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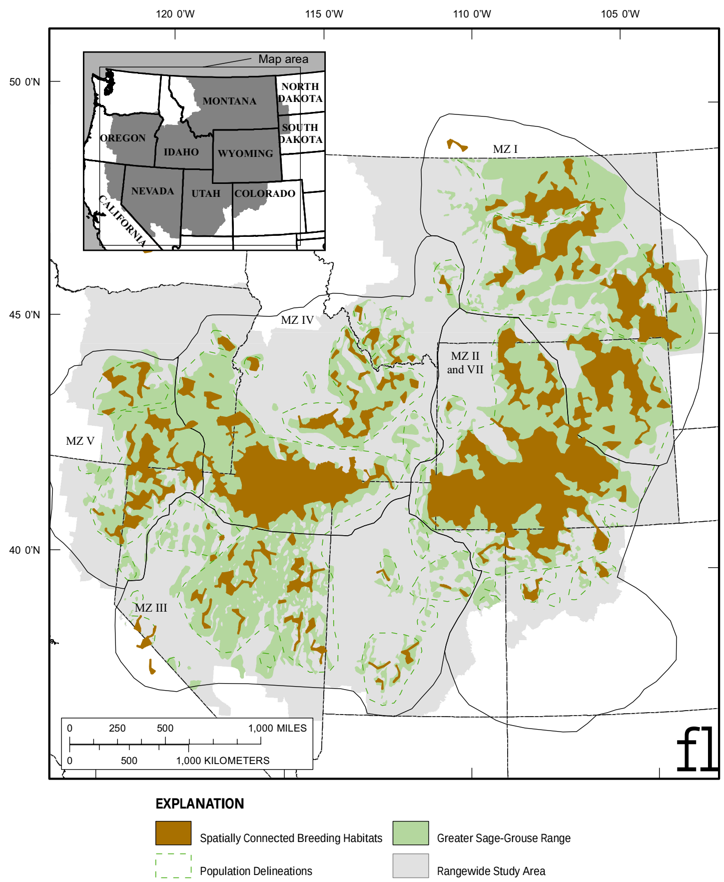

Figure 6. Spatial connectivity within sage-grouse population structure across the current species range.

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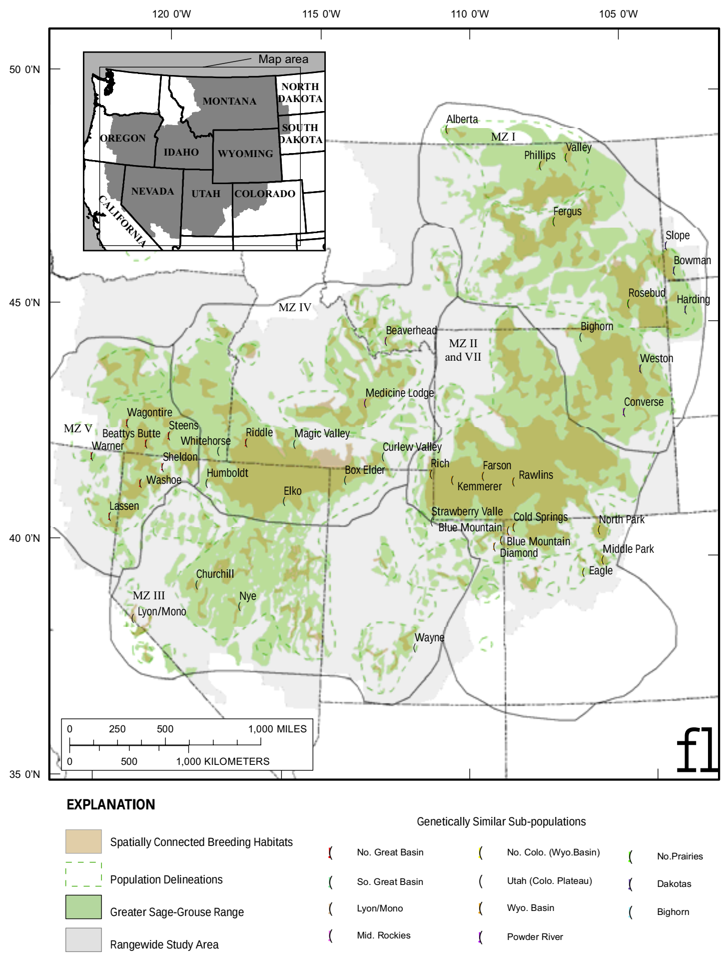

Figure 7. Map of sampling sites for the microsatellite analysis assigned by 'Structure' analysis; genetic similarity is implied for sub-populations with similar color coding.

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Habitat characteristics and ecosystem associations

Sage-grouse are a sagebrush obligate species that rely on a variety of sagebrush dominated communities to meet various needs throughout their life cycle (Patterson 1952, Braun et al. 1976, Connelly et al. 2004, Connelly 2005, Miller et al. 2011). Sage-grouse are closely tied to sagebrush communities and the range of sage-grouse includes at least eleven species, or subspecies (as many as 20 identified in some states), of sagebrush (*Artemisia* spp.) that differ in their associated plant communities, productivity, resilience, and ability to resist disturbance (Miller and Eddleman 2000, West and Young 2000, Connelly et al. 2004, Knick and Connelly 2011a). Sagebrush communities are comprised of diverse plant communities that include perennial grasses and forb species influenced by abiotic conditions such as topography, elevation, precipitation, and soil (Miller and Eddleman 2000, Connelly et al. 2004). The species of sagebrush most commonly associated with sage-grouse include *Artemisia tridentata* ssp. *wyomingensis* (Wyoming big sagebrush), *A. t.* ssp. *vaseyana* (mountain big sagebrush), *A.t. tridentata* (basin big sagebrush), *A. arbuscula* (low sagebrush), *A. nova* (black sagebrush), *A. frigida* (fringed sagebrush), and *A. cana* (silver sagebrush, Schroeder et al. 1999, Connelly et al. 2004). As such, the distribution of sage-grouse is highly correlated with the distribution of sagebrush in North America (Schroeder et al. 2004).

In the spring, during the breeding season, sage-grouse males seek out lek sites that are open areas of bare soil, shortgrass steppe, windswept ridges, or exposed knolls in which to gather and perform their ritualized mating displays (Patterson 1952, Connelly et al. 2004) in order to attract females for breeding. The location of active leks is generally known, and this information has been used to define MZs, planning units, and research designs, as discussed throughout this report. The timing of lek attendance varies considerably depending on snow depth, elevation, weather, and geographic region with first attendance ranging from the end of February to early April and ending in late May or early June (Eng 1963, Schroeder et al. 1999, Aldridge 2000, Hausleitner 2003, Connelly et al. 2004). Such lek

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Comment [SSK17]: Do you mean in total, or does species composition somehow come into play.. Consider moving this sentence to the beginning part of the paragraph.

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sites are typically open areas (low shrub cover) located in the midst denser shrub stands which together provide the necessary combination of visibility, protection, food, and thermal regulation (Connelly et al. 1981, Connelly et al. 2000b, Connelly et al. 2011b). Females visit leks for copulation and then can travel more than 20 km (12.5 mi) for nesting afterward (Connelly et al. 2000c), yet distances from the lek to nesting areas is highly variable. Five studies that included 301 nest locations revealed that the distance from lek of capture to nesting areas averaged from 3.4 km to 7.8 km (2.1 – 4.8 mi) (Schroeder et al. 1999). Nesting areas tend to be surrounded by sagebrush with an understory of native grasses and forbs with ample vertical and horizontal structure to support a diversity of insect prey, provide cover, as well as herbaceous forage for pre-laying and nesting hens (Gregg 1991, Schroeder et al. 1999, Connelly et al. 2000b, Connelly et al. 2004, Connelly et al. 2011b). Vegetation characteristics of successful nesting areas have been described with details not provided here (Connelly et al. 2000c).

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Brood rearing for sage-grouse occurs in the summer season as egg-laying and incubation typically occur 3-4 weeks after peak lek attendance (Schroeder 1997, Aldridge and Brigham 2003b, Hausleitner 2003, Connelly et al. 2004). Broods are typically found in areas near nest sites for the first 2-3 weeks after hatching (Connelly et al. 2004). Such habitat needs to provide adequate cover and areas with sufficient forbs and insects to ensure chick survival in this life stage (Connelly et al. 2004). As the chicks get older, sage-grouse tend to move into more moist areas (streambeds or wet meadows) **because as** herbaceous vegetation dries out, wetter areas provide more forbs and insects for hens and their chicks (Schroeder et al. 1999, Connelly et al. 2000a). **H**ens without broods and male sage-grouse use wetter areas that are close to sagebrush cover in late summer (Connelly et al. 2004).

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Toward the end of summer and in fall and winter, the diet of sage-grouse shifts completely to sagebrush (Schroeder et al. 1999). During this time, sage-grouse also depend on sagebrush for cover. Habitat selection at the sagebrush stand level during winter months is driven by the depth of snow

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(Patterson 1952, Hupp 1989), the availability of sagebrush above the snow (Connelly et al. 2004), and topographic patterns (Beck 1977, Crawford et al. 2004) that create localized habitats providing cover and forage. Because use and availability of these seasonal habitats are spread across a given landscape, sage-grouse require vast areas of contiguous sagebrush to meet their needs on an annual basis (Patterson 1952, Connelly et al. 2004, Connelly et al. 2011e, Wisdom et al. 2011).

Sagebrush vegetation types are strongly determined by environmental limitations and gradients driven primarily by temperature and precipitation patterns (Miller et al. 2011). The sagebrush-steppe occurs in the northern portion of the range of sage-grouse from British Columbia and the Columbian Basin in the northwest, south through the northern Great Basin, Snake River Plain, and east through Montana, the Wyoming Basin and northern Colorado Plateau (Figure 8). In this type, sagebrush typically co-dominates with perennial bunchgrasses (Miller et al. 2011). The second major type, Great Basin sagebrush, is found south (and west) below the polar front gradient where the herbaceous component contributes a smaller portion of the total plant cover (Miller and Eddleman 2000) due to hydrologic patterns. Thus, in this type, sagebrush is frequently the canopy dominant with little understory (Miller et al. 2011). The Great Basin sagebrush community type extends from the Colorado Plateau west across Nevada and Utah, and into California (Miller et al. 2011). A third major sagebrush vegetation type, the mixed shrubland, occurs in the Bighorn Basin in north-central Wyoming. A fourth type includes the silver sagebrush-grasslands that are found in eastern Montana and Wyoming (Miller et al. 2011) that support sage-grouse populations within *A. cana* and *A. filifolia* associations.

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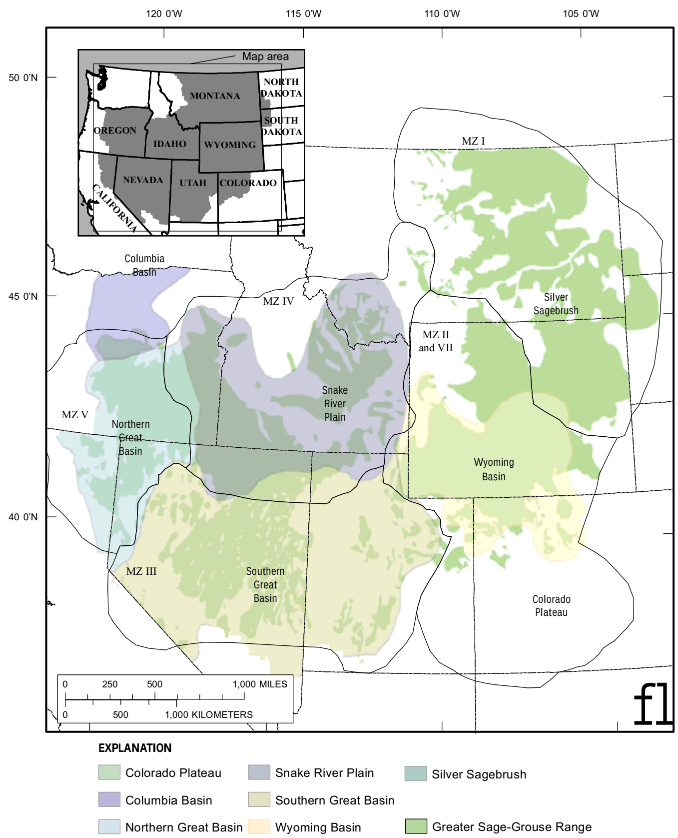

Figure 8. The relative position of seven major sagebrush biomes, including the southern Great Basin types (Southern, Northern and Colorado Plateau), northern sagebrush steppe (Snake River Plain, Wyoming Basin and Columbia Basin) and northern prairies (includes the Silver Sagebrush subclass).

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Multi-scale Habitat Selection

Sage-grouse are currently estimated to occupy 668,000 km^2 (165 million acres) across the western United States and Canada (Knick and Connelly 2011a), and this range encompasses tremendous variability in habitat conditions, anthropogenic activities, and grouse populations. Development of comprehensive monitoring approaches lead to formal recognition that habitat selection assessments need to utilize approaches that address multiple spatial scales to represent selection processes of the animals (Connelly et al. 2003b, Connelly et al. 2011d). First-order selection (1) is the geographic range and defines the sage-grouse population of interest, and within this geographic range (2) second-order selection hinges on large, relatively intact regions of habitat and is often identified using subpopulation distributions (for example, geographic proximity and potential connections among leks or regional population connectivity using genetics). Third-order selection (3) represents refinement of habitats used by subpopulations by identifying seasonal habitats (e.g., nesting habitat), patch selection and migration habitats. Finally, assessment can be made of the fourth-order of behavioral classification (4) by quantifying food and cover attributes and foraging behavior at particular sites. In practice, selection of food items is nested within selection of feeding site because selection of a particular site determines the array of food items available to be selected; importantly, habitat value and use will best be determined using a combination of these characteristics (not one alone). To accurately characterize sage-grouse habitat selection for a given population at the first- and second-orders, or landscape spatial scales, the migratory nature (e.g., seasonal movements) of the population must be well understood (see Connelly et al. 2000), and this may include very large areas on an annual basis. It has been suggested that migratory populations may range across a habitat the size of the state of Rhode Island (Connelly et al. 2003b).

The relative importance of a particular seasonal habitat may be dictated by *quantity* (e.g., critical winter habitat may represent a small proportion of the available sagebrush habitats in the area), *quality*

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Comment [SSK19]: It's funny to mention the east coast here. I'm not sure how big Rhode Island is. It might be better to just state the size (rather than invoke those easterners!)

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(e.g., *potential* early brood-rearing habitats may be wide-spread, but sub-optimal forb cover may reduce value and use of some areas), and *juxtaposition* (e.g., the necessary proximity of suitable early brood-rearing sites and suitable nesting sites) which together describe relevant local-scale spatial heterogeneity within broadly suitable and available habitats. It is also likely that movement corridors between seasonal sites have particular value for sage-grouse as seasonal habitats (distinct from origination and destination habitats), especially for migratory populations moving long distances between seasons (Connelly et al. 2003). Although the optimal proportions of distinct seasonal habitats required on a landscape for productive sage-grouse populations are unknown, sage-grouse productivity is generally increased if individuals are able to space themselves widely across the available landscape allowing them full-advantage of variations in land and habitat to satisfy their cover, forage, solitude and migratory needs (Holloran and Anderson 2005).

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III. Characterization of important threats and issues

The USFWS 12-month finding, in agreement with recent reviews, research, and analyses provided by the science and management communities (Federal Register 50 CFR Part 17; FWS-R6-ES-2010-0018, Connelly et al. 2004, Knick and J.W. Connelly 2011), recognized a range of important influences on sage-grouse populations and their successful conservation. These common threats and issues fall into five main categories which were recognized by USFWS in the published findings – habitat change (Factor A), over-utilization (Factor B), disease and predation (Factor C), chemical poisoning (Factor E), and policy and land-use (Factor D) – which may vary in relative importance among MZs but are inclusive and representative of the suite of threats and issues across the species' range. Each of these topics are addressed in the following pages, with particular attention paid to issues identified by USFWS and others that contribute to direct or indirect impacts on sage-grouse populations. With this broad outlook, it is important to recognize that while over-utilization, disease and predation, and chemical poisoning are recognized as having direct effects (e.g., mortality) on sage-grouse populations, the effect size of these factors are considered relatively small compared to indirect effects on populations via habitat degradation, policy limitations, and competing land-uses. Habitat Change (Factor A), which represents a suite of changes in both local conditions (implications for forage, cover and nest quality, for example) as well as regional landscape patterns (implications for net habitat availability, connectivity and isolation, for example), includes the bulk of factors identified in previous research and litigation as affecting sage-grouse populations. Despite research and expertise that address the role of these factors in habitat condition and function of the sagebrush ecosystem, causal connections that precisely relate these factors to population responses are not known in many cases (and likely cannot be consistently and accurately translated as simple causal mechanisms); this is often the case with indirect (i.e., complicated ecological) relationships. Thus, many of the following sections

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outline connections between activities, patterns, and processes recognized as threats to the condition (measured, theoretical, desired) of the sagebrush ecosystem and the likely, or expected, response of local sage-grouse populations to these influences, as presented in the literature. These discussions and diagnoses may recognize local population details, however, detailed local distinctions are largely beyond the scope of this effort. The broad scale patterns and associations occurring range-wide and regionally, which are summarized here, will benefit from incorporation with detailed knowledge of local managers, including unpublished reports and similar locally explicit references, when translating these regional patterns into local conservation planning. Therefore, this summary and spatial analysis will inform and enhance local understanding by providing broad-scale data and interpretation allowing local conditions and issues to be put into context and thereby informing the process of developing complete and comprehensive land and resource management planning.

This distinction (local detail versus regional perspective) is consistent with the multiple-scale approach to management and conservation being applied here, whereby this report provides "global" (scale I), and "regional" perspectives (II and III), and leaves local perspectives to be informed by local professionals. The local data, and associated local decisions, are critically important to conservation and management success but they cannot be accurately represented here (without vastly expanding the scope, effort and temporal span of the effort). Information on sage-grouse has been accumulated from many different populations residing in different habitats, and current knowledge is based on combining these disparate sources and extrapolating understanding derived from specific populations and circumstances to establish range-wide consistencies (Crawford et al. 2004). Confounding factors across all populations and analytical units include different causes of mortality in different areas, differences between migratory and resident populations, temporal and spatial differences in habitat conditions,

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nuances and variability in population estimates, and differences in cycling rates and current position relative to long-term and short-term trends (Fedy and Doherty 2011).

Recent developments in wildlife conservation have included a shift from project-level to landscape-level perspectives in conservation planning. However, effective management of a species of wildlife under this paradigm typically requires the consideration of several scales. Sage-grouse are a wide-ranging species, and large landscapes **must be** conserved to maintain the species (Connelly et al. 2004, Connelly et al. 2011d). However, habitat degradation – one of the overriding mechanistic factors resulting in population declines – will have to be handled at much smaller scales to restore the condition and function of rangelands.

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Factor A: Habitat Change

Sage-grouse populations typically occupy habitats with a diversity of species and subspecies of sagebrush interspersed with a variety of other habitats (riparian meadows, agricultural lands, grasslands, sagebrush habitats with some conifer or deciduous trees); these habitats are usually intermixed in a sagebrush-dominated landscape and are often used by sage-grouse during certain times of the year (summer) or during certain years, for example, above normal snow pack (Connelly et al. 2011d). The natural variation in vegetation, the dynamic nature of sagebrush habitats, and the variation in the habitats selected by sage-grouse across a landscape imply that characterizing habitats using a single value or narrow range of values, for example, 15 to 25% sagebrush canopy cover in breeding habitat (Connelly et al. 2000c), is insufficient to describe sage-grouse habitat requirements. **T**he differing seasonal requirements of sage-grouse may dictate that multiple attributes in a particular site are important, reinforcing emphasis on a combination of the shrub overstory and the herbaceous understory which are important individually and in **combination** (Connelly et al. 2011d). **Seasonal habitats often overlap, however; for example, winter habitat may also provide brood-rearing habitat.**

Interspersion and juxtaposition of the differing cover types used by sage-grouse on an annual basis

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Comment [SSK20]: I don't know where this sentence goes. The earlier thoughts focused on the different requirements by sg seasonally, thus multiple attributes are important in one space. This sentence is almost the flip side, that the habitats can fulfill more than one seaons's need. It may be better to leave this sentence out. I think the point is there.

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within the range of a local population will greatly influence the effectiveness of the landscape to provide quality sage-grouse habitat (Connelly et al. 2011d). Planning and evaluation of conservation targets related to habitat change is therefore complex because sage-grouse habitat requirements must be accounted for at multiple scales. Healthy, productive and sufficiently isolated (safe) local habitats that provide specific seasonal requirements (fourth-order habitat selection), such as sagebrush, grasses, forbs, and insects in spring-summer will be nested within a landscape of large, contiguous acres of sagebrush (second-order selection), a mosaic of sagebrush, grass, and forb cover which provides suitable cover and forage opportunities (e.g., good condition), and within proximity to allow seasonal movement and use (third-order selection) of neighboring, quality (forth-order) habitats on the best ranges for sage-grouse (Dzialak et al. 2012).

Human alterations, uses and impacts coupled with natural variability (e.g., drought) have changed the extent, condition and distribution of sagebrush-steppe and the ecosystem services this biome provides (Meinke et al. 2009); current sage-grouse range is estimated to be 56% of historic (pre-European settlement) distribution (Stiver et al. 2006a). Disrupted disturbance regimes, degraded or depressed native species, and dominance by introduced noxious plants have moved many of these systems towards, or beyond, critical thresholds from which restoration is difficult, or excessively time-consuming and expensive (Meinke et al. 2009). Three of the fundamental characteristics of the sagebrush biome that have been altered from pre-settlement conditions include: (1) the total area of sagebrush shrublands has been reduced; (2) the composition and structure of (the vegetation and soils of) sagebrush communities has been changed by diffuse (press) forms of stress, including increased abundance and performance of invasive species and decreased abundance and performance of native species; (3) fragmentation created by roads, power-lines, fences, energy developments, urbanization and other anthropogenic features isolate populations by restricting movements (Connelly et al. 2004). For

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example, 75% of the shrub steppe growing on deep soils has been converted to agricultural croplands (Connelly et al. 2004), and intense historic land-use (esp. livestock grazing) in the late 19th and early 20th centuries reduced the dominance of native grasses, trampled microbiotic crusts, and encouraged expansion of Eurasian grasses (Anderson and Inouye 2001, Ponzetti et al. 2007, Root and McCune 2012). Therefore, long-term conservation of the species as well as sagebrush habitats may, simply stated, hinge on adaptation, reclamation and recovery of native ecosystems from historic land uses and former practices.

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The combination of natural variability (for example, drought) and a legacy of multiple human land-uses with various but widespread impacts has induced changes in the extent, condition and distribution of sagebrush ecosystems and the biological services they provide. Currently, few intact sagebrush ecosystems remain in reference condition to provide crucial habitat functions, which has important consequences for the distribution of wildlife in the region (Connelly et al. 2004). The human footprint is most intense at low elevations near valley floors and may have disproportionate effect on sage-grouse populations reliant on these habitats during critical portions of the year (Leu and Hanser 2011). Across the sage-grouse range, lek count **declines** were lower when human-footprint scores exceeded '2' at leks, or when median scores exceeded '3' within either 5 km or 18 km (3.1 or 11.2 mi) of a lek (Johnson et al. 2011). The human-footprint index indicates the spatial accumulation of effects due to anthropogenic features – including human habitation, highways and roads, railroads, power lines, agricultural lands, campgrounds, rest stops, landfills, oil and gas developments, and human-induced fires – on a landscape expressed on a 1 to 10 scale (Johnson et al. 2011, Leu and Hanser 2011), thus these values (2 and 3) are towards the low-intensity end of this distribution. Within this report, six sections summarize information regarding contributions of the human-footprint to sage-grouse habitat conditions: (A1) fragmentation and connectivity, (A2) agricultural conversion, (A3) urbanization and

Comment [SSK24]: this sentence needs help. "Which" refers to the fact stated in the earlier phrase, yet that's not clear

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Comment [SSK25]: Which report, Johnson et al. 2011 or this one?

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human habitation, (A4) general infrastructure, including highways and improved surface roads, railroads, transmission lines and power lines, communication towers, and fences, (A5) energy development and associated infrastructure, and (A6) fire.

A1. Habitat Fragmentation & Connectivity

Sage-grouse populations generally rely on large, interconnected expanses of sagebrush to accommodate local migrations and access to seasonal habitats distributed within their inhabited range (Connelly et al. 2004) and ‘fragmentation’ represents the dissection of large expanses via various mechanisms. Conclusive, consistent data establishing minimum sizes of sagebrush-dominated landscapes necessary to support viable populations of sage-grouse are unavailable (Connelly et al. 2011d). However some quantitative indications exist, for example sage-grouse populations in Idaho used an annual range of at least 2,764 km^2 (683,000 acres; Leonard et al. 2000). Research in Wyoming and Montana suggested that a sagebrush-dominated landscape 314 km^2 (77,600 acres) in size may provide the area necessary to maintain breeding habitat around a given lek (Doherty et al. 2008). The size of a landscape capable of supporting breeding habitats of an interspersed population (e.g., an area with multiple leks spaced <10 km, 6.2 miles, apart) may exceed 1,000 km^2 (24,700 acres, Doherty et al. 2008). Investigations from Idaho and Wyoming suggest that relatively large blocks of sagebrush habitat (>4,000 ha; 9900 acres) are critical to successful reproduction and over-winter survival (Leonard et al. 2000, Walker et al. 2007a). Mean sagebrush patch size within an 18 km radius (1018 km^2, 250,000 acres) was more than 9 times as large in occupied versus extirpated sage-grouse range; sagebrush patch size in occupied range averaged 4,173 ha (10,300 acres; Wisdom et al. 2011). Based on natural geographic patterns, it has been suggested that sage-grouse may have adapted to a scale of natural fragmentation in sagebrush habitats organized at 4.5 to 9 km (2.8 – 5.6 mi; Leu and Hanser 2011); research on selection behavior indicated similar, emergent patterns based on spacing between leks

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(nearest-neighbor distances of 5.9 km; 0.36 mi), mean lek to nest movements (5.1 km, 3.2 mi), and nest to summer range movements generally limited to less than 10 km (6.2 mi, Fedy 2012), supporting this contention.

The scale of the landscape used by sage-grouse changes throughout seasons and may differ between populations based on available habitats. Strong site fidelity of sage-grouse – established for nesting habitat (Fischer 1993, Holloran et al. 2005, Thompson 2012) and suggested for other seasonal habitats (Berry and Eng 1985, Thompson 2012) – indicates that the "landscape" targeted by an individual female during different life-history stages may be relatively small. The overall landscape requirements for an individual would be the conglomeration of these seasonal habitats combined with the necessary migration corridors (the length of these corridors will be different between and within populations depending on the local landscape as much as the birds). Thus, the landscape required by an individual is a combination of the seasonal habitat requirements on a relatively small scale, the juxtapositional requirements of those seasonal habitats, and the habitats required to move between those seasonal ranges. Distances between consecutive-year nests of 740 m on average suggest a female will nest (repeatedly) within a 172 ha (425 acre) area over its lifetime (Fischer 1993, Holloran et al. 2005). Additionally, a high degree of fidelity of female offspring to their natal home ranges has been observed (e.g., yearling females nesting close to their natal nest), suggesting that family groups of females may inhabit relatively distinct areas (Thompson 2012). Based on cumulative mean daily movements of sage-grouse broods between hatch and 2 weeks post-hatch (Gregg, U.S. Fish and Wildlife Service; unpublished data), early brood-rearing tends to occur within 4.6 km (2.9 mi) of the nest. Sage-grouse generally move ≤10 km (6.2 mi) from nests to summer range – but may travel as far as 82 km (50 mi; Fedy 2012) – and remain in relatively distinct locations upon reaching summer range (Connelly et al. 2011d). In contrast, a majority of sage-grouse move >10 km from summer to winter locations, with

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movements of up to 83 km (52 mi) documented (Fedy 2012). Sage-grouse tend to be more adaptive in their movements during winter and have been documented traveling similarly long distances in search of exposed sagebrush in response to severe storm events in Wyoming (F. Blomquist, Wyoming BLM; unpublished data). Movements from spring to summer range and from summer to winter range generally occur along sagebrush-dominated habitats (Jensen 2006, Connelly et al. 2011d), indicating the importance of range conditions outside priority habitats, as well as within.

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In addition to the size of selected habitat patches, lek persistence is strongly related to lek connectivity, which is a measure of the relationship between each lek with the maintenance of a regional population network with active dispersal and genetic mixing among sub-populations (Knick and Hanser 2011a). Centrally located, large lek sites have greater importance and metapopulation implications, whereas abandoned leks have lower connectivity importance (Knick and Hanser 2011a). Dispersal distances reported in the literature were compiled and combined to establish the connectivity scale; reported dispersal distances range from 7.4 to 10.6 km (4.6 - 6.6 mi) for males, 8.8 and 13.1 km (5.5 – 8.1 mi) for females, and distances of 27.6 km (17 mi) are within the range of variation (Knick and Hanser 2011a). Gene flow in sage-grouse populations is likely limited to the movement of individuals between neighboring populations and not likely the result of long-distance movements of individuals across large portions of the species' range (Oyler-McCance et al. 2005b). Thus, regional connectivity among leks represents a fundamental source of genetic re-combination and metapopulation structure that supports the long-term viability of the species.

A2. Conversion to Agriculture

One of the fundamental characteristics of western landscapes which have been altered from pre-settlement conditions includes a reduction in the total land area dominated by sagebrush (Connelly et al. 2004). Development of vegetation and soil using clearing, tillage, and irrigation (amongst other

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practices including seeding, application of fertilizers, pesticides, and herbicides) results in long-term conversion of native sage-grouse habitats to sustained human uses (obviously agriculture, but also subdivisions and exurban developments in portions of all MZs). Cultivated agriculture, primarily cropland, covers more than 230,000 km^2 (56.8 million acres; 11%;) of the total land area within the estimated, historic distribution of sage-grouse, including a 50km (31 mi) buffer (Knick and Connelly 2011a). Agriculture is defined as predominantly cropland, or lands that have been converted for the production of foods and goods (Knick and Connelly 2011a). The primary agricultural regions in the sagebrush biome include central Washington and northern Oregon, the Snake River Plains of southern Idaho, northern Utah, northern Montana, southern Alberta, southern Saskatchewan, and western North Dakota (Connelly et al. 2004). Thus, agricultural lands are widespread across the range of sage-grouse (Table 4, Figure 9). Approximately 4.4 million acres (3.04%; 17,800 km^2) of designated sage-grouse habitat has been converted to crops throughout the range of the species, with approximately 261,400 acres (2.25%; 1050 km^2) of priority habitats and 3.1 million acres (8.90%; 12,500 km^2) of general habitats converted in MZ I, the MZ most influenced by agriculture. Indirect effects to sage-grouse of crop lands – assessed as the spatial foraging scale of sage-grouse avian predators which may be attracted to agricultural lands (6.9 km, 4.3 mi) – influence most (approximately 84.2%) of priority habitats throughout the species range. Although little BLM land has been directly converted, BLM lands account for approximately 50% of the priority habitats indirectly influenced by agriculture. Areas converted to croplands are generally those with deeper, loamy soils that are able to be irrigated while sagebrush remains in arid areas where soils and topography are limiting to crops; agriculture has replaced 75% of the shrub steppe in deep soils but only 15% in shallow soils (Connelly et al. 2004). Summary analyses indicate that while agricultural conversion is widespread across and within MZs, current overlap with

Comment [SSK27]: Table 4 needs considerable more explanation - define direct footprint; state what the column Indirect Influence means. The footnote appears to explain how the 6.9 km distance was chosen. Is it a buffer around sagebrush? Also explain what relative influence means. All of this can be done in footnotes so that the table can stand alone.

Comment [SSK28]: The figure legend should also define direct and indirect influences so that the figure can stand alone.

PPH and PGH designations vary among MZs, which will help differentiate priorities among management entities within each MZ (Table 4).

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Table 4. Agricultural lands* (crops, tillage, and similar, not open range) across sage-grouse range summarized using PPH and PGH within respective Management Zones (MZs).

	PPH					PGH				
Management Zone Entity	SG Habitat (acres)	Direct Footprint (acres)	6.9km Indirect Influence[1] (Acres)	Direct Footprint (%)	Relative Influence[2] (%)	SG Habitat (acres)	Direct Footprint (acres)	6.9km Indirect Influence[1] (Acres)	Direct Footprint (%)	Relative Influence[2] (%)
MZ I - GP	11,636,400	261,400	11,558,300	2.25	99.33	34,663,000	3,084,100	34,619,100	8.90	99.87
BLM	2,994,300	6,600	2,944,300	0.22	25	4,524,900	17,700	4,503,800	0.39	13
Forest Service	292,400	600	292,400	0.21	3	515,300	1,000	515,300	0.19	1
Tribal and Other Federal	219,700	1,300	219,700	0.59	2	2,427,700	534,900	2,427,800	22.03	7
Private	7,132,500	247,400	7,113,800	3.47	62	24,682,800	2,436,900	24,664,400	9.87	71
State	995,600	5,400	986,300	0.54	9	2,498,400	93,300	2,494,100	3.73	7
Other	1,900	0	1,900	0.00	0	13,900	300	13,900	2.16	0
MZ II and VII - WB & CP	17,476,000	113,000	14,711,100	0.65	84.18	19,200,200	402,300	15,046,400	2.10	78.37
BLM	9,021,200	2,100	7,091,200	0.02	48	9,012,500	3,200	6,324,600	0.04	42
Forest Service	162,000	0	124,100	0.00	1	452,500	300	407,400	0.07	3
Tribal and Other Federal	784,000	1,400	701,900	0.18	5	1,354,600	5,200	1,252,100	0.38	8
Private	6,233,900	106,100	5,627,900	1.70	38	7,394,800	385,900	6,194,900	5.22	41
State	1,244,800	3,300	1,135,900	0.27	8	979,800	7,700	861,400	0.79	6
Other	30,100	100	30,100	0.33	0	6,000	0	6,000	0.00	0
MZ III - SGB	10,028,500	80,000	8,086,800	0.80	80.64	3,970,100	4,600	2,803,800	0.12	70.62
BLM	6,309,400	3,800	4,679,000	0.06	58	3,199,800	1,000	2,191,500	0.03	78
Forest Service	1,236,200	400	1,065,000	0.03	13	356,200	0	243,300	0.00	9
Tribal and Other Federal	260,800	2,100	246,000	0.81	3	29,100	0	13,000	0.00	0
Private	1,836,200	72,900	1,720,100	3.97	21	384,800	3,500	355,700	0.91	13
State	385,900	800	376,500	0.21	5	200	0	200	0.00	0
MZ IV - SRP	21,930,600	72,300	18,309,700	0.33	83.49	10,958,500	257,400	9,762,400	2.35	89.09
BLM	13,710,700	14,800	10,960,600	0.11	60	4,928,200	14,500	4,227,900	0.29	43

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	PPH					PGH				
Management Zone Entity	SG Habitat (acres)	Direct Footprint (acres)	6.9km Indirect Influence[1] (Acres)	Direct Footprint (%)	Relative Influence[2] (%)	SG Habitat (acres)	Direct Footprint (acres)	6.9km Indirect Influence[1] (Acres)	Direct Footprint (%)	Relative Influence[2] (%)
Forest Service	1,613,800	900	1,452,800	0.06	8	1,113,500	1,800	1,009,300	0.16	10
Tribal and Other Federal	633,600	500	573,300	0.08	3	522,500	1,800	478,200	0.34	5
Private	4,890,200	55,200	4,404,300	1.13	24	3,516,742	233,600	3,272,000	6.64	34
State	1,019,373	800	855,800	0.08	5	846,200	4,400	743,600	0.52	8
Other	62,900	200	62,800	0.32	0	31,400	1,300	31,400	4.14	0
MZ V - NGB	7,097,200	6,300	4,711,300	0.09	66.38	5,808,000	58,300	4,948,800	1.00	85.21
BLM	5,117,500	300	3,333,900	0.01	71	4,196,700	700	3,435,400	0.02	69
Forest Service	62,200	0	60,800	0.00	1	114,900	0	104,700	0.00	2
Tribal and Other Federal	717,100	0	223,400	0.00	5	101,800	300	76,900	0.29	2
Private	798,000	3,000	696,300	0.38	15	1,199,000	55,700	1,155,900	4.65	23
State	64,900	0	60,200	0.00	1	115,800	400	96,100	0.35	2
Other	337,500	2,900	336,700	0.86	7	79,800	1,200	79,800	1.50	2

[*] Data Source: National Agriculture Statistics Service Cropland Data Layer 2012.

[1] Indirect influence distance derived from foraging distances of predators (Boarman and Heinrich 1999, Leu et al. 2008).

[2] For each MZ, these were calculated as the percent of the particular sage-grouse habitat type influenced by the indirect impact of the threat. For management entities within a management zone; these were calculated as the percent of the total indirect impact in the management zone represented by that management entity; i.e. the relative area of indirect influence among management entities.

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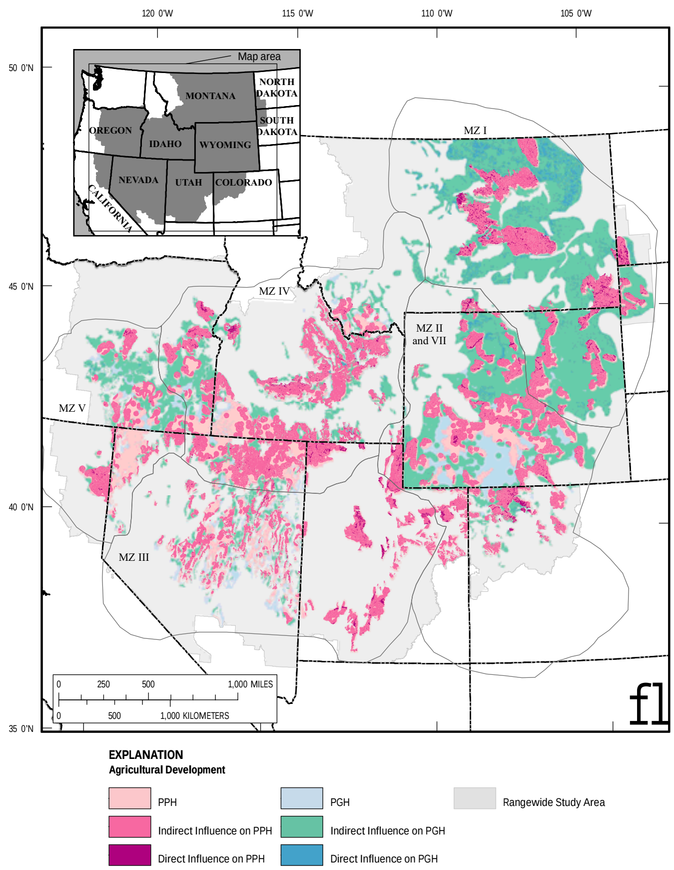

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Figure 9. Juxtaposition of agricultural land development and preliminary priority habitats and general habitats (PPH and PGH) across the sage-grouse range.

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Sage-grouse are considered a sagebrush-obligate, landscape-scale species as populations inhabit and rely on large, interconnected expanses of sagebrush (Connelly et al. 2004). A combined assessment of historic and modern ranges in Idaho estimated that sage-grouse populations used an annual range of at least 2,764 km^2 (683,000 acres, Leonard et al. 2000). Conversion of sagebrush to agriculture can influence the ability of sagebrush-dominated landscapes to support sage-grouse through direct habitat loss and fragmentation (Connelly et al. 2004). Isolation of shrub steppe habitats increased, mean patch size decreased, and number of patches increased with habitat conversion to agriculture in Washington (Connelly et al. 2004). Agricultural development can also indirectly influence sage-grouse by providing access to sagebrush habitats for predators such as domestic cats, red fox and corvids (Connelly et al. 2004).

In a comparison of currently occupied versus unoccupied sage-grouse range (see Schroeder et al. 2004), estimates indicated that sage-grouse were extirpated from areas of their range when the proportion of a 2,975 km^2 area (735,000 acres) in cropland exceeded 25% (Aldridge et al. 2008). A similar analysis of occupied versus unoccupied range reported areas where sagebrush cover was <27% (within a 1,018 km^2 (251,500 acre) search area) had a high probability of sage-grouse extirpation, areas with >50% sagebrush cover had high probabilities of sage-grouse persistence, and extirpated range contained approximately 3 times more area in agriculture compared to occupied range (Wisdom et al. 2011). In Idaho between 1975 and 1992, declines in the mean number of males per lek were strongly correlated to increases in the amount of land converted to agriculture, which increased 74% in the region during this period. The proportion of sagebrush habitat (positive effect) and the proportion of tillage agriculture (negative effect) within 6.4 km (4 mi) best explained lek persistence in northeastern Wyoming (Walker et al. 2007a). The percentage of cultivated land within 4 km (2.5 mi) of active leks in

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North Dakota was lower than around inactive leks, and the proportion of cultivated land (area of cultivated/area of non-cultivated) was greater within a region of the state historically occupied but currently not occupied compared to a region where sage-grouse still occurred (Smith et al. 2005).

A comparison of treatments in Wyoming, Montana and Colorado and found that eliminating ≥16% of the sagebrush-dominated area in a landscape closely associated with a group of leks either through plowing or herbicide spraying was correlated with a 50 to 100% reduction in the number of males occupying the leks (Swenson et al. 1987). A similar study suggested greater sensitivity with observed reduction in range-wide sage-grouse lek trends when agricultural land use exceeded 2.5% of the area within a 5 km (3.1 mi) radius (or 1.5% of the area within an 18 km, 11.2 mi, radius); trends in lek counts stabilized as the percent agricultural land increased beyond these proportions but few leks occurred in areas where the proportion of agricultural land exceeded 50% (Johnson et al. 2011). Conversion of 30% of the sagebrush-dominated winter habitats within a focused 202 km^2 area (50,000 acres) in Montana by plowing and conversion to cropland resulted in a 73% decline in the number of breeding male sage-grouse on leks in the area relative to controls (Johnson et al. 2011). In southern Canada, nesting sage-grouse avoided areas with a high proportion of anthropogenic edge habitats, (borders with a non-natural edge, such as cropland) and broods avoided areas close to cultivated cropland (Aldridge and Boyce 2007).

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The sage-grouse habitat management guidelines (Connelly et al. 2000c) recommend that no more than 20% of nesting, early brood-rearing and winter habitats exist in states not dominated by a sagebrush overstory at any one time. The research presented here suggests that this guideline may be most appropriate for short-term habitat treatments (for example, vegetation and fuel treatments). Available research suggests: (1) sage-grouse populations may become extirpated when the proportion of a landscape permanently converted from sagebrush to agriculture exceeds 25 to 27%; (2) substantial

Comment [SSK29]: This sentence needs some clarification. First, do you mean collectively in states (e.g., CO and NV for example) or not more than 20% in individual states? Minor point, but confusing to us lay people! Secondly, when you say “at any one time”, do you mean seasonally or between years (if habitat changes)? I know, picky, picky!!

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declines in lek counts may occur when this proportion exceeds 16%; and (3) lek count declines may occur when the proportion is as low as 1.5 to 2.5% of the landscape.

A3. Urbanization

Low densities of indigenous peoples in western North America (estimated range from one person per 6km^2 (1500 acres) to as low as one person per every 90 km^2 (22,000 acres) in the Great Basin) probably limited their impact on the biophysical landscape, although their activities for hunting, gathering, and burning may have been significant locally (Connelly et al. 2004). Ultimately, settlement by Europeans in sagebrush habitats had a much greater effect on transforming or converting habitats and altering disturbance regimes and animal communities than **behaviors** exerted by the low densities of indigenous people (Connelly et al. 2004). Human populations have grown and expanded over the past century, primarily in the western portion of the sagebrush biome. Human populations in sagebrush habitats increased between 166 and 666% between 1920 and 2000, and between 19 and 31% between 1990 and 2000; the amount of uninhabited area (0 residents/km^2) within the Great Basin decreased from 90,000 km^2 (22.2 million acres) in 1990 to <12,000 km^2 (3 million acres) in 2004 (Knick and Connelly 2011a). Although urbanized areas occur throughout the range of sage-grouse, the direct footprint is relatively small with approximately 792,700 acres (0.56%; 3200 km^2) of sage-grouse habitat directly converted to urbanized areas (Table 5, Figure 10). Preliminary priority habitats in Utah in particular, and to a lesser degree priority habitat in MZs II and VII, have a higher urbanized footprint than the remainder of the species range. Indirect impacts of urban areas – assessed as the spatial foraging scale of sage-grouse avian predators which may be attracted to urban areas (6.9 km, 4.3 mi) – influences a relatively small percentage (approximately 5.7%) of priority habitats throughout the species range suggesting localized potential impacts (versus widespread potential impacts such as with agriculture). BLM lands account for approximately 38% of the priority habitats indirectly influenced by urban areas.

Comment [SSK30]: My earlier comments for Table 4 and Fig 9 pertain here as well

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Rural areas have also been developed throughout the sagebrush region, particularly around urban centers and major highways (Knick and Connelly 2011a). Although many urban developments in rural areas continue to provide some sagebrush habitat in contrast to total urban conversion, habitat fragmentation and disturbance from human dwellings and activities probably render much of the area inhospitable to sage-grouse (Connelly et al. 2004). Comparison of currently occupied to historically occupied (presumed extirpated) sage-grouse range determined that mean human density (circa 1950 and 2000) was up to 26 times lower in currently occupied range (Aldridge et al. 2008, Wisdom et al. 2011).

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Table 5. Summary of the direct and indirect influences of urban areas* across sage-grouse Management Zones by acres of PPH and PGH.

Management Zone Entity	PPH SG Habitat (acres)	PPH Direct Footprint (acres)	PPH 6.9km Indirect Influence[1] (Acres)	PPH Direct Footprint (%)	PPH Relative Influence[2] (%)	PGH SG Habitat (acres)	PGH Direct Footprint (acres)	PGH 6.9km Indirect Influence[1] (Acres)	PGH Direct Footprint (%)	PGH Relative Influence[2] (%)
MZ I - GP	11,636,400	5,000	436,600	0.04	3.75	34,663,000	130,100	2,733,300	0.38	7.89
BLM	2,994,300	100	34,600	0.00	8	4,524,900	9,300	190,300	0.21	7
Forest Service	292,400	100	9,600	0.03	2	515,300	0	32,400	0.00	1
Tribal and Other Federal	219,700	0	400	0.00	0	2,427,700	200	100,700	0.01	4
Private	7,132,500	4,100	331,800	0.06	76	24,682,800	113,200	2,188,300	0.46	80
State	995,600	800	59,800	0.08	14	2,498,400	7,300	219,000	0.29	8
Other	1,900	0	300	0.00	0	13,900	0	2,600	0.00	0
MZ II and VII - WB & CP	17,476,000	155,700	1,875,000	0.89	10.73	19,200,200	353,400	3,841,800	1.84	20.01
BLM	9,021,200	37,400	820,900	0.41	44	9,012,500	106,200	1,431,100	1.18	37
Forest Service	162,000	0	3,500	0.00	0	452,500	24,600	80,500	5.44	2
Tribal and Other Federal	784,000	32,400	86,000	4.13	5	1,354,600	2,500	145,000	0.18	4
Private	6,233,900	79,100	833,600	1.27	44	7,394,800	209,300	2,008,500	2.83	52
State	1,244,800	6,800	126,300	0.55	7	979,800	10,900	175,800	1.11	5
Other	30,100	0	4,700	0.00	0	6,000	0	800	0.00	0
MZ III - SGB	10,028,500	57,200	909,800	0.57	9.07	3,970,100	14,500	144,900	0.37	3.65
BLM	6,309,400	4,100	226,500	0.06	25	3,199,800	2,200	81,000	0.07	56
Forest Service	1,236,200	0	50,400	0.00	6	356,200	0	2,400	0.00	2
Tribal and Other Federal	260,800	100	50,400	0.04	6	29,100	0	3,700	0.00	3
Private	1,836,200	51,500	527,500	2.80	58	384,800	12,300	57,700	3.20	40
State	385,900	1,500	54,900	0.39	6	200	0	100	0.00	0
MZ IV - SRP	21,930,600	5,200	635,900	0.02	2.90	10,958,500	66,700	937,800	0.61	8.56
BLM	13,710,700	1,100	386,600	0.01	61	4,928,200	19,700	277,700	0.40	30
Forest Service	1,613,800	0	48,000	0.00	8	1,113,500	700	39,200	0.06	4
Tribal and Other Federal	633,600	4,100	20,700	0.65	3	522,500	100	28,200	0.02	3

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Management Zone Entity	PPH SG Habitat (acres)	PPH Direct Footprint (acres)	PPH 6.9km Indirect Influence[1] (Acres)	PPH Direct Footprint (%)	PPH Relative Influence[2] (%)	PGH SG Habitat (acres)	PGH Direct Footprint (acres)	PGH 6.9km Indirect Influence[1] (Acres)	PGH Direct Footprint (%)	PGH Relative Influence[2] (%)
Private	4,890,200	0	153,400	0.00	24	3,516,742	43,400	535,500	1.23	57
State	1,019,373	0	26,900	0.00	4	846,200	2,800	56,800	0.33	6
Other	62,900	0	400	0.00	0	31,400	0	300	0.00	0
MZ V - NGB	7,097,200	300	17,000	0.00	0.24	5,808,000	4,600	92,200	0.08	1.59
BLM	5,117,500	0	3,900	0.00	23	4,196,700	0	19,700	0.00	21
Forest Service	62,200	0	0	0.00	0	114,900	0	1,800	0.00	2
Tribal and Other Federal	717,100	0	0	0.00	0	101,800	100	400	0.10	0
Private	798,000	300	13,000	0.04	76	1,199,000	4,500	65,300	0.38	71
State	64,900	0	0	0.00	0	115,800	0	0	0.00	0
Other	337,500	0	0	0.00	0	79,800	0	5,000	0.00	5

[*] Data Source: Tele Atlas ESRI Street Map Premium for ArcGIS v 9.0, 2008

[1] Indirect influence distance derived from foraging distances of predators (Boarman and Heinrich 1999, Leu et al. 2008).

[2] For each MZ these were calculated as the percent of the particular sage-grouse habitat type influenced by the indirect impact of the threat. For management entities within a management zone, these were calculated as the percent of the total indirect impact in the management zone represented by that management entity; i.e. the relative area of indirect influence among management entities.

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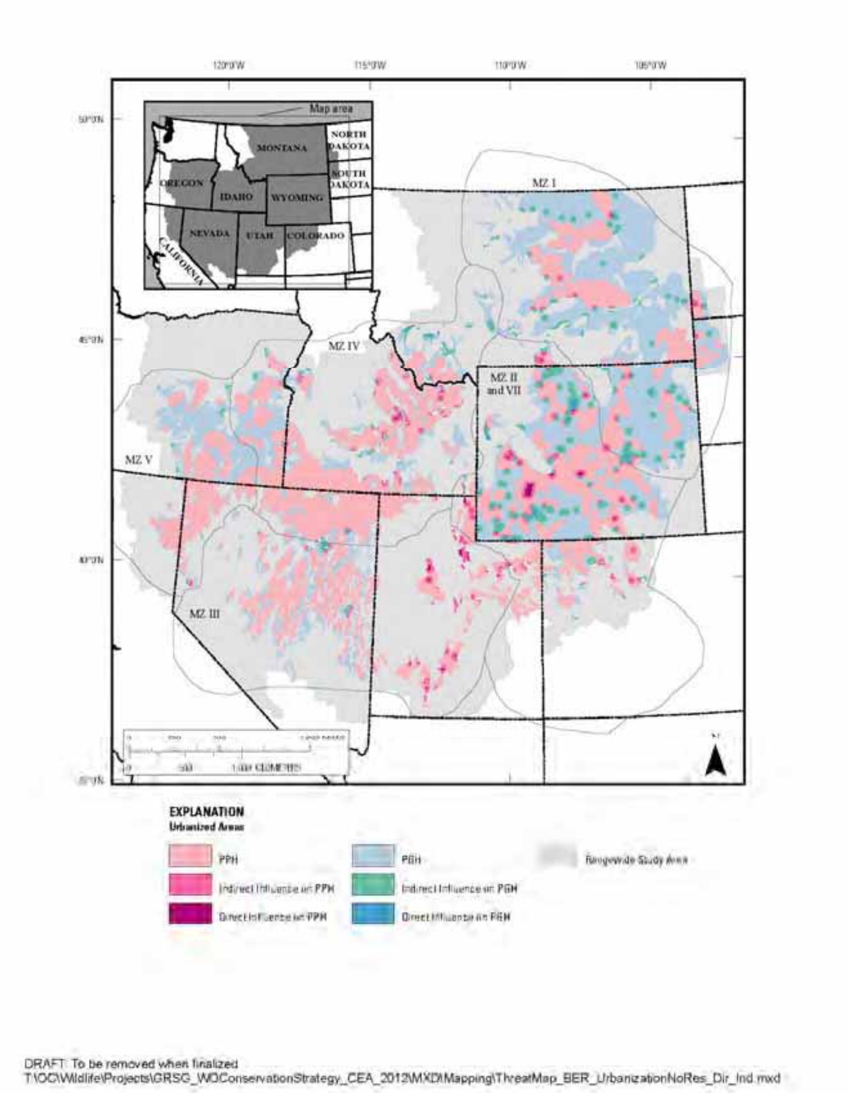

Figure 10. Distribution of urban areas, with anticipated direct and indirect effects, within PPH and PGH across the sage-grouse range.

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There is little information directly assessing the response of sage-grouse to urbanization. Research in Canada revealed that brood-rearing females avoided habitats associated with a high density of urban developments (Aldridge and Boyce 2007). Urban areas by themselves remove habitat and present inhospitable environments for sage-grouse, but the physical boundaries of cities are small relative to the total sagebrush area The roads, railways, power lines and communications corridors connecting urban centers may exert a greater influence on sagebrush habitats than that exerted by the actual city (Connelly et al. 2004). Additionally, recreation, including hiking, hunting and fishing, and OHV use in areas surrounding urban centers can negatively influence sage-grouse through habitat loss and fragmentation, facilitation of exotic plant spread, animal displacement or avoidance, establishment of population barriers, or increased human-wildlife encounters that increase wildlife mortality (Connelly et al. 2004). Recreation on lands managed by the BLM remains a significant land use with potential impacts to range conditions and sage-grouse populations (Connelly et al. 2004, also see Section III.A12. Other Land Uses). The cumulative nature of changes to the sagebrush biome as a result of human encroachment needs to be considered when managing sage-grouse. Potential synergistic effects of the components of urbanization – including the direct and indirect stresses on habitats surrounding urban centers – may influence sage-grouse habitat use and demography making growth and mitigation of urban areas and effects an important consideration in many MZs. For example, the development of an energy field (discussed in length below) involves more than the infrastructure required to extract the resource. Urban centers near the developing field will expand with the increased human population in the area, communication towers and power lines will be erected, traffic on highways will increase, recreational use of areas surrounding urban centers will increase, and all these factors individually and in combination may influence sage-grouse populations (Johnson et al. 2011).

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A4. Infrastructure

Interstates and major highways are ubiquitous throughout the range of sage-grouse, directly influencing 1,338,200 acres (5400 km^2; 2%) of sage-grouse PPH habitat and more than 3 million acres (12,100 km^2) of PPH and PGH combined, with indirect influences estimated on over 139 million acres (565,800 km^2) across the range of the species (Table 6, Figure 11). Secondary paved roads exist in most sagebrush regions in densities up to >5 km/km^2 (~1.25 miles/100acres) less than 5% of the sage-grouse range is more than 2.5 km (1.5 mi) from a paved road, and almost no area of sagebrush is more than 6.9 km (4.3 mi) from a paved road (Knick and Connelly 2011a). Indirectly – assessed as 7.5 km (4.6 mi) for interstates and 3km (1.9 mi) for highways, primary and secondary routes -- interstates and major highways potentially influence (indirectly) more than 95% of priority habitats throughout the range of the species. A large proportion of these roads exist as rights-of-way on public lands, including 55% of BLM managed PPH and 5% of USFS managed PPH (52% and 5% of PGH, respectively; Table 8). In contrast to roads, major railroads are not as widespread throughout the range of sage-grouse, and directly influence only 30,300 acres (120 km^2; 0.02%) of sage-grouse habitat across the range of the species (Table 7, Figure 12). Railroads are slightly more widespread in MZ I and in Wyoming portions of MZs II and VII; additionally, railroads may have a relatively important influence in some priority habitats in central Utah. Indirect effects of railroads were assessed using estimated contributions to spread of exotic plant species (3 km, 1.9 mi), which potentially influence approximately 4% of priority sage-grouse habitats across the range.

Transmission lines and major power lines are widespread throughout the range of sage-grouse and are especially prevalent in in MZ II and VII and in priority habitats in eastern portions of MZs III and IV (Table 8, Figure 13). Major power lines directly influence approximately 1,848,000 acres (7500 km^2; 1.29%) of sage-grouse habitats throughout the range of the species, with approximately 281,800

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acres (1100 km^2; 1.61%) of priority habitats and 434,900 acres (1760 km^2; 12.27%) of general habitats directly influenced in MZ II and VII – the largest among MZs. Indirect impacts of urban areas – assessed as the spatial foraging scale of sage-grouse avian predators which may be attracted to power lines (6.9 km, 4.3 mi) – influences approximately 26.4% of priority habitats throughout the species range, and approximately 40% of priority habitats in MZs II and VII. BLM lands account for approximately 48% of the priority habitats indirectly influenced by power lines. Non-wind power related vertical structures are widespread and directly influence approximately 15,200 acres (61 km^2; 0.01%) of sage-grouse habitat throughout the range of the species (Table 8). A minimum of 10,182 communication towers exist in or within 50 km (30 mi) of current sage-grouse range (Knick and Connelly 2011a). Indirect effects of vertical structures – assessed as the spatial foraging scale of sage-grouse avian predators which may be attracted to these structures (6.9 km, 4.3 mi) – influence approximately 33.4% of priority habitats throughout the range of the species, so the potential indirect effects of vertical structures are not insignificant. BLM lands account for approximately 45% of the priority habitats indirectly influenced by vertical structures. Fences are ubiquitous throughout sage-grouse range, with areas having fence densities exceeding 1.5 km/km2 (4 miles/1000 acres) in all MZs except western portions of MZ III (Knick and Connelly 2011a). Approximately 167,700 miles of fence are present within BLM and USFS managed allotment and pasture boundaries on sage-grouse habitats, with approximately 78,300 miles (126,000 km) of fence present on these public lands, in priority habitats (Table 9). These estimates of fence densities across the range of the species are approximately 0.75 miles per section (one section equals one square mile) and exceed 1 mile/section (6km/10km^2) in priority habitats in MZ I, without accounting for similar fencing on private lands.

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Compared to occupied range, extirpated sage-grouse range was 60% closer to highways and had 25% higher densities of roads compared to occupied range (Wisdom et al. 2011). Mean distance to

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transmission lines was more than 2 times farther in occupied range than in extirpated range, and the distance to communication towers averaged almost 2 times as far in occupied versus extirpated range (Wisdom et al. 2011). Although relatively few leks across the range of the species had interstate highways nearby, **declines** in the numbers of males on leks closer to interstates were slightly less than those farther from interstates, and there was a consistent downward trend relative to the length of interstate within 5 km, 3.1 miles (Johnson et al. 2011). Similarly, despite low numbers of communication towers across the sagebrush biome, sage-grouse lek trends across the range of the species generally increased with distance to nearest tower and generally decreased with increasing numbers of towers within 5 km (3.1 mi) and 18 km (11.2 mi) of leks (Johnson et al. 2011). Sage-grouse population response to a human footprint metric (see Section III.A) indicated that sage-grouse generally respond negatively to increased anthropogenic infrastructures located in sagebrush habitats. Roads and power lines are especially widespread throughout the range of the species, and communication towers are becoming increasingly prevalent. Although the response of sage-grouse to communication towers may be correlated with human development in general as these towers are often concentrated along major roadways and near urban centers (Johnson et al. 2011), an extensive rural network exists and with an increase in these types of structures throughout the sagebrush biome (for example, meteorological towers at proposed wind developments) the accumulation of effects is likely to have indirect effects on sage-grouse habitat quality.

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Table 6. Summary of the distribution of roads* across sage-grouse habitats (PPH and PGH) by Management Zone.

	PPH					PGH				
Management Zone Entity	SG Habitat (acres)	Direct Footprint (acres)	Indirect Influence[1] (acres)	Direct Footprint (%)	Relative Influence[2] (%)	SG Habitat (acres)	Direct Footprint (acres)	Indirect Influence[1] (acres)	Direct Footprint (%)	Relative Influence[2] (%)
MZ I - GP	11,636,400	255,300	11,602,600	2.19	100	34,663,000	887,300	34,604,700	2.56	99.83
BLM	2,994,300	48,200	2,971,300	1.61	26	4,524,900	79,600	4,511,000	1.76	13
Forest Service	292,400	7,200	292,400	2.46	3	515,300	12,300	515,100	2.39	1
Tribal and Other Federal	219,700	3,300	218,100	1.50	2	2,427,700	61,500	2,418,200	2.53	7
Private	7,132,500	176,200	7,127,900	2.47	61	24,682,800	675,000	24,653,700	2.73	71
State	995,600	20,300	991,200	2.04	9	2,498,400	58,600	2,492,700	2.35	7
Other	1,900	0	1,800	0.00	0	13,900	300	13,900	2.16	0
MZ II and VII - WB & CP	17,476,000	431,400	17,395,000	2.47	100	19,200,200	483,200	19,062,400	2.52	99.28
BLM	9,021,200	209,600	8,993,500	2.32	52	9,012,500	188,800	8,948,200	2.09	47
Forest Service	162,000	2,900	160,700	1.79	1	452,500	5,600	420,300	1.24	2
Tribal and Other Federal	784,000	17,100	769,100	2.18	4	1,354,600	28,600	1,341,700	2.11	7
Private	6,233,900	170,800	6,200,300	2.74	36	7,394,800	236,700	7,370,400	3.20	39
State	1,244,800	30,200	1,241,300	2.43	7	979,800	23,400	975,800	2.39	5
Other	30,100	900	30,100	2.99	0	6,000	200	6,000	3.33	0
MZ III - SGB	10,028,500	211,700	9,599,100	2.11	96	3,970,100	71,700	3,772,500	1.81	95.02
BLM	6,309,400	115,700	6,003,000	1.83	63	3,199,800	56,900	3,061,200	1.78	81
Forest Service	1,236,200	20,900	1,180,700	1.69	12	356,200	4,400	331,100	1.24	9
Tribal and Other Federal	260,800	8,800	260,600	3.37	3	29,100	600	28,000	2.06	1
Private	1,836,200	56,800	1,774,400	3.09	18	384,800	9,800	352,000	2.55	9
State	385,900	9,400	380,200	2.44	4	200	0	200	0.00	0
MZ IV - SRP	21,930,600	351,700	20,890,500	1.60	95	10,958,500	187,900	10,638,900	1.71	97.08
BLM	13,710,700	199,400	13,075,200	1.45	63	4,928,200	68,500	4,799,300	1.39	45
Forest Service	1,613,800	20,100	1,479,200	1.25	7	1,113,500	12,900	1,047,800	1.16	10
Tribal and Other Federal	633,600	11,200	628,200	1.77	3	522,500	8,000	449,300	1.53	4
Private	4,890,200	100,900	4,643,900	2.06	22	3,516,700	83,500	3,485,800	2.37	33
State	1,019,400	18,800	1,001,100	1.84	5	846,200	14,100	825,300	1.67	8

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	PPH					PGH				
Management Zone Entity	SG Habitat (acres)	Direct Footprint (acres)	Indirect Influence[1] (acres)	Direct Footprint (%)	Relative Influence[2] (%)	SG Habitat (acres)	Direct Footprint (acres)	Indirect Influence[1] (acres)	Direct Footprint (%)	Relative Influence[2] (%)
Other	62,900	1,200	62,900	1.91	0	31,400	800	31,400	2.55	0
MZ V - NGB	7,097,200	88,100	6,608,800	1.24	93	5,808,000	99,100	5,636,800	1.71	97.05
BLM	5,117,500	54,300	4,724,400	1.06	71	4,196,700	59,900	4,034,200	1.43	72
Forest Service	62,200	2,000	62,200	3.22	1	114,900	3,600	114,900	3.13	2
Tribal and Other Federal	717,100	6,900	639,800	0.96	10	101,800	2,200	99,500	2.16	2
Private	798,000	17,400	788,600	2.18	12	*1,199,000*	29,400	1,194,600	2.45	21
State	64,900	1,300	64,200	2.00	1	115,800	2,100	115,600	1.81	2
Other	337,500	6,200	329,500	1.84	5	79,800	1,900	77,900	2.38	1

[*] Data Source: Tele Atlas ESRI StreetMap Premium for ArcGIS v 9.0 2008

[1] Indirect influence of roads was calculated using 7.5km for interstates and 3km for highways, primary routes, and secondary routes. (Connelly et al. 2004, Holloran 2005, Lyon 2000).

[2] For each MZ, calculated as the percent of the particular sage-grouse habitat type influenced by the indirect impact of the threat. For management entities within a management zone, calculated as the percent of the total indirect impact in the management zone represented by that management entity; i.e. the relative area of indirect influence among management entities.

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1 Table 7. Summary of the distribution of railroads* across sage-grouse habitats (PPH and PGH) by Management Zone.

	PPH					PGH				
Management Zone Entity	SG Habitat (acres)	Direct Footprint (acres)	3km Indirect Influence[1] (acres)	Direct Footprint (%)	Relative Influence[2] (%)	SG Habitat (acres)	Direct Footprint (acres)	3km Indirect Influence[1] (acres)	Direct Footprint (%)	Relative Influence[2] (%)
MZ I - GP	11,636,400	1,200	405,100	0.01	3.48	34,663,000	10,800	2,947,400	0.03	8.50
BLM	2,994,300	100	17,700	0.00	4	4,524,900	400	198,100	0.01	7
Forest Service	292,400	0	2,900	0.00	1	515,300	200	59,100	0.04	2
Tribal and Other Federal	219,700	0	0	0.00	0	2,427,700	600	173,300	0.02	6
Private	7,132,500	1,100	353,000	0.02	87	24,682,800	8,900	2,312,700	0.04	78
State	995,600	100	31,000	0.01	8	2,498,400	700	201,300	0.03	7
Other	1,900	0	400	0.00	0	13,900	0	2,900	0.00	0
MZ II and VII - WB & CP	17,476,000	3,000	924,500	0.02	5.29	19,200,200	7,100	1,811,500	0.04	9.43
BLM	9,021,200	900	371,800	0.01	40	9,012,500	1,400	556,200	0.02	31
Forest Service	162,000	0	200	0.00	0	452,500	0	2,000	0.00	0
Tribal and Other Federal	784,000	100	28,100	0.01	3	1,354,600	300	71,800	0.02	4
Private	6,233,900	1,900	472,700	0.03	51	7,394,800	5,000	1,091,900	0.07	60
State	1,244,800	200	46,700	0.02	5	979,800	400	89,500	0.04	5
Other	30,100	0	5,000	0.00	1	6,000	0	100	0.00	0
MZ III - SGB	10,028,500	2,300	526,300	0.02	5.25	3,970,100	200	75,900	0.01	1.91
BLM	6,309,400	600	189,000	0.01	36	3,199,800	200	57,300	0.01	75
Forest Service	1,236,200	0	10,300	0.00	2	356,200	0	0	0.00	0
Tribal and Other Federal	260,800	400	37,100	0.15	7	29,100	0	0	0.00	0
Private	1,836,200	1,000	250,400	0.05	48	384,800	100	18,700	0.03	25
State	385,900	200	39,500	0.05	8	200	0	0	0.00	0
MZ IV - SRP	21,930,600	2,100	747,200	0.01	3.41	10,958,500	3,000	829,100	0.03	7.57
BLM	13,710,700	1,000	440,400	0.01	59	4,928,200	900	323,900	0.02	39
Forest Service	1,613,800	100	17,000	0.01	2	1,113,500	0	4,600	0.00	1
Tribal and Other Federal	633,600	100	58,000	0.02	8	522,500	100	12,300	0.02	1
Private	4,890,200	800	210,800	0.02	28	3,516,742	1,900	440,100	0.05	53
State	1,019,373	100	20,900	0.01	3	846,200	100	46,700	0.01	6
Other	62,900	0	100	0.00	0	31,400	0	1,600	0.00	0

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	PPH					PGH				
Management Zone Entity	SG Habitat (acres)	Direct Footprint (acres)	3km Indirect Influence[1] (acres)	Direct Footprint (%)	Relative Influence[2] (%)	SG Habitat (acres)	Direct Footprint (acres)	3km Indirect Influence[1] (acres)	Direct Footprint (%)	Relative Influence[2] (%)
MZ V - NGB	7,097,200	400	140,300	0.01	1.98	5,808,000	200	76,200	0.00	1.31
BLM	5,117,500	200	78,600	0.00	56	4,196,700	0	29,400	0.00	39
Forest Service	62,200	0	0	0.00	0	114,900	0	2,800	0.00	4
Tribal and Other Federal	717,100	0	4,800	0.00	3	101,800	0	1,400	0.00	2
Private	798,000	0	100	0.00	0	1,199,000	100	34,900	0.01	46
State	64,900	0	2,700	0.00	2	115,800	0	200	0.00	0
Other	337,500	200	54,100	0.06	39	79,800	0	7,600	0.00	10

[*] Data Source: Tele Atlas ESRI StreetMap Premium for ArcGIS v 9.0, 2008

[1] Indirect influence distance derived from estimated spread of exotic plants (Knick et al. 2011).

[2] For each MZ, these were calculated as the percent of the particular sage-grouse habitat type influenced by the indirect impact of the threat. For management entities within a management zone, these were calculated as the percent of the total indirect impact in the management zone represented by that management entity; i.e. the relative area of indirect influence among management entities.

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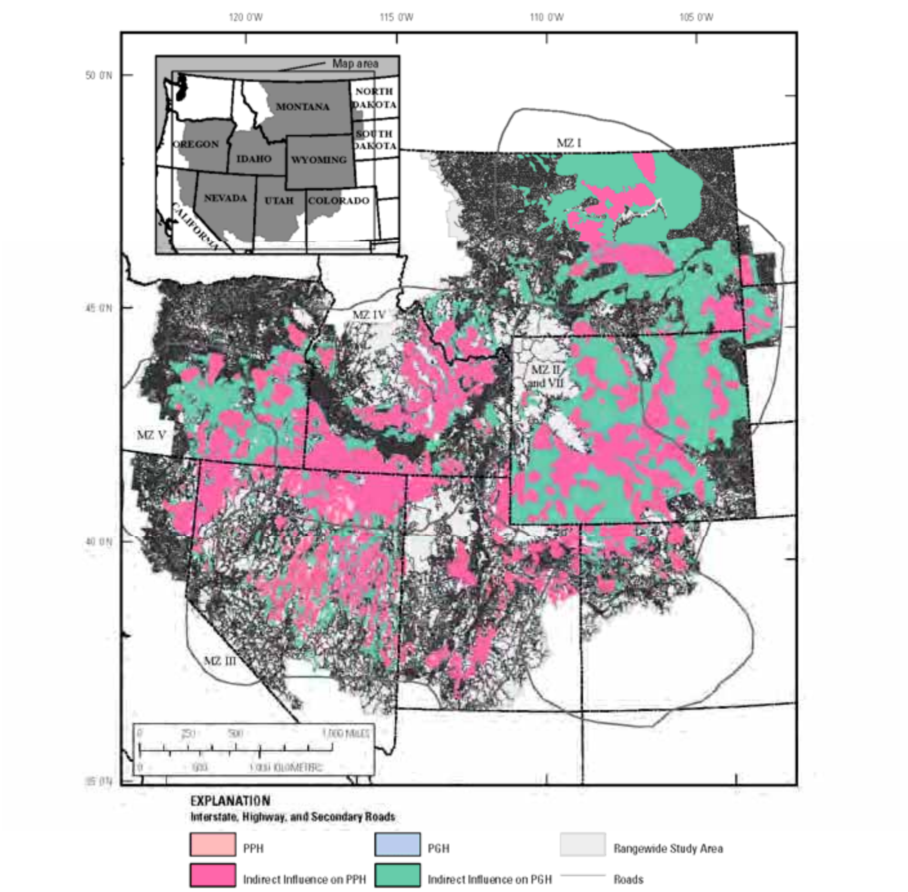

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Figure 11. Direct and Indirect influence of Roads within PPH and PGH, by Management Zone.

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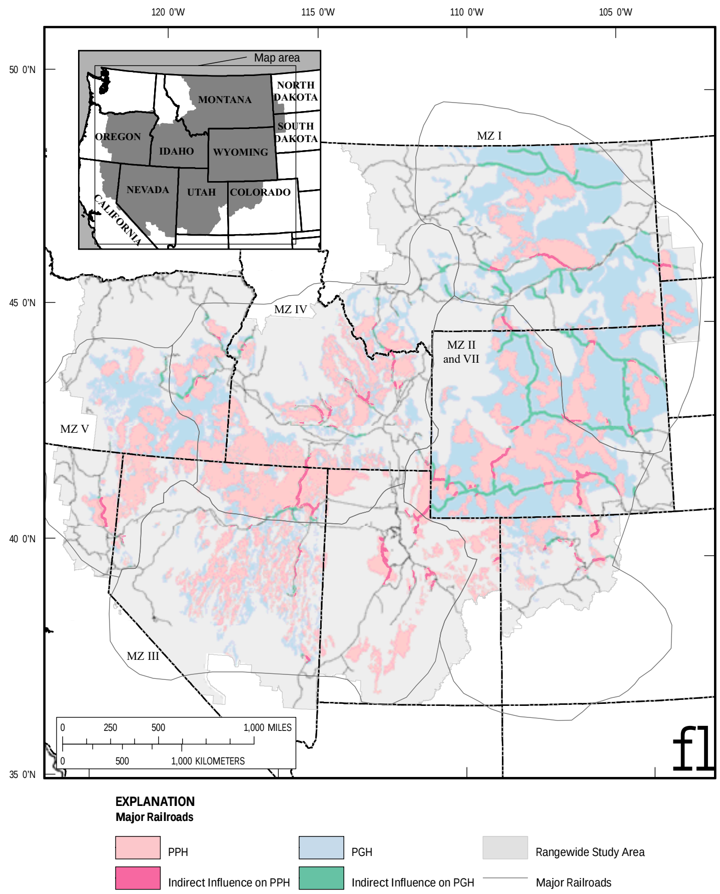

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Figure 12. Direct and Indirect effect of Railroads within PPH and PGH by Management Zone.

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Lekking and nesting sage-grouse appear to avoid road infrastructure and activity. Along Interstate 80 in Wyoming and Utah **between 1970 and 2003, there were** no leks within 2 km (1.25 mi) of the interstate **and fewer** leks within 7.5 km (4.7 mi) **than within 7.5-15 km (4.7-9.3 mi) of the interstate (Connelley et al. 2004). Additionally, there were** higher rates of decline in lek counts within **than beyond** 7.5 km **of the interstate**. Negative relationships between the length of road segments within 3.2 km (2 mi) of leks and the probability of lek occurrence were found in Montana and southern Canada with the impacts of increasing road lengths (implying larger roads) being greatest for larger leks (>25 males); the probability of occurrence of a large lek approached 0% as the length of road segments within 3.2 km (2 mi) of a lek exceeded 100 km (62 miles; Tack 2009).

Generally, road effect-distances (the distance from a road at which a population density decrease is detected) are positively correlated with increased traffic density and speed (Forman and Alexander 1998). The upgrade of haul roads associated with surface coal mining activity in Colorado resulted in increased traffic levels and was correlated with declines in the number of displaying males on sage-grouse leks situated within 2 km (1.25 mi) of the road (Remington and Braun 1991). Rates of decline in sage-grouse male lek attendance increased as traffic volumes on roads near leks increased, and vehicle activity on roads during the daily strutting period (i.e., early morning) had a greater influence on male lek attendance compared to roads with no vehicle activity during early morning in southwestern Wyoming (Holloran 2005). In central Wyoming, peak male attendance (i.e., abundance) at leks experimentally treated with noise recorded at roads in a gas field decreased 73% relative to paired controls (Blickley 2012).

Sage-grouse avoided nesting and summering near major roads (for example, paved secondary highways) in south-central Wyoming (LeBeau 2012), and traffic disturbance (1 to 12 vehicles/day) within 3 km (1.9 mi) of leks during the breeding season reduced nest-initiation rates and increased

Comment [SSK35]: It's often nice to have a short introductory sentence that summarizes what followis in the paragraph. See what you think about this one.

Comment [SSK36]: The sentence was just too long with too much information to read easily. Try this.

Deleted: An examination of leks within 100 km (62 mi)of

Comment [SSK37]: Presenting both metric and English units through out seems a bit awkward and may not be necessary because you have a conversion table upfront. However, there may be SPN or client preferences here. If you can avoid doing so, it would help the readability.

Deleted: found

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Deleted: between 1970 and 2003 on leks

Deleted: compared to leks 7.5 to 15 km (4.7 – 9.3 mi) from the interstate

Deleted: (Connelly et al. 2004).

Comment [SSK38]: There are many specific finding presented in the road section that may be boiled down to many fewer statements, depending on what the audience is needing. I'd double-check on that.…

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distances moved from leks during nest site selection of female sage-grouse in southwestern Wyoming (Lyon and Anderson 2003). Nesting propensity (i.e., nest initiation rates) was 24% lower for females breeding on road-disturbed leks compared to undisturbed females, 56% of females breeding on disturbed leks initiated nests inconsecutive years compared to 82% of females breeding on undisturbed leks, and females moved twice as far from leks to nest locations if breeding on disturbed leks (Lyon and Anderson 2003). In summary, research suggests that roads within 7.5 km (4.7 mi) of leks negatively influence male lek attendance. Increased length of road (correlated with use), increased traffic levels on roads, and traffic activity during the early morning on roads within approximately 3 km (1.9 mi) of leks negatively influence male lek attendance. Although minimal traffic volumes (e.g., <12 vehicles/day) on these roads negatively influence sage-grouse, higher traffic volumes appear to have a greater effect. The intermittent noise characteristic of that produced by traffic is a cause of declines in male lek attendance; however, all potential causes of impact have not been experimentally examined. Roads within 3 km (1.9 mi) of leks also negatively influence female habitat selection and fecundity.

Transmission line and power line construction **is not** known to result in substantial direct habitat loss, however, sage-grouse avoidance of vertical structures, potentially due to raptor concentrations and raptor species composition relative to perches on flat landscapes, results in habitat exclusion via behavioral response. Additionally, the tendency of sage-grouse to fly relatively low, and in low light or when harried, may put them at a particularly high risk of collision with lines. Transmission lines generally refer to the high voltage lines transferring electricity to substations, whereas power lines refer to the lower voltage, smaller lines carrying electricity to consumers. The erection of a transmission line located within 200 m of an active sage-grouse lek and between the lek and male breeding season day use areas in northeastern Utah resulted in a 72% decline in the mean number of displaying males and an alteration in daily dispersal patterns during the breeding season within 2 years (Ellis 1985). This project

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Comment [SSK39]: But if the birds find the habitat near the structures unsuitable, isn't' that considered habitat loss. It's really the same as with roads above. Perhaps don't try to tease apart whether it's habitat loss or behavioral response, just call it the latter.

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also reported that the frequency of raptor-sage-grouse interactions during the breeding season increased 65% and golden eagle interactions alone increased 47% between pre- and post-transmission line comparisons (Ellis 1985). Negative effects of powerlines on lek persistence were documented in northeastern Wyoming; the probability of lek persistence decreased with proximity to power lines and with increasing proportion of powerlines within a 6.4 km (4 mi) window around leks (Walker et al. 2007a). Braun reported that use of areas near transmission lines by sage-grouse, as measured by pellet counts, increased as distance from transmission line increased up to 600 m (Braun 1998b). Sage-grouse avoided brood-rearing habitats within 4.7 km (2.9 mi) of transmission lines in south-central Wyoming (LeBeau 2012). Power line collisions accounted for 33% of juvenile (1st winter) mortality in low-elevation areas in Idaho (Beck et al. 2006). In general, it appears sage-grouse may avoid habitats within 0.6 to 4.7 km (0.4 – 2.9 mi) of a transmission line, and erection of a transmission line close to a lek will negatively influence sage-grouse lek attendance and breeding season behavior. Additionally, higher densities of power lines within 6.4 km (4 mi) of a lek may negatively influence lek persistence. Power lines may be locally-significant causes of mortality due to collisions. Potentially more important, poles and towers associated with transmission lines have been shown to influence raptor and corvid distributions and hunting efficiency resulting in increased predation on sage-grouse (Steenhof et al. 1993, Connelly et al. 2004). Foraging distances of avian, sage-grouse predators has been estimated at 6.9 km (4.3 miles, Knick and Connelly 2011a), suggesting that transmission and power lines may influence sage-grouse at large spatial scales (Connelly et al. 2004, Cresswell et al. 2010). While theoretical effects are clear and logical, information relating sage-grouse response to transmission lines and power lines, or the effects of these lines on sage-grouse demographics, is not extensive.

Comment [SSK40]: Again, lots of detailed findings in the rest of the paragraph. Consider condensing into a few general statements about (a) raptor and corvid distributions, (b) SG avoidance behavior and at what distances, (c) directo mortality from collisions , providing citations,(unless you suspect the clients want this level of detail)

Comment [SSK41]: If this sentence is reworked slightly, it could become the lead sentence in the paragraph.

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Table 8. Summary of the distribution of power transmission lines* across sage-grouse habitats (PPH and PGH) by Management Zone.

	PPH					PGH				
Management Zone Entity	SG Habitat (acres)	Direct Footprint (acres)	6.9km Indirect Influence[1] (acres)	Direct Footprint (%)	Relative Influence[2] (%)	SG Habitat (acres)	Direct Footprint (acres)	6.9km Indirect Influence[1] (acres)	Direct Footprint (%)	Relative Influence[2] (%)
MZ I - GP	11,636,400	75,900	2,387,000	0.65	20.51	34,663,000	590,200	12,829,100	1.70	37.01
BLM	2,994,300	7,300	321,300	0.24	13	4,524,900	35,500	978,600	0.78	8
Forest Service	292,400	1,300	40,800	0.44	2	515,300	7,300	157,600	1.42	1
Tribal and Other Federal	219,700	700	18,100	0.32	1	2,427,700	56,300	1,248,100	2.32	10
Private	7,132,500	58,500	1,782,300	0.82	75	24,682,800	452,600	9,496,500	1.83	74
State	995,600	8,100	224,200	0.81	9	2,498,400	37,800	943,700	1.51	7
Other	1,900	0	300	0.00	0	13,900	600	4,600	4.32	0
MZ II and VII - WB & CP	17,476,000	281,800	6,984,300	1.61	39.97	19,200,200	434,900	8,502,900	2.27	44.29
BLM	9,021,200	130,800	3,394,400	1.45	49	9,012,500	172,000	3,672,900	1.91	43
Forest Service	162,000	2,900	62,400	1.79	1	452,500	3,000	90,100	0.66	1
Tribal and Other Federal	784,000	7,500	252,800	0.96	4	1,354,600	33,900	645,600	2.50	8
Private	6,233,900	119,500	2,792,200	1.92	40	7,394,800	206,000	3,702,300	2.79	44
State	1,244,800	20,100	468,200	1.61	7	979,800	20,000	390,700	2.04	5
Other	30,100	1,000	14,300	3.32	0	6,000	100	1,300	1.67	0
MZ III - SGB	10,028,500	91,400	2,359,400	0.91	23.53	3,970,100	18,500	609,800	0.47	15.36
BLM	6,309,400	37,900	1,102,000	0.60	47	3,199,800	14,500	441,200	0.45	72
Forest Service	1,236,200	2,600	179,800	0.21	8	356,200	400	42,700	0.11	7
Tribal and Other Federal	260,800	800	89,900	0.31	4	29,100	0	1,700	0.00	0
Private	1,836,200	43,600	820,200	2.37	35	384,800	3,500	124,000	0.91	20
State	385,900	6,500	167,500	1.68	7	200	0	200	0.00	0
MZ IV - SRP	21,930,600	156,300	4,808,300	0.71	21.93	10,958,500	120,100	3,110,900	1.10	28.39
BLM	13,710,700	83,600	2,721,100	0.61	57	4,928,200	42,000	1,163,400	0.85	37
Forest Service	1,613,800	5,800	286,600	0.36	6	1,113,500	3,500	233,600	0.31	8
Tribal and Other Federal	633,600	10,700	237,100	1.69	5	522,500	4,700	129,300	0.90	4
Private	4,890,200	47,000	1,304,300	0.96	27	3,516,742	57,900	1,316,000	1.65	42
State	1,019,373	6,500	202,700	0.64	4	846,200	11,200	245,700	1.32	8

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Management Zone Entity	PPH					PGH				
	SG Habitat (acres)	Direct Footprint (acres)	6.9km Indirect Influence[1] (acres)	Direct Footprint (%)	Relative Influence[2] (%)	SG Habitat (acres)	Direct Footprint (acres)	6.9km Indirect Influence[1] (acres)	Direct Footprint (%)	Relative Influence[2] (%)
Other	62,900	2,800	56,600	4.45	1	31,400	900	22,900	2.87	1
MZ V - NGB	7,097,200	38,500	1,478,400	0.54	20.83	5,808,000	40,400	1,696,200	0.70	29.20
BLM	5,117,500	28,200	1,116,500	0.55	76	4,196,700	29,400	1,077,800	0.70	64
Forest Service	62,200	0	15,100	0.00	1	114,900	1,300	37,200	1.13	2
Tribal and Other Federal	717,100	0	2,700	0.00	0	101,800	900	22,200	0.88	1
Private	798,000	5,900	204,300	0.74	14	1,199,000	8,100	474,500	0.68	28
State	64,900	300	30,700	0.46	2	115,800	200	63,800	0.17	4
Other	337,500	4,100	109,000	1.21	7	79,800	500	20,600	0.63	1

[*] Data Source: EV Energy Map, Platts/Global Energy, 2005

[1] Indirect influence distance derived from foraging distances of predators (Boarman and Heinrich 1999, Leu et al. 2008).

[2] For each MZ, these were calculated as the percent of the particular sage-grouse habitat type influenced by the indirect impact of the threat. For management entities within a management zone, calculated as the percent of the total indirect impact in the management zone represented by that management entity; i.e. the relative area of indirect influence among management entities.

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Table 9. Summary of the distribution of communication towers and other vertical structures* across sage-grouse habitats (PPH and PGH) by Management Zone.

Management Zone Entity	PPH SG Habitat (acres)	PPH Direct Footprint (acres)	PPH 6.9km Indirect Influence[1] (acres)	PPH Direct Footprint (%)	PPH Relative Influence[2] (%)	PGH SG Habitat (acres)	PGH Direct Footprint (acres)	PGH 6.9km Indirect Influence[1] (acres)	PGH Direct Footprint (%)	PGH Relative Influence[2] (%)
MZ I - GP	11,636,400	400	3,969,600	0.00	34	34,663,000	5,700	19,294,600	0.02	55.66
BLM	2,994,300	0	665,300	0.00	17	4,524,900	200	1,891,000	0.00	10
Forest Service	292,400	0	104,500	0.00	3	515,300	100	279,300	0.02	1
Tribal and Other Federal	219,700	0	18,800	0.00	0	2,427,700	400	1,596,300	0.02	8
Private	7,132,500	300	2,881,200	0.00	73	24,682,800	4,700	14,125,500	0.02	73
State	995,600	0	299,300	0.00	8	2,498,400	200	1,397,000	0.01	7
Other	1,900	0	400	0.00	0	13,900	0	5,300	0.00	0
MZ II and VII - WB & CP	17,476,000	1,500	7,395,100	0.01	42	19,200,200	4,600	10,775,800	0.02	56.12
BLM	9,021,200	500	3,309,100	0.01	45	9,012,500	1,100	4,540,700	0.01	42
Forest Service	162,000	0	67,400	0.00	1	452,500	0	177,700	0.00	2
Tribal and Other Federal	784,000	100	322,200	0.01	4	1,354,600	100	685,500	0.01	6
Private	6,233,900	700	3,176,100	0.01	43	7,394,800	3,100	4,828,200	0.04	45
State	1,244,800	100	507,100	0.01	7	979,800	200	541,600	0.02	5
Other	30,100	0	13,100	0.00	0	6,000	0	2,200	0.00	0
MZ III - SGB	10,028,500	800	3,420,700	0.01	34	3,970,100	200	1,073,500	0.01	27.04
BLM	6,309,400	200	1,595,600	0.00	47	3,199,800	100	756,000	0.00	70
Forest Service	1,236,200	100	377,500	0.01	11	356,200	0	68,900	0.00	6
Tribal and Other Federal	260,800	0	121,300	0.00	4	29,100	0	9,800	0.00	1
Private	1,836,200	500	1,154,200	0.03	34	384,800	100	238,600	0.03	22
State	385,900	0	172,000	0.00	5	200	0	200	0.00	0
MZ IV - SRP	21,930,600	800	6,818,700	0.00	31	10,958,500	900	4,544,900	0.01	41.47
BLM	13,710,700	400	3,876,700	0.00	57	4,928,200	300	1,551,000	0.01	34
Forest Service	1,613,800	0	460,400	0.00	7	1,113,500	100	359,500	0.01	8
Tribal and Other Federal	633,600	0	280,400	0.00	4	522,500	100	153,000	0.02	3
Private	4,890,200	300	1,859,100	0.01	27	3,516,742	400	2,078,800	0.01	46
State	1,019,373	0	326,300	0.00	5	846,200	100	385,100	0.01	8
Other	62,900	0	15,800	0.00	0	31,400	0	17,500	0.00	0

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Management Zone Entity	PPH SG Habitat (acres)	PPH Direct Footprint (acres)	PPH 6.9km Indirect Influence[1] (acres)	PPH Direct Footprint (%)	PPH Relative Influence[2] (%)	PGH SG Habitat (acres)	PGH Direct Footprint (acres)	PGH 6.9km Indirect Influence[1] (acres)	PGH Direct Footprint (%)	PGH Relative Influence[2] (%)
MZ V - NGB	7,097,200	100	1,164,400	0.00	16	5,808,000	200	1,224,900	0.00	21.09
BLM	5,117,500	100	727,000	0.00	62	4,196,700	100	705,100	0.00	58
Forest Service	62,200	0	6,800	0.00	1	114,900	0	46,100	0.00	4
Tribal and Other Federal	717,100	0	45,800	0.00	4	101,800	0	17,600	0.00	1
Private	798,000	0	217,300	0.00	19	1,199,000	100	412,000	0.01	34
State	64,900	0	11,600	0.00	1	115,800	0	10,700	0.00	1
Other	337,500	0	155,900	0.00	13	79,800	0	33,400	0.00	3

* Data Source: Federal Communications Commission, 2009; Federal Aviation Administration Digital Obstacles File, 2011

[1] Indirect influence distance derived from foraging distances of predators (Boarman and Heinrich 1999, Leu et al. 2008).

[2] For each MZ, calculated as the percent of the particular sage-grouse habitat type influenced by the indirect impact of the threat. For management entities within a management zone, these were calculated as the percent of the total indirect impact in the management zone represented by that management entity; i.e. the relative area of indirect influence among management entities.

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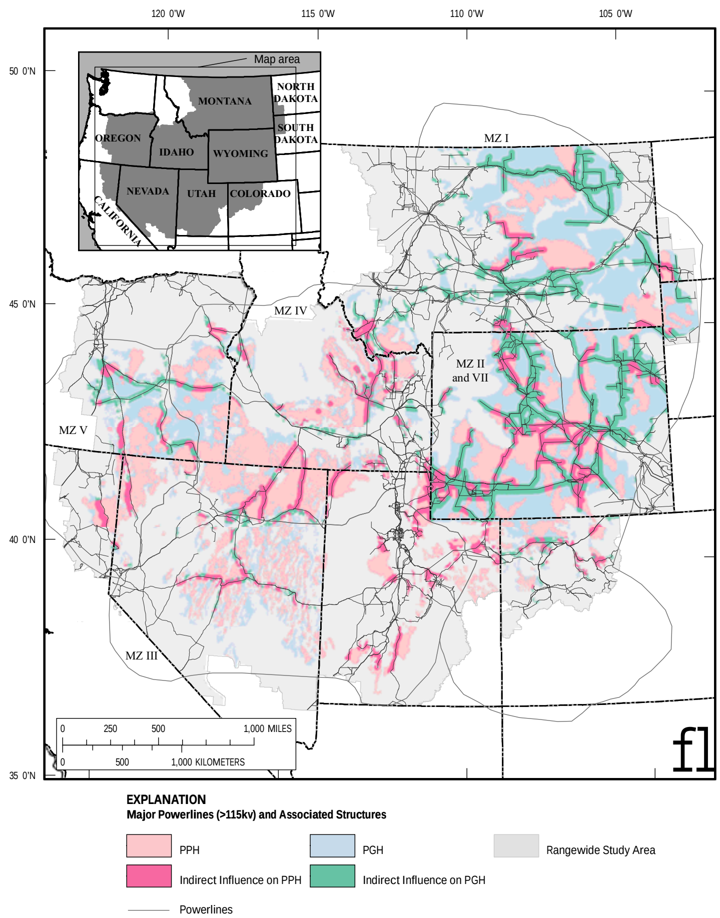

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Figure 13. Overlap of major transmission lines and associated infrastructure (Powerlines)* within PPH and PGH.

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Table 10. Miles of Fences on BLM and USFS Managed Allotments in Sage-grouse Habitat* using allotment and pasture boundaries as a surrogate for fence locations.

	PPH			PGH		
Management Zone Entity	SG Habitat (acres)	Direct Footprint (miles)	Average miles per section	SG Habitat (acres)	Direct Footprint (miles)	Average miles per section
MZ I - GP	11,636,400	18,700	1.03	34,663,000	48,200	0.89
BLM	2,994,300	6,100	1.30	4,524,900	11,300	1.60
Forest Service	292,400	500	1.09	515,300	900	1.12
Tribal and Other Federal	219,700	100	0.29	2,427,700	500	0.13
Private	7,132,500	10,700	0.96	24,682,800	32,100	0.83
State	995,600	1,400	0.90	2,498,400	3,300	0.85
Other	1,900	0	0.00	13,900	0	0.00
MZ II and VII - WB & CP	17,476,000	18,300	0.67	19,200,200	18,900	0.63
BLM	9,021,200	9,300	0.66	9,012,500	8,800	0.62
Forest Service	162,000	500	1.98	452,500	1,100	1.56
Tribal and Other Federal	784,000	400	0.33	1,354,600	500	0.24
Private	6,233,900	6,700	0.69	7,394,800	7,400	0.64
State	1,244,800	1,300	0.67	979,800	1,100	0.72
Other	30,100	0	0.00	6,000	0	0.00
MZ III - SGB	10,028,500	7,800	0.50	3,970,100	3,000	0.48
BLM	6,309,400	4,700	0.48	3,199,800	2,000	0.40
Forest Service	1,236,200	1,700	0.88	356,200	600	1.08
Tribal and Other Federal	260,800	100	0.25	29,100	0	0.00
Private	1,836,200	1,100	0.38	384,800	300	0.50
State	385,900	300	0.50	200	0	0.00
MZ IV - SRP	21,930,600	27,900	0.81	10,958,500	13,900	0.81
BLM	13,710,700	16,100	0.75	4,928,200	7,200	0.94
Forest Service	1,613,800	2,800	1.11	1,113,500	1,900	1.09
Tribal and Other Federal	633,600	400	0.40	522,500	400	0.49
Private	4,890,200	7,400	0.97	3,516,742	3,900	0.71
State	1,019,373	1,200	0.75	846,200	500	0.38
Other	62,900	0	0.00	31,400	0	0.00
MZ V - NGB	7,097,200	5,600	0.50	5,808,000	5,400	0.60
BLM	5,117,500	4,000	0.50	4,196,700	3,600	0.55
Forest Service	62,200	100	1.03	114,900	200	1.11
Tribal and Other Federal	717,100	100	0.09	101,800	100	0.63
Private	798,000	1,000	0.80	1,199,000	1,400	0.75
State	64,900	100	0.99	115,800	100	0.55
Other	337,500	300	0.57	79,800	100	0.80

* Data Source: BLM GSSP grazing allotments and pastures, 2012; USFS Enterprise Data Warehouse, 2012

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Fences represent potential movement barriers (especially woven-wire fences), predator perches or travel corridors, and are a potential cause of direct mortality to sage-grouse (Braun 1998b). Theoretically, not every fence is a problem, and those that tend to cause problems typically include one or more of the following characteristics: (1) constructed with steel t-posts, (2) constructed near leks, (3) bisect winter concentration areas, or (4) border riparian areas (Christiansen 2009). Areas of greater topographic relief (roughness) appear to have lower incidence of collisions apparently because the birds have to fly higher to avoid the ground (Christiansen 2009). At broad spatial scales **during the breeding season**, fence collision risk was lower in areas with high topographic ruggedness, higher in areas with increased fence density on the landscape, decreased with increasing distance to nearest lek (impacts detected within approximately 2 km, 1.25 miles, of leks), and increased with increasing lek size (Stevens et al. 2011, Stevens 2012). **Visibility of fences also influences collision rates, with greater rates associated with less visible fences, e.g., those** constructed using only steel t-post (without wooden posts) and wider segment widths (more than 4 m, or 13 ft) between posts (Stevens et al. 2011). Marking **both sides of** the top **fence** strand fence at 1-m intervals with vinyl-siding undersill with reflective metallic tape reduced sage-grouse collision frequency between 61 and 83% **(Christiansen 2009, Stevens 2012)**. **Decisions on the best design or treatment to mitigate collision risk must consider** tradeoff**s; for example, although** wooden posts are more visible **they** may provide better raptor perches **than** t-posts.

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A5. Energy Development

Oil and gas development in habitats used by sage-grouse and construction of accompanying power lines, roads, and pipelines began in the late 1800s with the discovery of oil in the Interior West (Connelly et al. 2004). Since the 1960's, development of natural gas resources in this region has dominated the industry (Connelly et al. 2004). The United States National Energy Policy projects an

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increase in oil consumption by 33%, in natural gas consumption by >50%, and in electricity by 45% by 2025 (Connelly et al. 2004). Development of oil and gas resources requires construction (well pads, access roads, **and** ancillary infrastructure including flow lines, other roads, compressor stations, pumping stations, and electrical facilities), drilling and extraction, and transport of oil and gas (Connelly et al. 2004). The expected economic production life of coal bed methane wells is 12-18 years and **of** oil and deep seam gas wells is 20-100 years with advanced technology (Connelly et al. 2004). Gas and oil wells are widespread throughout priority and general habitats, with concentrated development areas exceeding 10 wells/section (1 mi^2, 2.6 km^2) common throughout MZs I and II, **and** the far eastern portions of MZ III (Table 11, Figure 14), whereas current oil shale developments are concentrated solely in MZ VII (see Oil Shale Section, below). Notably, **most** research on the effects of energy development on sage-grouse has been focused in MZs I and II (Wyoming, Montana, Dakotas, and southern Canada). The relative consistency of distance and density effects of the infrastructure of gas and oil developments on sage-grouse across different development types – including shallow coal bed methane and deep gas and oil development (Naugle et al. 2011) – suggests results from these studies may be applicable to sage-grouse across the range of the species. Despite significant closures of public lands to oil and gas leasing within PPH and PGH (Figure 15; Table 12), current leases, including those leased but not yet developed, are substantial across sage-grouse ranges in MZs I and II (Figure 16a; Table 13), with potential for development based on locations of geologic fields for traditional oil and gas (Figure 16b) distributed extensively across eastern portions of sage-grouse range (MZs I, II, VII and eastern parts III) and potential for oil shale development concentrated in MZs II and VII (see Oil Shale Section, below).

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Table 11. Direct and indirect influence on Sage-grouse habitat from currently active or plugged and abandoned oil and natural gas wells within the last 10 years sage-grouse range within PPH and PGH designations.*

	PPH					PGH				
Management Zone Entity	SG Habitat (acres)	Direct Footprint (acres)	19km Indirect Influence[1] (acres)	Direct Footprint (%)	Relative Influence[2] (%)	SG Habitat (acres)	Direct Footprint (acres)	19km Indirect Influence[1] (acres)	Direct Footprint (%)	Relative Influence[2] (%)
MZ I - GP	11,636,400	30,000	11,636,000	0.26	100.00	34,663,000	187,600	34,598,600	0.54	99.81
BLM	2,994,300	4,600	2,994,300	0.15	26	4,524,900	26,200	4,504,900	0.58	13
Forest Service	292,400	1,500	292,400	0.51	3	515,300	2,100	515,000	0.41	1
Tribal and Other Federal	219,700	0	219,300	0.00	2	2,427,700	3,400	2,403,600	0.14	7
Private	7,132,500	21,400	7,132,500	0.30	61	24,682,800	140,400	24,667,500	0.57	71
State	995,600	2,500	995,600	0.25	9	2,498,400	15,400	2,493,600	0.62	7
Other	1,900	0	1,900	0.00	0	13,900	0	13,900	0.00	0
MZ II and VII - WB & CP	17,476,000	26,100	17,346,000	0.15	99.26	19,200,200	79,200	18,923,800	0.41	98.56
BLM	9,021,200	14,300	8,988,500	0.16	52	9,012,500	45,400	8,941,200	0.50	47
Forest Service	162,000	0	146,900	0.00	1	452,500	100	445,200	0.02	2
Tribal and Other Federal	784,000	1,300	783,100	0.17	5	1,354,600	3,100	1,349,700	0.23	7
Private	6,233,900	8,500	6,156,400	0.14	35	7,394,800	26,100	7,228,400	0.35	38
State	1,244,800	2,000	1,240,800	0.16	7	979,800	4,500	953,400	0.46	5
Other	30,100	0	30,100	0.00	0	6,000	0	6,000	0.00	0
MZ III - SGB	10,028,500	3,300	7,736,100	0.03	77.14	3,970,100	200	2,890,100	0.01	72.80
BLM	6,309,400	1,100	4,744,500	0.02	61	3,199,800	200	2,324,900	0.01	80
Forest Service	1,236,200	100	893,600	0.01	12	356,200	0	247,400	0.00	9
Tribal and Other Federal	260,800	400	205,100	0.15	3	29,100	0	9,900	0.00	0
Private	1,836,200	1,300	1,577,600	0.07	20	384,800	0	307,600	0.00	11
State	385,900	400	315,200	0.10	4	200	0	200	0.00	0
MZ IV - SRP	21,930,600	300	6,676,300	0.00	30.44	10,958,500	200	3,894,700	0.00	35.54
BLM	13,710,700	100	3,277,300	0.00	49	4,928,200	0	1,165,100	0.00	30
Forest Service	1,613,800	0	544,000	0.00	8	1,113,500	0	392,900	0.00	10
Tribal and Other Federal	633,600	0	208,600	0.00	3	522,500	0	128,000	0.00	3

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Management Zone Entity	PPH SG Habitat (acres)	PPH Direct Footprint (acres)	PPH 19km Indirect Influence[1] (acres)	PPH Direct Footprint (%)	PPH Relative Influence[2] (%)	PGH SG Habitat (acres)	PGH Direct Footprint (acres)	PGH 19km Indirect Influence[1] (acres)	PGH Direct Footprint (%)	PGH Relative Influence[2] (%)
Private	4,890,200	100	2,250,400	0.00	34	3,516,700	100	1,918,800	0.00	49
State	1,019,400	0	393,100	0.00	6	846,200	0	285,500	0.00	7
Other	62,900	0	2,800	0.00	0	31,400	0	4,400	0.00	0
MZ V - NGB	7,097,200	0	1,301,300	0.00	18.34	5,808,000	0	1,747,000	0.00	30.08
BLM	5,117,500	0	913,000	0.00	70	4,196,700	0	1,173,300	0.00	67
Forest Service	62,200	0	19,200	0.00	1	114,900	0	50,300	0.00	3
Tribal and Other Federal	717,100	0	7,400	0.00	1	101,800	0	7,600	0.00	0
Private	798,000	0	300,100	0.00	23	1,199,000	0	470,600	0.00	27
State	64,900	0	20,600	0.00	2	115,800	0	23,500	0.00	1
Other	337,500	0	41,000	0.00	3	79,800	0	21,700	0.00	1

* Data Source: BLM Automated Fluid Minerals Support System (AFMSS) Database 2011, Enerdeq IHS database 2011. Direct and indirect impacts are calculated for the surface management entity, however, subsurface mineral rights may be severed from surface rights.

[1] Indirect influence distance derived from area of identified demographic impact (Johnson et al. 2011 and Taylor et al. 2012).

[2] For each MZ, calculated as the percent of the particular sage-grouse habitat type influenced by the indirect impact of the threat. For management entities within a management zone, calculated as the percent of the total indirect impact in the management zone represented by that management entity; i.e. the relative area of indirect influence among management entities.

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Table 12. Distribution of habitats (PPH and PGH) closed to federal oil and gas development (surface-use closure) by Management Zone.*

	PPH			PGH		
Management Zone	SG Habitat (acres)	Federal Closed Areas (acres)	Federal Closed Areas (%)	SG Habitat (acres)	Federal Closed Areas (acres)	Federal Closed Areas (%)
MZ I - GP	11,636,400	720,800	6.19	34,663,000	4,164,700	12.01
MZ II and VII - WB & CP	17,476,000	1,302,400	7.45	19,200,200	1,242,400	6.47
MZ III - SGB	10,028,500	329,700	3.29	3,970,100	241,300	6.08
MZ IV - SRP	21,930,600	1,709,200	7.79	10,958,500	727,400	6.64
MZ V - NGB	7,097,200	744,000	10.48	5,808,000	82,400	1.42

* Data Source: BLM Automated Fluid Minerals Support System (AFMSS) Database 2011, Enerdeq IHS database 2011

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Table 13. The distribution of existing leases (currently under development or held by production and currently undeveloped) for oil and gas exploration (Valid Existing Rights) on public lands across sage-grouse habitats (PPH and PGH) by Management Zone.*

	PPH			PGH		
Management Zone Entity	SG Habitat (acres)	Federal leases (acres)	Federal Leases (% habitat type)	SG Habitat (acres)	Federal leases (acres)	Federal Leases (% habitat type)
MZ I - GP	11,636,400	1,304,600	11.21	34,663,000	5,016,800	14.47
Leased - Held By Production		388,400	3.34		2,607,900	7.52
Leased - Undeveloped		916,200	7.87		2,408,900	6.95
MZ II and VII - WB & CP	17,476,000	3,161,000	18.09	19,200,200	4,620,200	24.06
Leased - Held By Production		680,500	3.89		2,134,600	11.12
Leased - Undeveloped		2,480,500	14.19		2,485,600	12.95
MZ III - SGB	10,028,500	1,300,600	12.97	3,970,100	513,300	12.93
Leased - Held By Production		39,000	0.39		1,300	0.03
Leased - Undeveloped		1,261,600	12.58		512,000	12.90
MZ IV - SRP	21,930,600	245,900	1.12	10,958,500	100,200	0.91
Leased - Held By Production		0	0.00		0	0.00
Leased - Undeveloped		245,900	1.12		100,200	0.91
MZ V - NGB	7,097,200	0	0.00	5,808,000	0	0.00

* Data Source: BLM Automated Fluid Minerals Support System (AFMSS) Database 2011, Enerdeq IHS database 2011. Leased areas are calculated based on federal subsurface management; however, subsurface mineral rights may be severed from surface rights.