. 54), sage-grouse are highly susceptible to WNv (Clark *et al.* 2006, p. 18) and outbreaks probably result in mortality rates nearing 100 percent of infected birds (Naugle *et al.* 2004, p. 711; Walker *et al.* 2004, p. 4; McLean 2006, pp. 53–54).

West Nile virus is transmitted among birds mainly through a mosquito-bird-mosquito infection cycle that relies on optimal climate conditions and movement of birds (McLean 2006, p. 52). Sage-grouse have transmitted WNv to each other without an intermediary vector in laboratory conditions as well, however (Cornish 2014, pers. comm.). Direct transmission between sage-grouse is likely to occur in the wild, but its frequency and importance are unknown (McLean 2006, p. 54–55).

Several mosquito species that carry WNv feed on both birds and mammals and occur in western North America (Marra *et al.* 2004, p. 394). One of these, *Culex tarsalis* is the primary vector of WNv in in sage-grouse (Goddard *et al.* 2002, p. 1390; Marra *et al.* 2004, p. 394; Naugle *et al.* 2004, p. 711; Naugle *et al.* 2005, p. 617). Individuals of *C. tarsalis* can disperse as far as 18 km (11.2 mi) (Doherty 2007, p. 17; Walker and Naugle 2011, p. 129 and references therein), which allow them to move between water sources spreading the disease more widely. *C. tarsalis* is capable of overwinter survival and adults can therefore transmit the disease in the early spring, increasing the length of exposure of sgegrouse to potential infection (Nasci *et al.* 2001, entire; Goddard *et al.* 2003, p. 745; Reisen et al. 2006a, entire; Doherty 2007, pp. 19–20). , Female mosquitos can also transmit the virus directly to their offspring (Goddard *et al.* 2003, p. 744) creating more vectors without the complex and inconsistent weather variables necessary for virus and mosquito maturation.

Ambient temperature and availability of surface water where *C. tarsalis* breeds are important components of the WNv transmission cycle in sage-grouse (Walker and Naugle 2011, p. 129). These variables influence seasonal, inter-annual, and spatial patterns in WNv occurrence in the species (Walker and Naugle 2011, p. 131). Low ambient temperature inhibits mosquito activity and virus replication (Naugle *et al.* 2005, p. 621; Reisen *et al.* 2006b, p. 313), thus limiting potential transmission to and among sage-grouse to summer months (mid-May to mid-September), when the warmest temperatures support both rapid development of mosquito larvae and replication of the virus in mosquitoes (Dohm *et al.* 2002, entire; Ciota *et al.* 2014, pp. 56–57). West Nile virus detections and mortalities in sage-grouse typically peak along with temperature in July and August (Walker *et al.* 2004, p. 5; Naugle *et al.* 2005, p. 620; Walker *et al.* 2007b, p. 693). Reduced and delayed WNv transmission in sage-grouse has occurred in years with lower than average summer temperatures (Naugle *et al.* 2005, pp. 620–621; Walker *et al.* 2007b, pp. 694–695).
Because summer temperatures tend to decrease with increasing elevation, mosquito abundance (including that of *C. tarsalis*) also decreases with increasing elevation (Barker *et al.* 2009, p. 288–289). Sage-grouse are not known to have been infected with WNv at elevations higher than approximately 2,300 m (7,546 ft.) above sea level (Walker and Naugle 2011, p. 130); birds using summer habitat at elevations inhospitable to mosquitoes are less likely to contract WNv than bird's downslope (Walker and Naugle 2011, p. 131). The sage-grouse populations in northwestern Colorado and western Wyoming, for example, may currently face relatively low risk of exposure to WNv owing to their occurrence at high elevations (Walker and Naugle 2011, p. 140).

West Nile virus outbreaks in humans are associated with drought conditions and high ambient temperature in spring and summer (Epstein and Defilippo 2001, p. 106), and drought conditions likely increase the probability of WNv outbreaks in sage-grouse as well. When high temperature and drought combine, sage-grouse are concentrated in shrinking mesic habitats or at a dwindling number of water sources, potentially earlier in the year (Schrag et al. 2011, p. 2). Contact between mosquitoes and birds increases, and the risk of WNv transmission and an outbreak among sage-grouse is elevated (Shaman et al. 2005, p.135; Reisen et al. 2006, p. 313; Walker et al. 2007, pp. 694–695; Walker and Naugle 2011, p. 131).

Current Impacts

Sage-grouse infected with WNv are affected rapidly and are likely to die in as few as six days. They remain competent hosts for the disease and can infect others until death (Clark *et al.* 2006, p. 18). Mortality is not inevitable: a very small proportion of infected birds survive, as evidenced by the presence of WNv-specific antibodies in live birds (Walker *et al.* 2007b; Dusek *et al.* 2014; but see Clark *et al.* 2006, p. 17). Antibodies may be heritable (Walker et al. 2007b, p. 694). Mortality rates in experimentally infected birds were very high and most birds die (Clark *et al.* 2006, pp. 17–18). The low proportion of WNv antibodies found in blood samples from thousands of free-ranging sage-grouse suggests that the survival rate among infected birds in the wild is also extremely low (Walker *et al.* 2007b, p. 694; Dusek *et al.* 2014, p. 6). Based on this information, the rate of increasing resistance to

WNv in sage-grouse is likely to low (projected over a 20-year period; Walker and Naugle 2011, pp. 137–139). Rates of WNv infection and the occurrence of outbreaks in sage-grouse are likely to be governed by climate and other conditions that limit mosquito reproduction and virus replication rather than by increasing disease resistance in the birds (Walker *et al.* 2007b, p. 694; Zou *et al.* 2007, p. 417; Walker and Naugle 2011, p. 139).

The duration of immunity in birds that survive WNv infection is unknown (Marra *et al.* 2004, p. 397), as is the rate of sub-lethal or residual effects in sage-grouse. Birds of some other species that survive WNv infection were found 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. 254), all of which can affect survival, reproduction, or both (Walker and Naugle 2011, p. 136). Sage-grouse that survive WNv infection may thus experience low survival subsequently, but reduced productivity or overwinter survival resulting from WNv have not been documented (Walker *et al.* 2007b, p. 694).

In the absence of WNv, mortality in adult sage-grouse in late summer is typically low, therefore mortality pulses caused by WNv during this season may result in additive mortality (Naugle *et al.* 2004, p. 711; Walker *et al.* 2004, p. 3; Naugle *et al.* 2005, p. 620). High mortality rates from WNv deaths can reduce average annual adult survival, a limiting factor in sage-grouse population growth (Johnson and Braun 1999, p. 81; Taylor *et al.* 2012, p. 343). As an example, survival in several populations in Alberta, eastern Montana, and northeast Wyoming declined 25 percent in July and August of 2003 as a result of WNv infection (Naugle *et al.* 2004, p. 711). Population-level impacts also can result from WNv mortality in juvenile sage-grouse by decreasing recruitment into the breeding population the following year (Kaczor 2008, p. 65; Taylor *et al.* 2012, p. 343). This occurred in South Dakota, where WNv mortality rates over two years among juvenile sage-grouse ranged between 6.5 and 71 percent in (Kaczor 2008, p. 63) reducing recruitment the subsequent spring by 2 to 4 percent (Kaczor 2008, p. 65).

Impacts to vital rates can have adverse consequences at the population level (Naugle *et al.* 2005, p. 621), especially for small, isolated populations (Naugle *et al.* 2004, pp. 704, 711; Walker *et al.* 2004, p. 4). At Spotted Horse, Wyoming where WNv was documented in sage-grouse in 2003, counts of males at the five leks comprising one small population declined to the point of no activity (Walker *et al.* 2004, p. 4), and this small population was deemed extirpated by 2005 (Walker and Naugle 2011, pp. 134–135). To date, this is the only documented instance of population extirpation of sage-grouse attributable to WNv. Lek surveys in northeastern Wyoming in 2004 indicated that sage-grouse populations did not decline regionally, although sage-grouse survival rates in July through September of that year were consistently lower in areas with confirmed WNv mortalities than those without (Walker and Naugle 2011, p. 135). Currently about 27 sage-grouse populations are identified as small and isolated (USFWS 2013a, pp. 16–29).

The lower incidence of WNv in 2004 and 2005 rangewide compared with 2003 suggests that key components of WNv transmission (mosquito reproduction and virus replication) are dependent on annual and local conditions, especially temperature and precipitation (as well as the availability of mosquito breeding habitat; Zou *et al.* 2006, p. 1039). This relationship between summer temperature and WNv incidence also was found in other species in the Red River Valley of North Dakota, Minnesota, and Manitoba in 2004 and 2005 (Bell *et al.* 2006, p. 1246). The impacts of the disease to sage-grouse thus are variable from year to year (Naugle *et al.* 2005, p. 621 see Figure 1 in Walker and Naugle 2011, p. 132).

Location and Extent

Specific climatic and habitat conditions are necessary for WNv to occur in sage-grouse. Although WNv is present throughout the range of sage-grouse, on a finer scale the presence of natural and artificial water sources that provide aquatic breeding habitat for *C. tarsalis* influence WNv distribution (Zou *et al.* 2006, p. 1035; Doherty 2007, pp. 60–61). In addition, local, seasonal, and inter-annual variation in prevalence and transmission of WNv are mediated by abiotic factors such as temperature and precipitation, as described above. No rangewide WNv surveillance program for sage-grouse exists, and dedicated studies have been few (e.g., Naugle *et al.* 2005, entire; Walker *et al.* 2007b, entire; Dusek *et al.* 2014, entire). Most of the detailed documentation of WNv in sage-grouse comes principally from sites where radio-tracking studies and chance have yielded carcasses fresh enough for testing. The presence of WNv antibodies in small numbers of live birds in the eastern portion of the range and in southeastern Oregon (described above) indicate only that WNv has occurred in those locations, but again provides no information about infection rates, mortality rates, or when infections took place (Walker *et al.* 2007b, p. 694). Many WNv-related mortalities in sage-grouse likely go undocumented and our knowledge of the locations and extent of WNv occurrence in sage-grouse, described below, is probably incomplete.

Sage-grouse mortality resulting from WNv has been detected in 10 of 11 states and one of two Canadian provinces in the species' range (Tables 22-1, 22-2). To date, no sage-grouse mortality from WNv has been identified in either Washington or Saskatchewan. However, based on known patterns of WNv-related mortalities in Montana and Alberta, sage-grouse are likely to have been infected in Saskatchewan as well (Walker and Naugle 2011, p. 133). The presence of WNv in other species within the range of sage-grouse in Washington suggests that the birds there are likely to be at risk of exposure to the disease (USGS 2014). The lack of documentation is likely an artifact; without dedicated monitoring (and recovery of carcasses while tissues are still suitable for disease assays), WNv occurrence is difficult to document conclusively, and variation in vital rates and other mortality sources can mask the impacts of WNv at the population level (Walker and Naugle 2011, p. 140).

Table 22-1: Distribution by state/province and year of sage-grouse carcasses testing positive for West Nile virus. "X" indicates a minimum of one positive test; no number was reported in these instances

State or Province	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Min. Total
California		3	X								4
Colorado		1		4							5
Idaho				11		X	2				14
Montana	4	2	X	2	2						11
Nevada			X								1
North Dakota			1	1	8						10
Oregon				4							4
South Dakota				2	5						7
Utah	1		1								2

State or Province	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Min. Total
Washington											0
Wyoming	13	4	X	3	1	X	3			2	28
Alberta	5		X								6
Saskatchewan											0
Minimum total	23	10	7	27	16	2	5	0	0	2	92

Table 22-2: Distribution by WAFWA Management Zone of sage-grouse carcasses testing positive for West Nile virus. Totals are minimums; see Table 1

Management Zone	No. WNv-positive Carcasses
I	55
II	12
III	7
IV	14
V	4
VI	0
VII	(N/A)
TOTAL	92

West Nile virus was first detected in in sage-grouse in 2003 (Naugle *et al.* 2004, p. 705). Between 2004 and 2009, annual sage-grouse mortalities confirmed as cases of WNv have been localized and patchily distributed across the range and among years (Table 22-1). Few mortality events have been documented since. While record-breaking high temperatures were favorable for WNv replication and outbreak, the concurrent record-breaking lack of precipitation (NOAA 2012) likely inhibited the life cycle of *C. tarsalis*. However, we caution that no rangewide disease surveillance program exists, and the distribution of documented WNv mortalities in sage-grouse may better reflect monitoring than disease incidence.

Projected Future Impacts (Timescale, Likelihood of Future Impacts and Anticipated Changes from Present)

Currently available future projections of WNv impacts to sage-grouse use a 20-year timeframe and project effects out to the year 2030 (Schrag *et al.* 2010, p. 5; Walker and Naugle 2011, pp. 136–140). This timeframe was not chosen based on measures of certainty associated with the results of model outputs, but rather in order to encompass a meaningful period for implementing and adapting management actions (Schrag *et al.* 2010, p. 5). Therefore we cannot identify a timescale for projecting WNv.

West Nile virus will continue to affect the species because sage-grouse are highly susceptible to the disease, the capacity for the species to develop resistance is thought to be very low (Walker *et al.* 2007b, p.694; Walker and Naugle 2011, p. 139), and options for controlling mosquitoes on a landscape-scale are limited. Characterizing population-level effects of WNv-related mortality (such as changes in population growth-rates) in sage-grouse in the future is complicated by the lack of a surveillance program for the disease, and vital rates that vary widely among populations, such as nest success and juvenile survival (Walker and Naugle 2011, pp. 137–140). However, population modeling experiments using a 20-year timeframe suggest that chronic WNv mortality will contribute to a decrease in population growth rates and only slight increases in the rate of resistance to the disease throughout the sage-grouse's range (Walker and Naugle 2011, pp. 136–139). Significant population declines in North Dakota are attributed in part to a suspected WNv outbreak. Population numbers there have not recovered (Robinson, pers. comm. 2015).

Population-level impacts have potential to increase owing to interaction of disease with other stressors, especially climate change and ongoing habitat loss and degradation (McLean 2006, p. 50; Walker and Naugle 2011, p. 139). Key factors likely to drive future impacts of WNv to sage-grouse include ambient temperature, precipitation, the availability of surface water that provides mosquito breeding habitat, and intrinsic feedback of WNv impacts within sage-grouse populations (e.g., impacts to population growth rates). Ambient temperature is expected to increase in the future across the range of sage-grouse, and annual precipitation, while expected to increase rangewide, will change in seasonality and vary at finer spatial scales. The availability of surface water for breeding mosquitoes will increase if the development of oil and gas extraction, including coal-bed natural gas, continues to increase, especially in the eastern half of the species' range (Naugle *et al.* 2011, p. 490–493; Manier *et al.* 2013, pp. 51, 53, 57).

The long-term response of sage-grouse populations affected by WNv probably will depend on factors that influence exposure and susceptibility, such as temperature, land uses, availability of surface water, and population size (Walker and Naugle 2011 pp. 137–139). Over time (a projected 20-year time-frame), chronic mortality from WNv is likely to have an adverse effect on population growth rates, with small, isolated, or genetically depauperate populations sustaining greater impacts or risking extirpation if outbreaks reduce population size below a threshold where recovery is no longer possible (Walker and Naugle 2011, pp. 137–139, 140). Impacts from WNv can act synergistically with other threats to further reduce population size, connectivity, and/or persistence (Walker *et al.* 2007a, p. 2652; see ***Small Populations*** chapter).

The ongoing proliferation of artificial surface water (and mosquito breeding habitat) in otherwise arid sagebrush-steppe can facilitate the spread of WNv in the range of sage-grouse (Schrag *et al.* 2010, p. 13; Walker and Naugle 2011, p. 132). Small, persistent water sources such as discharge ponds from coal-bed natural gas development, watering infrastructure for livestock, and irrigated agriculture often harbor vegetation conducive to mosquito breeding (Zou *et al.* 2006; Doherty 2007, pp. 60–61, 80–81). Such artificial water sources, notably discharge ponds, have increased significantly in the range of sage-grouse in recent years, resulting in a concomitant increase in persistent breeding habitat for *C. tarsalis* (e.g., Doherty 2007, pp. 58–59). Climate change is projected to affect seasonal and geographic patterns in temperature and precipitation across the range of sage-grouse (see *Climate Change* chapter). In general, ambient temperature is projected to increase (Abatzoglou and Kolden 2011, p. 474; IPCC 2013, pp. 5–6, 20) which will improve breeding conditions for *C. lateralis* and replication conditions for WNv

(Reisen *et al.* 2006, pp. 312–313; Zou *et al.* 2007, p. 5), and result in a longer mosquito and disease-transmission season that begins earlier in the year (Schrag *et al.* 2010, p. 8). A rangewide increase in temperature will also like result in conditions favorable for mosquitoes and WNv transmission in high elevation habitats that currently act as refugia from WNv for sage-grouse (Schrag *et al.* 2010, p. 10).

Like ambient temperature, precipitation across the range of sage-grouse also will be affected by global climate change, but changes in the distribution, timing, and amount of precipitation are projected to be more variable. The distribution of natural breeding habitat for mosquitoes is likely to be altered by rangewide changes in precipitation patterns**.** In areas where climate change is likely to result in decreased precipitation, such as the southern Great Basin (Management Zones III and VII; Abatzoglou and Kolden 2011, p. 474), the distribution and areal extent of natural surface water are likely to decrease as well. This scenario would reduce the availability of breeding habitat for mosquitoes. However, chronic drought would also result in the shrinking or disappearance of natural mesic habitats on which sage-grouse females and broods rely in mid-to-late summer (Connelly *et al.* 2000a, p. 971), thus increasing concentrations of birds at fewer water sources (Connelly *et al.* 2004, p. 10-10). These circumstances are documented to improve conditions for transmission of other parasite-borne diseases as well (Honess and Post 1968, entire; Thorne *et al*. 1982, pp. 108, 112). Such conditions also favor bacterial and fungal infections that are potentially serious but that have only rarely been documented in sage-grouse to date (e.g., *Clostridium perfringens*, *Salmonella* spp., *Mycoplasma* spp., *Mycobacterium avium* (avian tuberculosis), *Pasteurella multocida* (avian cholera), and *Aspergillus fumigatus*; Christensen and Tate 2011, pp. 123–124). The incidence of some or all of these infections could increase under conditions of climate change (Christiansen and Tate 2011, pp. 119, 126).

Threat Amelioration

Recommendations for reducing the risk of WNv to sage-grouse across the range principally involve conservation of large populations at elevations currently higher than mosquitoes and WNv can survive and reproduce (Walker and Naugle 2011, p. 140), and controlling mosquitos and their breeding habitat (Walker and Naugle 2011, pp. 140–141). For example, water produced during coal-bed natural gas development could be re-injected rather than discharged to surface ponds; these ponds and other anthropogenic surface water such as stock tanks and guzzlers can be constructed or managed to reduce their suitability as mosquito breeding habitat (Doherty 2007, pp. 81–84). Water sources known to host breeding *C. tarsalis* can be stocked with *Gambusia* spp. or other fish that feed on mosquito larvae (Doherty 2007, p. 85) or treated with widely used mosquito larvicide (e.g., *Bacillus thuringiensis* v. *israelensis*), which is known to be highly effective in controlling larvae of *Culex* and other mosquitoes (Russell *et al.* 2003, pp. 1788–1789; Doherty 2007, p. 84; reviewed in Lacey 2007, entire) and has been applied experimentally in the Powder River Basin in Wyoming to control *C. tarsalis* (Big Horn Environmental 2009, pp. 4–8; Big Horn Environmental 2011, pp. 22–24; see below). The extent to which irrigated agriculture contributes to mosquito breeding habitat and WNv risk to sage-grouse is not well known (Stiver *et al.* 2006, p. 9-12). In areas where agriculture is deemed to be an important contribution to mosquito breeding habitat, employing practices to ensure that irrigation ditches are clean and drained completely and that flooded fields maintain sufficient water to support mosquito fish can reduce breeding habitat or make it inhospitable to mosquitoes (SYMVCD 2008, pp. 17–18, 21–23). The benefits of widespread pesticide spraying for control of adult mosquitoes must be weighed against the potential adverse impacts to other species (Marra *et al.* 2004, p. 401; Walker and Naugle 2011, p. 141). Finally, intensive monitoring is necessary to shed light on long-term, population-level impacts of

WNv (Walker and Naugle 2011, p.140), and centralized database housing the results of monitoring and research would improve rangewide information-sharing about WNv incidence (Stiver *et al.* 2006, p. 9-21). Montana's draft sage-grosuse conservation plan would outline and encourage voluntary disease management practices on private lands, such as removing mosquito habitat and using the BLM's pond construction report (State of Montana 2014, pp. 17, 20, 27). Some of these BMPs could help reduce local concentrations of mosquitos, if implemented. In addition, lands currently enrolled in CCAAs reduce disease through mosquito treatment and appropriate placement of water sources. Approximately 0.17 percent of occupied range in MZ I, 0.78 percent of MZ II, 2.47 percent of MZ IV, and 4.67 percent of MZ V are enrolled in CCAAs in Wyoming and Oregon. Federal lands enrolled in CCAs in Wyoming, Oregon, and Idaho account for 0.04 percent of occupied range in MZ I, 0.21 percent of MZ II, 3.13 percent of MZ IV, and 4.67 percent of MZ V. See the ***Non-regulatory Conservation Efforts*** section and Table 28-7 for approximate acreages and additional information. Wyoming's state conservation plan addresses WNv by requiring that water managers reduce mosquito breeding habitats by apply larvacide to standing water and design water impoundments with flow-through or aeration.

Actions and Effectiveness

Proactive measures to reduce the impact of WNv on sage-grouse have been limited and are typically economically prohibitive to implement on a landscape scale. To date, management or conservation actions have not been implemented at a scale that would reduce disease incidence or the risk of disease rangewide. Experimental treatments of ponds with mosquito larvicide resulted in greatly reduced numbers of *C. tarsalis* larvae (Big Horn Environmental Consultants 2009, pp. 5–7; Big Horn Environmental Consultants 2011, p. 23) and are promising, but no statistical analyses or feasibility assessment of broad-scale implementation are available. Similarly, in 2014, Chesapeake Energy Corporation instituted a program to test and treat standing water created by oil and gas development in eastern Wyoming (Chesapeake Energy Corporation 2014, p. 2-6) but results are not yet available.

Vaccination, if a WNv vaccine were developed for sage-grouse, is unlikely to be a practicable option for disease management in a free-ranging population. At this time, no such vaccine exists. Experimental vaccination of captive sage-grouse to date has been largely ineffective (mortality rates were reduced from 100 to 80 percent in five birds; Clark *et al.* 2006, p. 17).

Assessment of Potential Threat

With the exception of WNv, we could find no evidence that disease poses a threat to sage-grouse across the species' range. Variable environmental conditions such as climate change and anthropogenic alteration of sage-grouse habitat are likely to cause changes in the incidence of WNv and perhaps in other parasites and pathogens that occur in sage-grouse and in their effects on individual birds or populations. Sub-lethal effects of these diseases and parasitic infections on sage-grouse have never been studied and are unknown. The lack of information about recent incidence or adverse effects of most sage-grouse parasites prevents us from predicting with any confidence what conditions might give rise to changes in their occurrence. Therefore, although we do not currently consider the majority of sage-grouse parasites to be threats to the species, we cannot evaluate their potential to become significant threats within the timeframe of our analysis. When outbreaks occur, the affected sage-grouse populations experience high rates of mortality that can result in reduction in survival and recruitment rates; these impacts are especially significant for small, isolated populations (e.g. Spotted Horse, WY).

Without a comprehensive surveillance program to monitor the re-emergence and spread of WNv, the extent and effects of this disease on sage-grouse rangewide cannot be assessed.

WNv currently is a localized threat that has had significant impacts on small, isolated sage-grouse populations. Currently, 27 sage-grouse populations are thought to be small and isolated (USFWS 2013, pp. 16–29); most of these occur on the periphery of the species' range. Ongoing habitat loss that results in continued fragmentation and isolation of populations has the potential to multiply these local effects of WNv across the species' range. The incidence of WNv is likely to increase across the species' range in the foreseeable future. The most significant factors likely to affect future occurrence are climate change and the abundance and the distribution of anthropogenic surface water. Climatic conditions that support the persistence of WNv within the range of sage-grouse are unlikely to change in the next several decades, and may be exacerbated by climate change.

CHAPTER 23: PREDATION

Sage-grouse are prey and as such predation is the most common cause of direct mortality for sage-grouse during all life stages (Schroeder *et al.* 1999, p. 9; Connelly *et al.* 2000a, p. 228; Connelly *et al.* 2011a, p. 66; Blomberg *et al.* 2013b, p. 347; Caudill *et al.* 2014, p. 808). Sage-grouse have co-evolved with their predators, resulting in the development of cryptic plumage and behavioral adaptations to minimize predation (Schroeder *et al.* 1999, p. 10; Coates *et al.* 2008, p. 69; Coates and Delehanty 2008, p. 635; Hagen 2011, p. 96). Although many generalist predators will consume sage-grouse, most depend predominantly on rodents and lagomorphs and none specialize on the species (Hagen 2011, p. 97). In intact sagebrush landscapes, sage-grouse nest success and adult survival rates are generally high (Hagen 2011, p. 95); however, predation can become a factor limiting population sustainability in places where the habitat quality has been compromised by anthropogenic activities (Gregg *et al.* 1994, p. 165; Coates and Delehanty 2010, p. 246; Lockyer *et al.* 2013, p. 242).

Major predators of adult sage-grouse include many species of diurnal raptors (especially the golden eagle), coyotes (*Canis latrans*), bobcats (*Lynx rufus*), and red foxes (Hartzler 1974, pp. 532-536; Schroeder *et al.* 1999, pp. 10–11; Schroeder and Baydack 2001, p. 25; Rowland and Wisdom 2002, p. 14; Mezquida *et al.* 2006, p. 749; Hagen 2011, p. 97; Orning 2013, p. 18). Juvenile sage-grouse also are killed by several raptor species as well as common ravens, badgers (*Taxidea taxus)*, coyotes, red foxes, weasels (*Mustela* spp.), and snakes (*Pituophis* spp.) (Braun 1995, entire; Schroeder *et al.* 1999, p. 10; Lockyer *et al.* 2013, p. 248). Nest predators include badgers, bobcats, coyotes, striped skunks (*Mephitis frenata*), weasels, common ravens, American crows (*C. brachyrhynchos*), and magpies (*Pica* spp.) (Patterson 1952, p. 62; Aldridge 1998, p. 6; Schroeder and Baydack 2001, p. 25; Coates *et al.* 2008, pp. 424–425; Lockyer *et al.* 2013, entire). Elk and domestic cows (*Bovus* spp.) have been observed eating sage-grouse eggs (Holloran and Anderson 2003, p. 309; Coates *et al.* 2008, pp. 425–426); however, the prevalence of these occurrences is unknown. Video monitoring has shown that upon discovery of a sage-grouse nest, in most cases the cow will sniff the nest contents without consuming eggs (Coates *et al.* 2008, p. 426). Although they are physically incapable of puncturing eggs due to their limited gape width, ground squirrels (*Spermophilus* spp.) sometimes attempt to predate nests but have only been observed successfully accessing an egg on one occasion after the squirrel dropped the egg and broke the shell (Coates *et al.* 2008, p. 425; Lockyer *et al.* 2013, p. 250). Other small mammals and snakes (*Crotalus viridus* and *Pituophis* spp.) have been observed visiting sage-grouse nests, but none resulted in egg predation events seemingly due to insufficient gape width (Coates *et al.* 2008, p. 425; Connelly *et al.* 2011a, p. 65; Lockyer *et al.* 2013, pp. 248–250).

Sage-grouse mortality rates due to predation vary widely by location and year, and short-term studies are often not representative of population dynamics for the species across the range (Taylor *et al.* 2012, p. 337). Predation causes between 52 and 90 percent of all sage-grouse deaths (Connelly *et al.* 2000a, p. 228; Blomberg *et al.* 2013a, p. 152; Blomberg *et al.* 2013b, p. 347; Caudill *et al.* 2014, p. 811). Predation of adult sage-grouse is low outside the lekking, nesting, and brood-rearing seasons (Connelly *et al.* 2000a, p. 230; Naugle *et al.* 2004, p. 711; Moynahan *et al.* 2006, p. 1536; Hagen 2011, p. 97). Adult male sage-grouse are susceptible to predation on the lek, presumably because male sage-grouse are conspicuous while performing their mating displays (Schroeder *et al.* 1999, p. 10; Schroeder and Baydack 2001, p. 25; Aspbury and Gibson 2004, p. 1127-1128; Hagen 2011, p. 97). Because leks are attended daily by numerous sage-grouse, predators also may be attracted to these areas during the breeding season. Adult female sage-grouse are susceptible to predators while on the nest (Connelly *et al.*

2000a, p. 227; Hagen 2011, p. 97). Females will abandon their nest when disturbed by predators (Patterson 1952, p. 110), likely reducing this mortality (Hagen 2011, p. 97), but resulting in nest loss. However, females that nest successfully appear to be more susceptible to predation than females that are unsuccessful (Blomberg *et al.* 2013a, p. 154; Davis *et al.* 2014, p. 1350). Causes for the increased levels of predation on successful nesters are widely speculated (Schroeder *et al.* 1999, p. 10; Dawson *et al.* 2000, p. 2097; Hanssen *et al.* 2005, p. 1044; Davis *et al.* 2014, p. 1350), including hens defending nests or chicks and increased visibility during early brood rearing.

Estimates of predation rates of juvenile sage-grouse are limited due to the difficulties in studying this age class (Aldridge and Boyce 2007, p. 509; Hagen 2011, p. 98), but appear to be variable. Mortality due to predation during the first 28 days after hatching has been estimated to be 82 percent (Gregg *et al.* 2007, p. 648), but juvenile sage-grouse greater than 10 weeks of age experience comparatively low mortality (14 to 36 percent) (Beck *et al.* 2006, p. 1075; Caudill *et al.* 2014, p. 808). Juveniles that migrate greater distances to winter habitat may experience lower survival due to increased exposure to predators (Beck *et al.* 2006, p. 1076). Based on partial estimates from three studies, Crawford *et al.* (2004, p. 4 and references therein) reported survival of juveniles to their first breeding season was low, approximately 10 percent, and predation was one of several factors they cited as affecting juvenile survival. However, Connelly *et al.* (2011a, p. 64) pointed out that the estimate of 10 percent is likely biased low, as at least two of the four studies that were the basis of this estimate were from areas with fragmented or otherwise marginal habitat.

Sage-grouse nests are also subject to varying levels of predation. Because nest success is affected by predator effectiveness as well as densities (Coates and Delehanty 2010, p. 246; Doherty *et al.* 2014, pp. 322–323), nest success can vary by as much as 30 percent at the same site over consecutive years (Taylor *et al.* 2012, p. 342). Most sage-grouse nest success rates are greater than 40 percent (Connelly *et al.* 2004, p. 10-1; Connelly *et al.* 2011a, p. 63), and depredations represent only a portion of nest failures (Patterson 1952, p. 104; Holloran and Anderson 2003, p. 309; Moynahan *et al.* 2007, p. 1777). However, inflated levels of predation due to poor nesting habitat (e.g., areas lacking tall grass and medium height shrub cover) have been shown to be detrimental to sage-grouse nesting success rates (Gregg 1991, p. 30; Gregg *et al.* 1994, p. 165; Connelly *et al.* 2011a, pp. 63-64). In two recent studies in northwestern Nevada (Lockyer *et al.* 2013, p. 252) and central Wyoming (Webb *et al.* 2012, p. 7), where habitat alterations have boosted predator populations, researchers found that at least 64 and 68 percent of nests, respectively, failed due to predation. Nest predation can be total (all eggs destroyed) or partial (one or more eggs destroyed), but females usually abandon their nests in both cases (Coates 2007, p. 26; Lockyer *et al.* 2013, pp. 246–248). Renesting efforts may compensate for some of the nest failures due to predation (Schroeder 1997, p. 938), but renesting rates are highly variable (Connelly *et al.* 2011a, p. 64; Lockyer *et al.* 2013, Table S1) ranging between 9 and 43 percent (Connelly *et al.* 2011a, p. 56 and references therein; Taylor *et al.* 2012, p. 340; Davis *et al.* 2014, p. 1351). Therefore, renesting is unlikely to completely offset losses from initial nest failure.

Predation has historically been the primary source of sage-grouse mortality (Schroeder *et al.* 1999, p. 9; Connelly *et al.* 2000, p. 228; Connelly *et al.* 2011, p. 66), but the increased habitat fragmentation and development that began across the sagebrush-steppe in the late 19th century (West 1996, p. 334) has caused predator dynamics to change (Fichter and Williams 1967, p. 225; Baxter *et al.* 2007, p. 266; Coates and Delehanty 2010, p. 240 and references therein). For this landscape scale species, decreasing habitat quality and quantity has created a situation in which the sage-grouse is more vulnerable to predation (Connelly *et al.* 1991, p. 524; Coates 2007, p. 38–39; Hagen 2011, p. 96). Impacts including agricultural development, landscape fragmentation, and encroaching human populations have the potential to increase predation pressure on sage-grouse if sage-grouse to nest in less suitable or marginal habitats, increasing travel time through habitats where they are vulnerable to predation, and increasing the diversity and density of predators (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 and Delehanty 2010, p. 246; Dinkins *et al.* 2014a, p. 639). Degraded and fragmented landscapes can benefit predators by increasing their kill efficiency, as well as subsidizing their food and nest or den substrate (Hagen 2011, p. 100). These habitats also provide limited concealment cover for sage-grouse nests and young, and result in a greater likelihood of predation, especially by visual predators such as ravens (Coates and Delehanty 2010, p. 245; Webb *et al.* 2012, p. 11) whose abundance in fragmented habitats has increased substantially (Coates and Delehanty 2010, p. 244 and references therein; Coates *et al.* 2014, p. 350; Sauer *et al.* 2014,p. X).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; DeLong *et al.* 1995, p. 91; Schroeder and Baydack 2001, p. 28; Coates 2007, p. 2; Hagen 2011, p. 98).

Current impacts

Sage-grouse female mortality, chick mortality, and nest failure are the primary mechanisms impacting sage-grouse population growth directly (Aldridge and Brigham 2001, p. 542; Beck *et al.* 2006, p. 1076; Baxter *et al.* 2008, p. 185; Taylor *et al.* 2012, p. 343; Dinkins *et al.* 2014b, p. 319). Nest success and chick survival are essential to population recruitment, and failure in either stage can impact annual productivity (Crawford and Lutz 1985, p. 73; Schroeder and Baydack 2001, p. 26; Beck *et al.* 2006, p, 1076; Dinkins *et al.* 2012, p. 600; Lockyer *et al.* 2013, p. 242). Juvenile mortality due to predation may be limiting population growth in some locations (Caudill *et al.* 2014, p. 808). Compared to other upland game birds, adult sage-grouse are expected to have higher survival rates and lower productivity, and therefore loss of long-lived individuals can influence population dynamics (Connelly *et al.* 2011a, p. 66; Taylor *et al.* 2012, p. 337).

Although increased predator densities are associated with increased predation rates (Coates and Delehanty 2010, p. 244; Coates *et al.* 2014, p. 350; Dinkins *et al.* 2014a, p. 640), the relatively high levels of predation observed in some areas are thought to be caused by an increase in predator diversity (Baxter *et al.* 2007, p. 259; Coates *et al.* 2014, p. 241). Abundance of red foxes, raccoons, and corvids, which historically were rare in the sagebrush landscape, has increased in association with human-altered landscapes (Johnson and Cassidy 1997, p. 222; Sovada *et al.* 1995, p. 5; Luginbuhl *et al.* 2001, p. 570). Raven occupancy can be deleterious to sage-grouse nest success (Bui *et al.* 2010, p.74) because ravens are visual predators that are most successful in degraded habitat with reduced canopy cover (Coates and Delehanty 2010, p. 245). Ranches, farms, and housing developments have resulted in the introduction of nonnative predators including domestic dogs (and cats (*Felis domesticus*) into sage-grouse habitats (Connelly *et al.* 2000b, p. 975; Connelly *et al.* 2004, p. 7-24). The addition of these predators on the landscape is an important change because generalist predators can have an additive effect on sage-grouse mortality due to the shared-predation hypothesis (Hagen 2011, p. 98) in which the combined effort of indiscriminant predators results in higher than average predation rates (Norrdahl and Korpimäki 2000, p. 529). While the presence or density of predators does not necessarily lead to increased mortality rates (Abrams 1993, p. 726), it is the synergistic relationship between new predator species, increased predators abundance, and habitat degradation that may influence sage-grouse populations.

Raven abundance has increased as much as 1,500 percent in some areas of western North America since the 1960s (Coates and Delehanty 2010, p. 244 and references therein; Sauer *et al.* 2014, p. X). Local attraction of ravens to nesting females may be facilitated by loss and fragmentation of native shrublands, which increases exposure of nests to potential predators (Aldridge and Boyce 2007, p. 522; Bui 2009, p. 32). The presence of ravens is negatively associated with sage-grouse nest and brood fate (Bui 2009, p. 27; Coates and Delehanty 2010, p. 244; Lockyer *et al.* 2013, p. 250). Anthropogenic structures in the environment increase the abundance of avian predation, particularly in low canopy cover areas, by providing ravens and raptors with hunting perches (Coates 2007, p. 155; Bui 2009, p. 2; Coates *et al.* 2014, p. 352). Development, including oil and gas infrastructure, residential houses, communication towers, power lines, fences, and trees, provide perching and nesting habitat for predatory birds (Dinkins *et al.* 2012, p. 320). Trash, landfills, and road-kill have the potential to subsidize predator food sources, especially ravens (Kristan III *et al.* 2004, p. 250). In southern Wyoming, lower survival rates of female sage-grouse were associated with greater power line density (Dinkins *et al.* 2014b, p. 323). Reduction in patch size and diversity of sagebrush habitat are also likely to encourage the presence of the ravens (Coates *et al.* 2008, p. 426; Bui 2009, p. 4; Coates *et al.* 2014, p. 352). As more suitable sage-grouse habitat is converted to and impacted by oil fields, agriculture, and other exurban development, sage-grouse nesting and brood-rearing become increasingly spatially restricted (Bui 2009, p. 32). High sage-grouse nest densities, which result from habitat fragmentation or disturbance associated with the presence of edges, fencerows, or trails may increase predation rates because predators can more efficiently locate prey in these environments (Holloran 2005, p. C37; Holloran and Anderson 2005, p. 748). Pairs of territorial breeding ravens have been observed to predate two to three sage-grouse nests in a single nesting season, though this observation is likely to be lower than the actual total due to the opportunistic nature of the study (Howe and Coates 2014, pp. 2–3). The majority of depredations by ravens are likely caused by territorial breeding pairs rather than nonbreeding transient individuals (Bui *et al.* 2010, p. 74; Howe and Coates 2014, pp. 2–3).

Sage-grouse nest predation rates are related to the amount of herbaceous cover surrounding the nest (Gregg *et al.* 1994, p. 164; Braun 1995; DeLong *et al.* 1995, p. 90; Coggins 1998, p. 30; Connelly *et al.* 2000a, p. 975; Schroeder and Baydack 2001, p. 25; Coates *et al.* 2008, p. 636; Wing 2014, p. 21). Nest site characteristics, such as greater shrub cover, are essential for preventing predation by avian predators (Gregg *et al.* 1994, p. 164; Webb *et al.* 2012, p. 11). Nesting success of female sage-grouse is negatively correlated with reduced shrub canopy cover (Coates and Delehanty 2010, p. 245) and positively correlated with the presence of big sagebrush and grass and forb cover (Connelly *et al.* 2000a, p. 971). However, Coates (2007, p. 149) found that badger predation was facilitated by nest cover as it attracts small mammals, a badger's primary prey. Females actively select nest sites with a greater proportion of big sagebrush within the localized area (Schroeder and Baydack 2001, p. 25; Hagen *et al.* 2007, p. 46; Kirol 2012, p. 4; Dinkins *et al.* 2014a, p.639). However, site fidelity patterns may prevent sage-grouse from moving great distances to nest, even after failed nesting attempts (Holloran *et al.* 2010; Naugle *et al.* 2011). Adult birds may delay leaving habitats that are no longer suitable due to anthropogenic development and increased predator abundances, while yearling birds may be more flexible in shifting nesting location (Dinkins *et al.* 2014a, p. 638).

Sage-grouse mortality due to predation has likely had major population level effects in fragmented habitats and areas with human-subsidized predator populations (Hagen 2011, p. 95), especially within MZs III, VI, and VII (USFWS 2013, pp. 16–29). Decreased sagebrush abundance and distribution, which is known to lead to low nest success (see above), is associated with extirpation of the species (Wisdom *et al.* 2011, p. 465). Continually low productivity levels can lead to reduced annual recruitment and prevent population sustainability (Allen 1962). Sage-grouse populations with apparent nest success rates lower than 30 percent and female annual survival rates lower than 45 percent are considered sink populations that could become extirpated if conservation measures are not implemented (Hagen 2011, p. 100).

High predator abundance within a sage-grouse nesting area may negatively affect sage-grouse productivity without causing direct mortality. The increase in the numbers of corvids within the sagebrush ecosystem is an important change because sage-grouse nests are at greater risk of predation by these visual predators (Conover *et al.* 2010, p. 335). Even low but consistent raven presence can influence sage-grouse reproductive behavior (Bui 2009, p. 32; Dinkins *et al.* 2012, p. 606). Sage-grouse females tend to select nest and brood-rearing locations that are farther away from predator perches and have lower densities of avian predators (Dinkins *et al.* 2012, p. 606; Dinkins *et al.* 2014a, p. 637). When nesting in areas with relatively higher abundances of ravens, females reduce the amount of time they spend off their nests, potentially compromising their ability to secure sufficient nutrition to complete the incubation period (Coates and Delehanty 2008, p. 636).

Location and Extent

Predation is the primary source of natural mortality across the range of the sage-grouse (Schroeder *et al.* 1999, p. 9; Connelly *et al.* 2000a, p. 228; Connelly *et al.* 2011a, p. 66; Blomberg *et al.* 2013b, p. 347; Caudill *et al.* 2014, p. 808). Landscape fragmentation and habitat loss is likely contributing to increased predation on this species. Data are lacking that definitively link sage-grouse population trends with predator abundance. At the rangewide scale, predation is not believed to be a widespread factor limiting sage-grouse population growth (Connelly *et al.* 2000b, p. 975; Connelly *et al.* 2004, p. 10-1). However, in localized areas where habitat is compromised by human activities, predation could be limiting local sage-grouse populations (Coates 2007, p. 131; Bui 2009, p. 33; Lockyer *et al.* 2013, p. 242).

In the Wyoming Basin, the influence of predators on survival and nest success may be significant, as this area has one of the few remaining intact sagebrush landscapes and the most highly connected network of sage-grouse leks (Knick and Hanser 2011, p. 391; Wisdom *et al.* 2011, p. 464). Raven abundance has increased in association with oil and gas development in western Wyoming, and ravens utilize road networks for foraging activities (Bui *et al.* 2010, p. 74). Holloran (2005, p. 58) attributed increased sage-grouse nest depredation to high corvid abundances in western Wyoming, which resulted from anthropogenic food and perching subsidies in areas of natural gas development. Raven abundance was also strongly associated with sage-grouse nest failure in Nevada, resulting in negative effects on sage-grouse reproduction (Coates 2007, p. 130; Lockyer *et al.* 2013, p. 242). Studies on increasing raven populations have also been recently conducted in Idaho (Coates *et al.* 2014; Howe *et al.* 2014) and central Utah (Conover *et al.* 2010), indicating that inflated raven populations may be becoming a widespread issue.

Mammalian predators and ravens are suspected of causing sage-grouse population decline and extirpation in Washington (Schroeder *et al.* 2014, p. 10). When sage-grouse were first reintroduced to the Crab Creek Management Unit in Lincoln County, Washington in 2008, sage-grouse experienced 92 percent mortality within six weeks of being released, primarily due to predation (Schroeder *et al.* 2008, pp. 11–12). Subsequent management activities addressed issues related to predation (including removing anthropogenic structures and managing predator populations near leks) and the population appears to be persisting (Schroeder *et al.* 2014, pp. 19, 22). Predator control efforts were conducted as a short-term management strategy to aid in the establishment of the reintroduced population (Schroeder *et al.* 2014, pp. 22, 24). Research on predators has not been conducted to determine if predation is limiting population growth outside of Crab Creek, but elevated rates of predation are expected to occur in other areas that have been fragmented by agriculture and anthropogenic features such as roads and fences (Schroeder *et al.* 2000, pp. 10–11).

In the Strawberry Valley of northwestern Utah where major habitat losses have occurred, low survival of sage-grouse may have been due to an unusually high density of red foxes, which were attracted to the area by human-subsidized food sources (Bunnell 2000, p. 45). Red foxes are suspected to be the primary cause of almost complete reproductive failure observed in the late 1990s (Bunnell 2000, pp. 36–37), and a predator-management program was put in place in 1999 through at least 2012 to reduce red fox, coyote, and raven populations (Bunnell 2000, p. 41; Baxter *et al.* 2009, p. 481; USDA 2013). More recent studies have shown that nest success rates may have improved and it is unclear if predation is currently limiting population growth (Baxter *et al.* 2013, p. 424).

Projected Future Impacts

Timescale for Projecting this Threat

Due to growing evidence of the difficulty and length of time required to restore sagebrush ecosystems (West *et al.* 1984, p. 262; Baker 2006, p. 177; Beck *et al.* 2009, p. 393; Morris *et al.* 2011, p. 494), we believe that elevated rates of predation as a result of degraded habitat and landscape fragmentation are expected to continue indefinitely in those areas. In some cases, natural sagebrush-steppe recovery can take from 14 to 32 years (Lesica *et al.* 2007, p. 266; Beck *et al.* 2009, p. 393) to upwards of 90 years (Baker 2006, p. 177; Morris *et al.* 2011, p. 494). . Until recovery actions have time to be successful, degraded habitats can act as population sinks where sage-grouse continue to be attracted but elevated predation rates cause the sage-grouse to have poor recruitment (Aldridge and Boyce 2007, p. 517-518).

Likelihood of Future Impacts

Because sage-grouse are prey, predation will continue to affect the species. Where habitat is not limited and is of good quality, predation is not a threat to sage-grouse persistence. However, the likelihood of elevated levels of predation continuing in areas where sage-grouse habitats have been impacted is high. As more habitats face development, we expect the risk of predation to increase, possibly with negative effects on sage-grouse population trends (Howe *et al.* 2014, p. 46). Except in places where conservation measures (e.g., removal of anthropogenic structures, restoration of degraded habitat, etc.) are initiated, sage-grouse that exist along the fringe of the species' range or in degraded habitats are expected to experience increased levels of predation due to continued influence from anthropogenic activities (Hagen *et al.* 2011, p. 100).

Anticipated Changes from Present

Sage-grouse may be subject to increasing 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 (e.g., exurban development, road development) (Coates 2007, pp. 154–155; Bui 2009, p. 16; Hagen 2011, p. 100), and we expect these indirect threats to continue to become more widespread in sagebrush habitats across the western states (see ***Infrastructure*** and ***Exurban Development*** chapters). Anthropogenic impacts on sagebrush habitats that increase suitability for ravens may limit local sage-grouse populations (Bui 2009, p. 32). Current land use practices in the intermountain West favor high predator (in particular raven) abundance relative to historical numbers (Coates *et al.* 2008, p. 426). In Utah, Wildlife Services has increased the number of ravens targeted with poison bait each year and ravens continue to depredate sage-grouse nests (UDWR 2015, pp. 71–72, 91–92.) The interaction between changes in habitat and predation may have substantial effects at the landscape level (Coates 2007, p. 3). As avian predators become more abundant, high-quality nesting and brood-rearing habitat for sage-grouse will likely become more limited (Bui *et al.* 2010, p. 74; Dinkins *et al.* 2012, p. 607).

Threat Amelioration

Maintaining large areas of intact sagebrush is widely recognized as being critical to ensuring the long-term viability of sage-grouse populations (Aldridge *et al.* 2008, p. 990-92; Connelly *et al.* 2011b, p. 560; Taylor *et al.* 2012, p. 344). In their review of literature regarding predation, Connelly *et al.* (2004, p. 10-1) noted that only two of nine studies examining survival and nest success indicated that predation had limited a sage-grouse population by decreasing nest success, and both studies indicated low nest success due to predation was ultimately related to poor nesting habitat. Conservation measures can limit the effects of predation by preventing habitat fragmentation caused by transmission lines, roads, and nonnative vegetation (Howe *et al.* 2014, p. 46). Elevated predation rates can also be prevented by restoring vegetative cover and reducing perches and food subsidies for predators (Bui 2009, pp. 36–37; Coates and Delehanty 2010, p. 246; Leu and Hanser 2011, p. 27; Taylor *et al.* 2012, p. 344; Lockyer *et al.* 2013, p. 252). Restoring connectivity in fragmented landscapes to reduce the amount of edge associated with patchy habitat may reduce the effects of avian predators, such as ravens (Howe *et al.* 2014, p. 46). Lands currently enrolled in CCAAs have requirements to remove predator attractants and perches. Approximately 0.17 percent of occupied range in MZ I, 0.78 percent of MZ II, 2.47 percent of MZ IV, and 4.67 percent of MZ V are enrolled in CCAAs in Wyoming and Oregon. Federal lands enrolled in CCAs in Wyoming, Oregon, and Idaho account for 0.04 percent of occupied range in MZ I, 0.21 percent of MZ II, 3.13 percent of MZ IV, and 4.67 percent of MZ V. See the ***Non-regulatory Conservation Efforts*** section and Table 28-7 for approximate acreages and additional information.

Predator removal programs are often suggested in response to inflated predation rates (Coates and Delehanty 2010, p. 246; Connelly *et al.* 2000b, p. 976). Studies assessing the effectiveness of predator control have failed to demonstrate an inverse relationship between predator numbers and sage-grouse nesting success or breeding population numbers (Slater 2003, p. 132; Orning 2013, p. 40). Predator removal programs can have short-term gains that may benefit small populations (Lawrence and Silvy 1995, p. 275; Coates and Delehanty 2004, p, 19). Predator removal may have greater benefits in areas with low habitat quality, but predator numbers quickly rebound without continual control (Hagen 2011, p. 99); thus, there is limited opportunity for useful application (Hagen *et al.* 2004, p. 77). Red fox removal in Utah appeared to increase adult sage-grouse survival and productivity, but the study did not compare these rates against other non-removal areas, so inferences are limited (Hagen 2011, p. 99). Two studies in Wyoming (Slater 2003, p. 133; Orning 2013, p. 18) demonstrated that coyote control failed to have an effect on sage-grouse nesting success. In a coyote prey base analysis, Johnson and Hansen (1979, p. 954) showed that sage-grouse and bird egg shells made up a very small percentage (0.4 to 2.4 percent) of analyzed scat samples. These studies suggest that, at least in some areas, coyotes may not be a significant predator of sage-grouse. Additionally, coyote removal can have unintended negative consequences for sage-grouse by potentially causing indirect effects, i.e., mesopredator release, in which mammalian nest predators like the red fox become more abundant; apparent competition, in which other top predators like the golden eagle become more abundant; and exploitative competition, in which other prey species such as jackrabbits become more abundant and compete for sage-grouse food sources (Mezquida *et al.* 2006, p. 755). Removal of ravens from an area in northeastern Nevada caused only short-term reductions in raven populations (less than 1 year) as transient birds from neighboring sites repopulated the removal area (Coates 2007, p. 151). Additionally, badger predation appeared to partially compensate for decreases in raven removal (Coates 2007, p. 152).

State plans in Utah and Montana include conservation measures and BMPs to address impacts to sage-grouse from predation. Utah's state plan identifies predation has a "key threat" in some of the state's Sage-Grouse Management Areas (SGMAs), largely due to increased populations of ravens and non-native canids, such as red fox (State of Utah 2013, p. 14). To help reduce this threat, Utah's plan explains that the USDA-APHIS Wildlife Services and the Utah Department of Agriculture and Food (UDAF) should control and manage predators in consultation with the Utah Department of Wildlife Resources (UDWR) (State of Utah 2013, p. 14). Further, Utah's plan guides these agencies to eliminate or minimize external food sources for predators, apply management practices to decrease predators, develop predator control strategies, and to monitor the success of control efforts (State of Utah 2013, p. 14). If local sage-grouse population decline due to predators, Montana's state plan would explore the feasibility of a predator management plan (State of Montana 2014, p. 4). Montana's state plan would also recommend conservation measures to reduce predation, such as removing debris, road kill, and tall structures (State of Montana 2014, p. 10). A summary of state regulations and conservation plans addressing predation, and other threats is in the Regulatory Mechanisms chapter (pp.X).

Assessment of Potential Threat

In 2010, the Service determined that the effects of predation did not significantly threaten sage-grouse such that the species should require listing under the Act as endangered or threatened (75 FR 13910, p. 13973) across its range. Since 2010, many studies have been published regarding the increase of predation abundance in various locations across the species' range. Those studies have elucidated the intricacies of the situation and provided managers with knowledge that will help them implement effective conservation strategies to help ameliorate the effects of predation.

The effects of predation can be compounded by threats that cause habitat fragmentation, changes to the vegetative communities, or artificially inflate predator populations; thus, predators have the potential to increase the incidence of sage-grouse mortality. The relatively high levels of predation observed in some areas are thought to be caused by an overall increase in predator species (Coates and Delehanty 2010, p. 246; Coates *et al.* 2014, p. 350) and an increase in predator effectiveness in degraded habitat, particularly areas altered by fragmentation (Burger *et al.* 1994, p. 252; Braun 1998, p. 6; Connelly *et al.*

2004, p. 7-23) and loss of cover (Gregg *et al.* 1994, p. 164; Ritchie *et al.* 1994, p. 128; Braun 1995, pp. 1–2; DeLong *et al.* 1995, p. 90; Coggins 1998, p. 30; Connelly *et al.* 2000a, p. 975; Schroeder and Baydack 2001, p. 25; Coates *et al.* 2008, p. 636; Wing 2014, p. 21). Where habitat is not limited and is of good quality, predation is not a significant stressor acting upon to the species. Continued landscape fragmentation is likely to increase the effects of predation on sage-grouse resulting in a reduction in sage-grouse productivity and abundance, particularly where the sage-grouse populations are small and isolated. However, there is limited scientific information on the extent to which such effects might be occurring. In the majority of cases, predator removal activities have not resulted in increased sage-grouse nesting success or population numbers. Mortality due to nest predation by ravens or other human-subsidized predators is increasing in some areas, but there is no indication this is causing a significant rangewide decline in population trends.

Other Threat Factors

CHAPTER 24: SMALL POPULATION AND LIFE HISTORY TRAITS AFFECTING POPULATION VIABILITY

Current Impacts

Location and Extent

Projected Future Impacts

Timescale for Projecting this Threat

Likelihood of Future Impacts

Anticipated Changes from Present

Threat Amelioration Summary

Assessment of Potential Threat

CHAPTER 25: CONTAMINANTS

Contaminants occurring within the range of the sage-grouse include pesticides, mining and energy-related materials, garbage, animal/human waste, and fire retardants. Such contaminants may be introduced during agricultural and rangeland management practices, oil, gas, coal, and nuclear production, infrastructure and building construction, material transportation along pipelines, highways, and railroads, and wildfire management. Exposure of sage-grouse and their habitats to activities associated with contaminants began following European settler migration, human population expansion, and industrialization of the American West in the 19th and the 20th centuries. Nonrenewable fossil fuel energy development (e.g., petroleum products, coal) in sage-grouse habitats and accompanying infrastructure began in the late 1800s (Connelly *et al.* 2004, p. 7-38). Following the introduction of new chemicals after World War II, pesticide use substantially increased and many were used in sage-grouse habitat to remove sagebrush, other unwanted woody shrubs, and invasive plants (Baker *et al.* 1976, p. 166; Connelly *et al.* 2004, p. 7-28; Beck *et al.* 2012, p. 445), and to control nuisance insects (Blus and Connelly 1989, p. 1139). Herbicide application to kill sagebrush was more common in areas with grass understories (e.g., Wyoming), compared to portions of the sage-grouse range without much grass (e.g., Nevada) (Vale 1974, p. 276). Recently, treatment of sagebrush with herbicides has increasingly been intended to improve sagebrush habitats for native wildlife instead of improving livestock foraging (Beck *et al.* 2012, p. 446). While the specific types of contaminants associated with these various activities may have changed over time, sources for contaminants across the range of the sage-grouse have remained consistent. However, regulation of air and water pollution and the establishment of national air and water quality standards (Lewis 1988, entire) have likely influenced the level of contaminants in the environment and their impacts on wildlife.

Current Impacts

Direct exposure to contaminants may impact health and survival of sage-grouse. Mortality of sage-grouse can occur if they enter oil and gas wastewater pits. Exposure to spills or leaks of contaminants associated with oil and gas pipelines occurring within the occupied range of the species may lead to mortalities or morbidity to sage-grouse. Similarly, given the extensive network of highways and railroad lines that occur throughout the range of sage-grouse (see ***Infrastructure*** chapter), there is potential for direct exposure of sage-grouse to contaminants resulting from spills or leaks of hazardous materials being conveyed along these transportation corridors. Radionuclides (radioactive atoms) from nuclear research facilities, oil and gas activities, or mining, if intercepted by wildlife, can cause internal damage from radioactive decay (Kennedy *et al.* 1990, p. 10). Exposure of sage-grouse to radionuclides has been documented at the Department of Energy Idaho National Engineering Laboratory in eastern Idaho (Connelly and Markham 1983, pp. 175–176). Mining may directly expose sage-grouse to elevated levels of metals, other minerals, and/or contaminated fluids used in the extraction. Toxic concentrations of metals or chemicals used in mining have been found in birds occurring near mining operations (Pristos and Ma 1997, p. 203; Beyer *et al.* 2004, p. 116; Hansen *et al.* 2011, p. 593). Direct exposure to pesticides may have lethal or sublethal effects to sage-grouse, depending on the pesticide, level of exposure, and area sprayed. Sage-grouse may use areas sprayed with various pesticides, including agricultural areas (e.g., hay meadows and alfalfa fields) and rangelands used for domestic livestock grazing (Peterson 1970, p. 154; Wallestad and Eng 1975, pp. 629–630; Klebenow 1982, p. 113; Beck and Mitchell 2000, p. 997). Insecticides have been documented to cause mortality (Ward *et al.* 1942, p. 57; Post 1951, p. 383; Blus *et al.* 1989, p. 1142; Blus and Connelly 1998, p. 23;

Christiansen and Tate 2011, p. 20), abnormal behavior (Dahlen and Haugen 1954, p. 477; McEwen and Brown 1966, p. 609; Blus *et al.* 1989, p. 1141), and increased risk of predation or collision with vehicles and mowing equipment (Christiansen and Tate 2011, p. 20) in sage-grouse. Within sage-grouse habitat, high-density oil and gas development, combustion engine emissions, and dust from roads and wind erosion produce airborne pollutants that may reach or exceed quality standards in localized areas for short periods of time (BLM 2008d, pp. 4–74, 4-82 to 4–88; Helmig *et al.* 2014, p. 4710; Macey *et al.* 2014, p. 15). Birds may be sensitive to and have negative health consequences when directly exposed to air contaminants (Cuesta *et al.* 2005, p. 776; Olsgard 2007, p. iv; Olsgard *et al.* 2008, p. 1105; Olsgard *et al.* 2009, p. 178). Direct exposure to contaminants may lead to mortality or impact health of individual sage-grouse.

Sage-grouse may be indirectly affected when contaminants are introduced into their habitat. Spills, leaks, or purposeful application of hazardous substances can result in vegetation die-off, reduction of insects important in the diet of sage-grouse, and loss of suitable water sources. Herbicide applications can kill sagebrush and forbs important as food sources for sage-grouse (Carr 1968 cited in Call and Maser 1985, p. 14). Loss of vegetation cover can also result in increased soil erosion and subsequent reduced soil depths, decreased water infiltration, and reduced water storage capacity (Miller *et al.* 2011, p. 174), further degrading vegetation and riparian areas used by sage-grouse. Use of insecticides, including neonicotinoids, may reduce insect populations and indirectly expose insect-eating birds to insecticides (Mineau and Palmer 2013, p. 20; Gibbons *et al.* 2015, p. 105) in agriculture or rangelands used by sage-grouse or in close proximity to areas occupied by sage-grouse. Wildlife may be indirectly exposed to pesticide proteins occurring in genetically-modified organism (GMOs) through bioaccumulation, particularly if diets include insects that consume GMOs (Wolfenbarger *et al.*2000, p. 2089). Human development potentially exposes sage-grouse to pathogens introduced from septic systems and waste disposal (Moore and Mills 1977, pp. 114–116, 135) that could negatively affect their health. Mining operations can contribute contamination to water sources in sage-grouse habitat as a result of blasting chemicals (e.g., ammonium nitrate, fuel oil) or metal leachate from waste rock or overburden (Moore and Mills 1977, pp. 115, 133; Adams and Picket 1998, p. 486; Ramirez and Rogers 2002, p. 434–435). Chemicals used to control wildfires within sagebrush ecosystems may reduce species richness of vegetation for short time periods (Larson *et al.* 1999, p. 115), potentially impacting vegetation important for sage-grouse nesting and brood-rearing. Air pollution can impact plant and insect health and abundance (Alstad and Edmonds, Jr. 1982, p. 369, University of Illinois 2002, pp. 1–2), both of which are necessary for sage-grouse diets. Sage-grouse are a landscape scale species, requiring large expanses of sagebrush to meet seasonal habitat requirements (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). The loss of habitat from fragmentation and conversion decreases the connectivity between seasonal habitats potentially resulting in the loss of the population (Doherty *et al*. 2008, p. 194). Contamination of sage-grouse habitat may increase habitat fragmentation or displace sage-grouse to less optimal habitat.

Direct exposure to contaminants may decrease sage-grouse survival and fitness while indirect exposure to contaminants may limit sage-grouse food, water, and cover, decreasing breeding, nesting, brood success, and adult survival. However, current literature on contaminant exposure to sage-grouse is lacking. For example, mortality of sage-grouse occurring as a result of oil and gas operations is difficult to quantify due to a lack of monitoring. A single sage-grouse carcass was found covered with oil in a wastewater pit associated with field development in 2006 but typically it is very difficult to identify oiled birds (Domenici 2008, pers. comm.). We expect that the number of sage-grouse occurring in the immediate vicinity of wastewater pits to be small because of the typically intense human activity in these areas, the lack of cover around the pits, and because sage-grouse typically do not require free water (Schroeder *et al.* 1999, p. 6). Most bird mortalities recorded in association with wastewater pits are water-dependent species (e.g., waterfowl) (Domenici 2008, pers. comm.); however, if the wastewater pits are not appropriately screened, sage-grouse could become oiled while pursing insects or drinking water. If these birds return to sagebrush cover and die, their carcasses are unlikely to be found as only the pits are surveyed. Furthermore, female birds returning to their nests can transfer the oil on their feathers to their eggs affecting embryo survival (Albers 1978, pp. 625–628; Hoffman and Gay 1981, pp. 778–782).

We found no documented occurrences of direct mortality to sage-grouse from chemical spills. We do not expect chemical spills are a significant source of mortality at the population level because such spills occur infrequently and typically impact small areas relative to the range of the species. Sage-grouse do not require water other than what they obtain from plant resources (Schroeder *et al.* 1999, p. 6); therefore, local water quality deterioration is not expected to have population-level impacts. Degradation of riparian areas from oil and gas extraction, mining operations, or human development could result in a loss of brood habitat, but we have not found documented occurrences of contamination of riparian areas leading to mortality of sage-grouse.

Although radionuclides were present in sage-grouse at DOE's Idaho National Engineer Laboratory in eastern Idaho, there were no apparent harmful effects to the population (Connelly and Markham 1983, pp. 175–176). With current provisions regulating nuclear energy development, it is unlikely that there will be population-level impacts to sage-grouse as a result of radionuclides or any other nuclear products from new and future facilities.

Impacts from pesticides may be underestimated if sage-grouse disperse from agricultural areas after exposure. The actual footprint of effects from cropland spraying cannot be estimated because the distances sage-grouse travel to irrigated and sprayed fields is unknown (Knick *et al.* 2011, p. 211). A comparison of applied levels of herbicides with toxicity studies of grouse, chickens, and other gamebirds (Carr 1968, as cited in Call and Maser 1985, p. 15) concluded that herbicides applied at recommended rates should not result in sage-grouse poisonings. Insecticides potentially affect sage-grouse over broad regions, but no rangewide estimates of mortality are available. In 1986, organophosphosphorus insecticides, methamidophos and dimethoate, were associated with 63 sage-grouse mortalities (Blus *et al.* 1989, p. 1142; Blus and Connelly 1998, p. 23) and remain registered for use in the U.S. (Christiansen and Tate 2011, p. 21), but we found no further records of sage-grouse mortalities from their use. The specific insecticides and dosages used by the Animal and Plant Health Inspection Service (APHIS) to suppress grasshoppers in the Rangeland Grasshopper and Mormon Cricket Suppression Program were not expected to be directly or indirectly toxic to sage-grouse (APHIS 2002, p.10). Much of the research related to pesticides that had either lethal or sublethal effects on sage-grouse was conducted on pesticides that have been banned or had their use further restricted for more than 20 years due to their toxic effects on the environment (e.g., toxaphene or chordane bait for grasshopper control, strychnine bate for above ground mammal control, dieldrin for crop pests). We currently do not have any information to demonstrate that banned pesticides are presently having negative impacts to sage-grouse populations through either illegal use or residues in the environment. Although a reduction in insect population levels resulting from insecticide application can potentially affect nesting sage-grouse and chicks (Willis *et al.* 1993, p. 40; George *et al.* 1995, p. 341; Schroeder *et al.* 1999, p. 16), we have no information as to whether insecticides are impacting survival or productivity of sage-grouse. Treatments for grasshopper suppression done by APHIS would typically not reduce the number of grasshoppers below levels that are present in non-outbreak years (APHIS 2002, p.10). Sage-grouse avoided areas sprayed by the herbicides due to a reduction of favored food plants (Martin 1970, pp. 316, 320) and stopped nesting in areas sprayed with herbicides to control shrubs (Klebenow 1970, p. 399). However, light applications of some herbicides may increase grass and forb production important to nesting and foraging activities by decreasing shrub canopy cover (Crawford *et al.* 2004, p. 2).

Presumably air emissions from oil and gas development are quickly dispersed in the windy, open conditions of sagebrush habitats (Moore and Mills 1977, p. 109), minimizing the potential direct effects on wildlife. We were unable to find any documented occurrences regarding the effects of gaseous emissions produced by oil and gas development on sage-grouse.

Location and Extent

Direct mortality from a sage-grouse entering and becoming trapped in a wastewater pit would be most likely to occur in MZs I and II, as these MZs are where most of the oil and gas developments occur in relation to occupied sage-grouse habitat. Additionally, it is likely that impacts from spills associated with oil and gas developments would be most frequent in these areas (see ***Nonrenewable Energy*** chapter). Impacts from mining-related contaminants would be most likely within MZs I, II, III, and IV (see ***Mining*** chapter). Contaminants related to human development would most often occur near human population centers. Urban and exurban development occurs at the highest levels in MZs II, V, and VI. The primary agricultural regions within historical sagebrush habitat occur in MZ I (19 percent of the total area) and VI (32 percent of the total area) (Knick *et al.* 2011, p. 209), though these activities, and therefore the contaminants associated with them (including pesticides), occur throughout the range of the species (see ***Exurban Development*** and ***Agricultural Conversion*** chapters). Contamination associated with nuclear energy is likely limited to facilities in Idaho (DOE's Idaho National Engineering Laboratory in eastern Idaho [MZ IV]) and one site in the range formerly occupied by the species (MZ VI, Nuclear Energy Institute 2015), and locations where future nuclear energy facilities are located. (Table 25-1).

Projected Future Impacts (Timescale, Likelihood of Future Impacts and Anticipated Changes from Present)The timescale for projecting impacts associated with contaminants is the same as the timescale of the activities that are the primary sources of contaminants. We anticipate that agricultural conversion will contribute to the modification (i.e., compounded effects from pesticides) of sage-grouse habitat and range for the foreseeable future. We anticipate that urban and exurban development will contribute to present and future habitat destruction (i.e., direct habitat loss) and modification (i.e., compounded effects from associated pesticides, garbage, human and pet waste) for the foreseeable future. We anticipate invasive plants and associated fires will occur on the landscape for the next 100 years or longer. The effects of oil and gas development are likely to continue for decades even with the current protective or mitigate measures in place. It is anticipated that mining activities within the range of the sage-grouse will continue indefinitely. Given the level of activities associated with contaminants sources across the range of the sage-grouse, it is highly likely that future impacts will continue across the range indefinitely.

Future impacts from contaminants compared to the present is directly associated with changes in the activities associated with contaminants. It is likely that sources of contaminants will increase across the sage-grouse range as the human population increases. Technological advances in industrial operations may decrease the risk of unintended releases of contaminants in the environment or allow for easier, faster clean-up response to such releases. Additional research and application techniques for pesticides may allow for more targeted application, potentially leading to fewer impacts on sage-grouse. However, based on the current state of activities within the sage-grouse range, it is likely that contaminants will stay at current levels or increase in the future.

Threat Amelioration Summary

Source activities for contaminants may be limited on lands enrolled in CCAAs, as CCAAs restrict agricultural conversion, habitat fragmentation, and removing sagebrush. Approximately 0.17 percent of occupied range in MZ I, 0.78 percent of MZ II, 2.47 percent of MZ IV, and 4.67 percent of MZ V are enrolled in CCAAs in Wyoming and Oregon. Federal lands enrolled in CCAs in Wyoming, Oregon, and Idaho account for 0.04 percent of occupied range in MZ I, 0.21 percent of MZ II, 3.13 percent of MZ IV, and 4.67 percent of MZ V. See the ***Non-regulatory Conservation Efforts*** section and Table 28-7 for approximate acreages and additional information.

Assessment of Potential Threat

Sources of contaminants to wildlife associated with human activities have increased since the 19th century and will likely continue to occur across the species range, potentially impacting air and water quality and vegetation and insect quantity. While contaminants may impact sage-grouse individuals, it is unlikely that contaminants will lead to widespread mortality or declines in sage-grouse populations or across MZs, as contamination exposure is typically localized or sporadically occurs across the range.

CHAPTER 26: MILITARY ACTIVITY

Several military facilities overlap to varying degrees with the occupied range of sage-grouse (in WA, UT, NV, ID, WY) and have confirmed sage-grouse presence (Table 26-1). These facilities when combined, however, encompass less than 1 percent of the currently estimated sage-grouse range and thus impacts to the species from military surface activities are limited.

Table 26-1 Military facilities that overlap portions of sage-grouse range. Acreage values given under Facility reflect area managed by DOD. Only small portion of managed lands see active use by sage-grouse.

State	Facility	Land use activities	Sage-grouse presence	Examples of sage-grouse conservation activities
ID	Mountain Home AFB (MHAFB), Mountain Home Range Complex (MHRC): Saylor Creek and Juniper Butte Ranges (SCR JBR), and remote facilities. MHAFB 6, 844 ac MHRC 126,000 ac	Military and small arms training, aircraft overflight, ordinance dropping, combat laser use. Other land uses include grazing, hunting, bird watching, hiking in designated areas.	Sage-grouse and sage-grouse habitat are not present on MHAFB or SAR. Sage-grouse can be found across the MHRC; 2 active leks located on SCR, active leks near but not on JBR proper.	Fire prevention, reporting, suppression, protocols. Ensure personnel recognize and report listed noxious weeds. Use native seeds to the maximum extent practicable in fire rehabilitation. Conserve sagebrush and known sage grouse use areas. Avoidance or limiting of some activities near leks.
MT	Malmstrom AFB	Much of the base's activities are aviation related (rather than ground-based). Approximately 25,000 miles airspace.	No sage-grouse on or around Malmstrom AFB proper, however a portion of missile field may have sage-grouse habitat in the vicinity	FWS (Montana FWCO) is working with DoD to inventory missile field sites, assess habitats, and provide recommendations to minimize potential effects associated with base operations.
NV	Nellis AFB (NAFB) and the Nevada Test and Training Range (NTTR). NAFB 14,147 ac NTTR 3 million ac	NTTR is used for training, testing, and weapons evaluation operations for the USAF, Army, Marine Corps, National Guard, and Navy, DoE, reserve forces, and other federal agencies. Other land uses are extremely limited but include grazing, bighorn sheep hunting.	No sage-grouse are present on NAFB proper. Sage-grouse potentially in North Range portion of NTTR, specifically Kawich mountain. Area accessible by helicopter, sage-grouse surveys by helicopter are being conducted.	Conserve populations of sage grouse at NTTR by avoiding and/or minimizing impacts to bird populations by mission actions where practical. Site specific management actions depending on land use activities. Timing and use restrictions in limited areas.
NV	Naval Air Station Fallon 241,000 ac	Aircraft operations and weapons training. Other land uses include grazing, hunting, biking, hiking, bird watching, other outdoor recreation.	Few to no sage-grouse known to occur on NAS Fallon-administered lands. Leks nearby in the Clan Alpine and Stillwater mountain ranges	Determine presence of suitable habitat and sage grouse leks and manage for the species accordingly. Has implemented noxious weed and soil erosion

				control programs.
UT	Dugway Proving Ground 797,974 ac	Dugway is a Major Range and Test Facility Base, with a primary mission to provide developmental and production testing to support the nation's chemical and biological defense programs.	Surveys on property have not located leks. Sage-grouse and leks observed near managed lands.	
WA	Joint Lewis-McChord Yakima Training Center 327,000 ac	Conducts aviation, maneuver and live fire training activities for multiple weapon systems. Other land uses include hunting, bird watching, biking, horseback riding, and other outdoor recreation.	Contains one of two populations in WA. Is designated as a PAC.	Direct protection of sage-grouse and their habitat (i.e. mating, nesting and brood rearing behavior and habitat) is done through timing and area restrictions, including air space restrictions.
WY	Wyoming National Guard, Sheridan Local Training Area 3,960 ac	Training includes practicing standard operating procedures, navigation skills. The WYARNG maintains one rifle range on the Sheridan LTA. Other land uses include grazing.	Incidental observation on property. Two occupied leks and one lek whose status is undetermined occur within 0.5 miles of the installation.	Conduct surveys for greater sage grouse by 2018
WY	Wyoming National Guard, Lander Local Training Area 1,360 ac	Training consists of live-fire exercises, land navigation exercises, procedures associated with establishing field operations and preparing convoys. Other land uses include grazing and hunting and public use of firing range with permission.	Incidental observations on property. Core area sage-grouse leks less than a mile north of the training area.	If projects are located within western big sagebrush communities, project planning measures should retain large tracts of the habitat and corridors to aid in the conservation of the sage-grouse

Military training and testing activities have the potential to negatively impact sage-grouse and their habitats. Training activities can and do ignite wildfires resulting in habitat loss and fragmentation. This has been a particular concern in MZ VI. Around one quarter of the remaining sage-grouse in MZ VI are located on Joint Lewis-McChord Yakima Training Center (JBLM YTC), formerly called the Yakima Training Center (WDFW 2013, p. 3). The JBLM YTC conducts aviation, maneuver, and live fire training activities for multiple weapon systems. Military operations have been modified to accommodate the needs of sage-grouse at JBLM-YTC, through close communication and cooperation of the Army and the Service. Direct protection of sage-grouse and their habitat (e.g., breeding, nesting, brood-rearing) is accomplished through timing and area restrictions, including air space restrictions. Vegetation restoration of shrub-steppe is required to address habitats impacted by wildfire and military training activities. Wildfire protection measures are required to prevent, contain, and rapidly extinguish wildfires. Monitoring of sage-grouse and their habitats, including monitoring of habitat restoration activities, are conducted within JBLM YTC jurisdictional boundaries.

In addition to impacts from wildfire, habitat can be further degraded by cross-country maneuvers with military vehicles. Mechanized military maneuvers are an intensive form of disturbance in sagebrush habitats, resulting in crushed and destroyed vegetation, soil compaction, increases in invasive plants and altered understory plant communities (Milchunas *et al*. 2000, pp. 535–537; Cadwell *et al*. 2001 cited in WDFW 2013, p. 3). This type of habitat loss and degradation, however, is limited.

Although military surface training activities are limited across the sage-grouse range, the military also manages more extensive sections of Special Use Airspace for both testing and training (Figure 26-1). The airspace configuration (i.e., size and volume of the airspace) used for training is dictated largely by logistical considerations; airspace must provide the opportunity for realistic, effective training operations (Ellsworth Air Force Base DEIS 2015, p. 1-7). Military training airspace occurs over portions of all MZs (Figure 26-1).

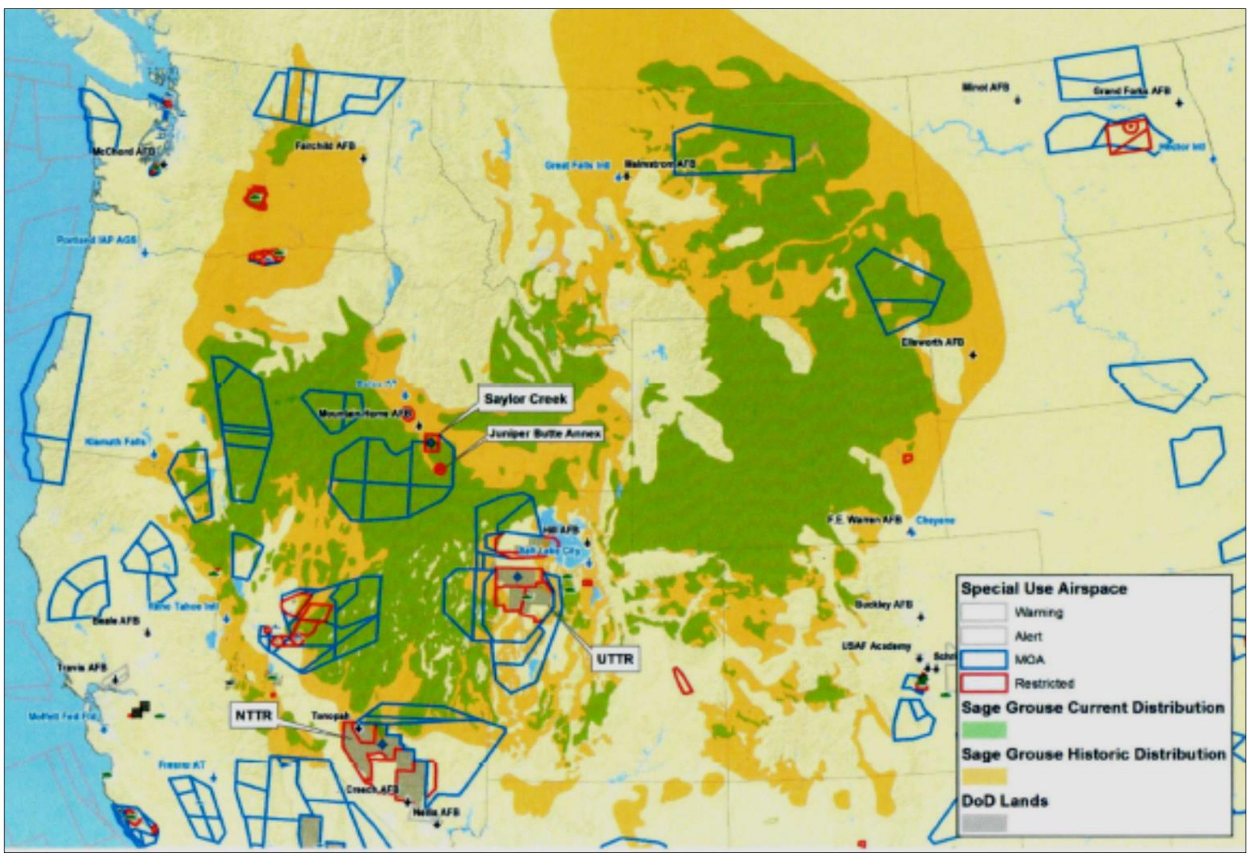

Figure 26-1. Special Use Airspace in relation to the sage-grouse range (from U.S. Air Force Greater Sage Grouse fact sheet)

Aircraft overflight noise and sonic booms could potentially have negative impacts to sage-grouse. Recent research has demonstrated that sage-grouse are sensitive to noise (Blickley *et al* 2012, p. 467). Blickley *et al*. (2012, entire), however, specifically examined sage-grouse response to vehicle and simulated drilling noises. Intermittent traffic noise had the biggest effect resulting in behavioral avoidance of the area (breeding habitat). The behavioral response of sage-grouse to overflight noise has not been examined. Potential impacts include increased detectability by predators and disruption of breeding and nesting behavior if sage-grouse repeatedly flush in response to the noise.

Recently the Federal Aviation Administration (FAA) approved plans to expand the Powder River Training Complex, effective in September 2015. The expansion will nearly quadruple the current training airspace at Ellsworth Air Force Base to 35,000 mi2 over parts of South Dakota, Montana, North Dakota and Wyoming within the occupied range of sage-grouse. No bombing range was proposed for this expansion. Low-level overflights are expected to be infrequent and will generally not be conducted during the early morning hours of peak sage-grouse breeding activity (Ellsworth Air Force Base DEIS 2015, p. 4-85).

The U.S. military must balance its role of public land steward with its primary mission of maintaining a well-trained, combat-ready fighting force. The Sikes Act (16 U.S.C. 670a-670f, as amended), enacted in 1960 with subsequent amendments, provides for cooperation between the U.S. Department of Defense (DoD) and DOI for planning, developing, and maintaining fish and wildlife resources on military lands (see ***Regulatory Mechanisms*** section). The Sikes Act applies to federal land under DoD control and requires military services to establish Integrated Natural Resources Management Plans (INRMPs) to conserve natural resources for their military installations. Through installation-specific INRMPs, developed in cooperation with the Service and State Fish and Wildlife agencies, the military has implemented conservation and mitigation actions for sage-grouse.

A primary first step common in INRMPs is to survey, locate, and map potential habitat and report any sightings of sage-grouse. Surveys and monitoring activities are typically maintained over years. Other actions common to INRMPs include fire prevention, suppression, and restoration, and treatment of invasive plants. These activities are not specifically targeted for sage-grouse conservation, but are included as general guidelines to benefit all wildlife and habitat stability of DoD lands. Examples of INRMP management guidelines specific to sage-grouse include monitoring of sage-grouse and their habitats, and limited timing and area use restrictions.

We recognize that military activities can degrade and fragment habitat for sage-grouse. Impacts from military activities can be severe; however, they are localized in relatively small portions of the sage-grouse range. The DoD has a record of coordination with the Service and State wildlife agencies in identifying and conserving wildlife resources. Potential impacts to sage-grouse are being mitigated to the extent practicable given the U.S. military's primary mission.