Greater Sage-grouse Species Description

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

Taxonomy

Greater sage-grouse are birds in the Phasianidae family, which is a diverse taxonomic group consisting of over 50 genera commonly known as grouse, turkeys, pheasants, partridges, francolins, and Old World quail. Greater sage-grouse are one of two species in the genus Centrocercus; the other being the Gunnison sage-grouse (*C. minimus*) (AOU 2000, pp. 849–850). The Gunnison and Greater sage-grouse werewas once considered ~~part of~~ a single ~~sage-grouse~~ species ~~in the western United State~~s, but in 2000 Gunnison sage-grouse was identified as a distinct species based on morphological (Hupp and Braun 1991,pp. 257–259; Young *et al*. 2000, pp. 447–448), genetic (Kahn *et al*. 1999, pp. 820-821; Oyler-McCance *et al*. 1999, pp.1460–1462), and behavioral (Barber1991, pp. 6–9; Young 1994; Young *et al*.2000, p. 449–451) differences and geographical isolation (AOU 2000, pp. 849-850; Young *et al*.2000, pp. 447–451)~~ (AOU 2000, pp. 849–850)~~.~~.~~

In 1957, prior to the Gunnison sage-grouse being described as a distinct species, the American Ornithologists' Union (AOU) recognized two subspecies of sage-grouse, the eastern sage-grouse (*Centrocercus urophasianus urophasianus*) and the western sage-grouse (C. u. phaios) (AOU 1957, p. 139). This subspecies classification was based solely on differences in coloration (specifically, reduced white markings and darker feathering on western birds) among 11 museum specimens collected from 8 locations in Washington, Oregon and California (Aldrich 1946, p. 129).

The 1957 AOU subspecies classification has not been revisited by AOU since 1957 and that taxonomic classification has been determined to be invalid by more recent information, including information on morphology, behavior, geography, and molecular genetics (Johnsgard 1983, p. 109; 2002, p. 108; Drut 1994, p. 2; Schroeder *et al*. 1999, p. 3; Banks 2000, 2002; Benedict *et al*. 2003, p. 301; (75 FR 13910, pp. 13912–13915). Thus, our analysis of the status of the greater sage-grouse (below) does not address considerations at the scale of subspecies. See the Taxonomy section of the FWS 2010 12-month finding (75 FR 13910; March 23, 2010, p. 13912) for additional details.

Genetics—PLACEHOLDER (Craig/Jesse – roll into small pops??)

An analysis of genetic variation of sage-grouse (Oyler-McCance et al. (2005, entire); Oyler-McCance and Quinn 2011) found a gradual shift across the range in both mitochondrial and nuclear data sets. This pattern suggests localized gene flow – movement among neighboring populations but not movement across the entire species' range (isolation by distance). A genetic clustering analysis conducted by Pritchard and Donnelly (2000) showed that all unique genetic clusters of sage-grouse were composed of populations geographically adjacent to one another. Most genetic clusters were large and consisted of many populations, but smaller, more fragmented areas on the periphery of the range in Colorado, Utah, Lyon-Mono in Nevada and California, and Washington, made up their own clusters which suggests lower

Comment [Craig1]: Missing ( ) check. Also FR citation page numbers.

Comment [Craig2]: Check this, the page number can go after the FR.

Comment [DP3]: I would suggest deleting this entire section. Its covered under taxonomy so why repeat here?

Comment [Craig4]: In 2010, this was a subsection of the taxonomy section needed to explain the genetic evidence for not recognizing the subspecies. It did not address small populations, barriers, or gene flow across the range.

Comment [DP5]: I took this summary out of Oyler-McCance and Quinn 2011. I don't know if we need anything more extensive. The citations do need page numbers

Comment [KNorman6]: Craig, Jesse, reusing 2010 and DPS amounts of gene flow in these areas (Pritchard and Donnelly 2000). These studies suggest that gene flow is likely limited to the movement of individuals between neighboring populations and not the result of long distance movements of individuals (Oyler-McCance and Quinn 2011). The results of genetic studies across the range of sage-grouse demonstrate a gradual shift of alleles, and with the exception of the Bi-state DPS, do not indicate significant genetic isolation at any location (Oyler-McCance et al. 2005, p. 1306).

Greater sage-grouse habitat–The sagebrush ecosystem

Greater sage-grouse (~~*Centrocercus urophasianus;*~~ hereafter sage-grouse) depend on a variety of shrub-steppe habitats throughout their life cycle, and is a sagebrush (Artemisia spp.) obligate (Patterson 1952, p. 48). Variable by elevation, location, and ecological site characteristics (fig. 1) across the range, sage-grouse use a variety of sagebrush species including but not limited to: Wyoming big sagebrush (Artemisia tridentata wyomingensis), mountain big sagebrush (A. t. vaseyana), basin big sagebrush (A. t. tridentate), black sagebrush (A. nova), fringed sagebrush (A. frigida), silver sagebrush (A. cana), and little sagebrush (A. arbuscula) (Patterson 1952, p. 48; Braun *et al*. 1976, p. 168; Schroeder *et al*. 1999, pp. 4-5; Connelly *et al*. 2000a, pp. 970-972; Connelly *et al*. 2004, p. 3-4; Connelly *et al*. 2004, p. 4-1; Miller *et al*. 2011, p. 145). Thus, sage-grouse distribution is strongly correlated with the distribution of sagebrush habitats (Schroeder *et al*. 2004, p. 364). Sage-grouse exhibit strong site fidelity (loyalty to a particular area even when the area is no longer of value) to seasonal habitats, which includes breeding, nesting, brood rearing, and wintering areas (Connelly *et al*. 2004, p. 3-1; Connelly *et al*. 2011, p. 60 and references therein). Sage-grouse are dependent on large areas of contiguous sagebrush to meet all seasonal habitat requirements (Patterson 1952, p. 48; Connelly *et al*. 2004, p. 4-1; Connelly *et al*. 2011, pp. 82–83; Wisdom *et al*. 2011, p. 465). ~~, and large-scale characteristics within surrounding landscapes influence sage-grouse habitat selection (Knick and Hanser 2011, pp. 396–405).~~

Comment [DP7]: shouldn't latin come first?

Comment [DMD8]: I suggest updating this with the citation from SAB, which provides a summary of site fidelity (e.g., leks, females to nesting areas).

Comment [DP9]: This is the SAB citation. It provides a rather extensive list of references supporting this concept, hence the citation stating "and references therein".

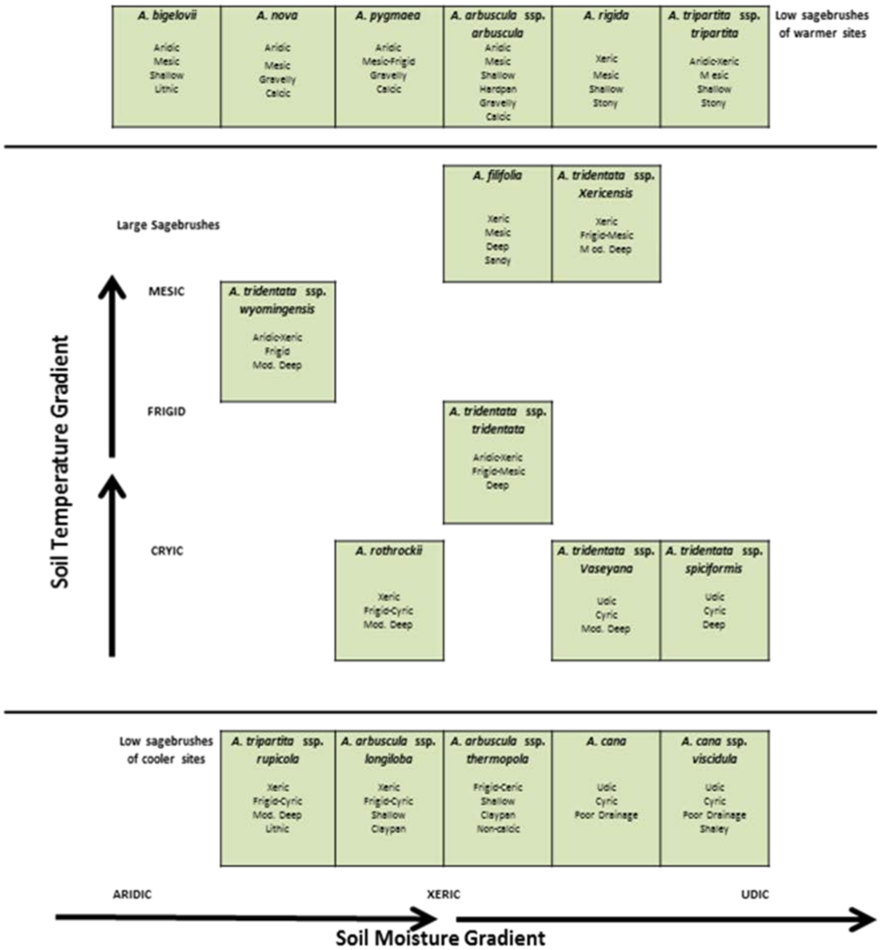

Figure 3-1. Ordination of major sagebrush taxa in the Intermountain Region against gradients of soil temperature and moisture (From Miller *et al*. 2011)

Comment [acn10]: I created this draft figure after Miller, I'm not married to it though. And will make better/prettier figure if we decide to keep.

Comment [DP11]: its not terribly informative here – wondering if its better placed in our discussion of fire?

~~Sage-grouse are dependent on large areas of contiguous sagebrush (Patterson 1952, p. 48; Connelly *et al*. 2004, p. 4-1; Connelly *et al*. 2011, pp. 82–83; Wisdom *et al*. 2011, p. 465), and large-scale characteristics within surrounding landscapes influence sage-grouse habitat selection (Knick and~~

~~Hanser 2011, pp. 396–405).~~ Sagebrush is the most widespread vegetation in the intermountain lowlands in the western United States (West and Young 2000, p. 259), and is considered one of the most imperiled ecosystems in North America (Knick *et al*. 2003, p. 612; Miller *et al*. 2011, p. 452, and references therein). Scientists recognize 13 species and 12 subspecies of sagebrush (Shultz 2009, p. 1), each with unique habitat requirements and responses to perturbations (West and Young 2000, p. 259). Sagebrush species and subspecies occurrence in an area is dictated by local soil type, soil moisture, and climatic conditions (West 1983, p. 333; West and Young 2000, p. 260; Miller *et al*. 2011, pp. 151–154). The degree of dominance by sagebrush varies with local site conditions and disturbance history. Plant associations, typically defined by native perennial grasses, further define distinctive sagebrush communities (Miller and Eddleman 2000, pp. 10-14; Connelly *et al*. 2004, p. 5-3), and are influenced by topography, elevation, precipitation, and soil type. These ecological site conditions influence the resistance and resiliency of sagebrush and their associated understories to natural and human-caused changes (Chambers *et al*. 2014, entire).

Sagebrush is typically divided into two groups, big sagebrush and low or dwarf sagebrush, based on their affinities for different soil types (West and Young 2000, p. 259). Big sagebrush species and subspecies, such as Wyoming big sagebrush, are limited to coarse-textured and/or well-drained sediments, whereas low (or dwarf) forms of sagebrush, such as black sage, typically occur where erosion has exposed clay or calcified soil horizons (West 1983, p. 334; West and Young 2000, p. 261). ~~Reflecting these soil differences, big sagebrush will die if surfaces are saturated long enough to create anaerobic conditions for 2 to 3 days (West and Young 2000, p. 259). Some low sagebrush are more tolerant of occasionally saturated soils, and many low sagebrush sites are partially flooded during spring snowmelt.~~ None of the sagebrush taxa tolerate soils with high salinity (West 1983, p. 333; West and Young 2000, p. 257).

Comment [DP12]: Unless we find that saturated soils are a significant problem in sagebrush persistence I suggest deleting.

Comment [LW 13]: Highlighting these could devalue the numerous other dozen(s) type of sagebrush and hybrids used by grouse.

All species of sagebrush produce large ephemeral leaves in the spring, which persist until reduced soil moisture occurs in the summer. Most species also produce smaller, over-wintering leaves in the late spring that last through summer and winter. Sagebrush have fibrous tap root systems, which allow the plants to draw surface soil moisture, and also to access water deep within the soil profile when surface water is limited (West and Young 2000, p. 259). Most sagebrush flower in the fall. However, during years of drought, or other moisture stress, flowering may not occur (West and Young 2000, p. 260). . Although seed viability and germination are high, seed dispersal is limited (West and Young 2000, p. 260). (citation?). Additionally, , sagebrush seeds typically do not remain viable for more than one growing season and evidence suggests seed banks are transient (i.e., seeds persist in the soil less than one year); however, seeds have higher odds of persisting in the seed bank if they are buried (Wijayratne and Pyke 2012, p. 438). (West and Young 2000, p. 260).

Sagebrush is long-lived, with plants of some species surviving up to 150 years (West 1983, p. 340). Sagebrush exhibit allelopathic effects, producing chemicals that reduce seed germination, seedling growth and root respiration of competing plant species and inhibit the activity of soil microbes and nitrogen fixation. Sagebrush has resistance to environmental extremes, with the exception of fire and occasionally defoliating insects (e.g., the webworm (Aroga spp.); West 1983, p. 341). Most species of sagebrush are killed by fire (Miller and Eddleman 2000, p. 17; West 1983, p. 341; West and Young 2000, p. 259), Depending on the species of sagebrush and other site-specific characteristics, fire return intervals from 10 to well over 300 years have been reported (McArthur 1994, p. 347; Peters and Bunting 1994, p. 33; Miller and Rose 1999, p. 556; Kilpatrick 2000, p. 1; Frost 1998, in Connelly *et al*. 2004, p. 7-4; Zouhar *et al*. 2008, p. 154; Baker 2011, pp. 190–197; Bukowski and Baker 2013, entire). In general, mean fire return intervals in low-lying, xeric, big sagebrush communities range from over 100 to 350 years, and return intervals decrease to 50 to over 200 years in more mesic areas, mountain sagebrush communities at higher elevations, during wetter climatic periods, and in locations associated with

Comment [DMD14]: Wijayratne, U. P., and D. A. Pyke. 2012. Burial increases seed longevity of two *Artemisia tridentata* (Asteraceae) subspecies. American Journal of Botany 99:438-447.

Comment [acn15]: I copied this directly from fire chapter.

grasslands (Baker 2006, p. 181; Mensing *et al*. 2006, p. 75; Baker 2011, pp. 194-195; Miller *et al*. 2011, p. 166; Bukowski and Baker 2013, entire). Natural sagebrush re-colonization in burned areas depends on the presence of adjacent live plants for a seed source or on the seed bank, if present (Miller and Eddleman 2000, p. 17).

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

Very little sagebrush within its extant range is undisturbed or unaltered from its condition prior to EuroAmerican settlement in the late 1800s (Knick *et al*. 2003, p. 612, and references therein). Due to the disruption of primary patterns, processes and components of sagebrush ecosystems since EuroAmerican settlement (Knick *et al*. 2003, p. 612; Miller *et al*. 2011, p. 147), the large range of abiotic variation, the minimal short-lived seed banks, and the long generation time of sagebrush, restoration of disturbed areas is very difficult, particularly at the scales required by sage-grouse to meet all their seasonal habitat requirements. Not all areas previously dominated by sagebrush can be restored because alteration of vegetation, nutrient cycles, topsoil, and cryptobiotic soil crusts have exceeded recovery thresholds (Knick *et al*. 2003, p. 620). Additionally, processes to restore sagebrush ecology are relatively unknown (Knick *et al*. 2003, p.620). Active restoration activities are often limited by financial and logistic resources ~~and lack of political motivation~~ (Knick *et al*. 2003, p.620; Miller *et al*. 2011, p. 147; Pyke 2011, p. 544) and may require decades or centuries (Knick *et al*. 2003, p.620, and references therein). Meaningful restoration for sage-grouse requires landscape, watershed, or eco-regional scale context rather than individual, unconnected efforts (Knick *et al*. 2003, p.623, and references therein; Wisdom *et al*. 2011, p. 469). Landscape restoration efforts require partnerships across multiple

Comment [DMD16]: Also see Pyke 2011, p. 544 who found that rehabilitation and restoration efforts are also hindered by cost and the ability to procure the equipment and seed needed for projects.

ownerships and jurisdictions in order to restore and maintain a connective network of intact vegetation (Knick *et al*. 2003, p. 623; Pyke 2011, p. 548; see discussion of landownership below). Except for areas where active restoration is attempted following disturbance (e.g., mining, wildfire), management efforts in sagebrush ecosystems are usually focused on maintenance (Miller *et al*. 2011, p. 183; Wisdom *et al*.2011, pp. 470, 472).

Although sage-grouse require large, interconnected expanses of sagebrush with healthy, native understories (Patterson 1952; Connelly *et al*. 2004, pp. 4-15; Knick *et al*. 2003, p. 623; Connelly *et al*. 2011b, p. 80; Pyke 2011, p. 540; Wisdom *et al*. 2011, p. 461), there is little information available regarding minimum sagebrush patch sizes required to support populations of sage-grouse. This is due in part to the migratory nature of some, but not all sage-grouse populations, the lack of juxtaposition of seasonal habitats, and differences in local, regional and range-wide ecological conditions which influences the distribution of sagebrush and associated understories. Where home ranges have been reported (Connelly *et al*. 2011a, p. 60 and references therein) they are extremely variable (4 to 615 km2 range [1.5 to 237.5 mi2]). Occupancy of a home range is also based on multiple variables, associated with both local vegetation characteristics and landscape characteristics (Knick *et al*. 2003, p. 621). Migratory populations of sage-grouse may use areas exceeding 2700 km^2 (667,185 acres, 1,042 mi^2; Leonard et al. 2000) ~~Pyke (2011, p. 540) estimated that a minimum of 4,000 ha (9,884 acres) was necessary for population sustainability.~~ Diurnal space use and seasonal movement patterns observed by Davis et al. (2014) exceeded estimates of individual home range size reported in previous investigations. The cumulative annual range was within a 3072 km^2 area (based on MCP).

~~However, he did not indicate whether this value was for migratory or non-migratory populations, nor if this included juxtaposition of all seasonal habitats.~~ Large seasonal and annual

Comment [DMD17]: This estimate is not from Pyke, instead he cites Leonard et al (2000) who reports values for migratory sage-grouse populations in Idaho and Walker et al. (2007).

Migratory populations of sage-grouse may use areas exceeding 2700 km^2 (e.g., Leonard et al. (2000)

Diurnal space use and seasonal movement patterns observed by Davis et al. (2014) exceeded estimates of individual home range size reported in previous investigations. The cumulative annual range was within a 3072 km^2 area (based on MCP).

movements emphasize the landscape nature of the sage-grouse (Knick *et al*. 2003, p. 624; Connelly *et al*. 2011a, p. 60).

Seasonal Habitat Selection and Life History Characteristics

Sage-grouse are dependent on large areas of contiguous sagebrush to meet all seasonal habitat requirements (Patterson 1952, p. 48; Connelly *et al*. 2004, p. 4-1; Connelly *et al*. 2011, pp. 82–83; Wisdom *et al*. 2011, p. 465). ~~Sage-grouse are dependent of seasonal habitats for persistence..say something here about how critical each of these seasonal habitats are for sage-grouse persistence.~~ Loss of any of these seasonal habitats could impact the ability of sage-grouse to persist in an area (Connelly et al. 2011, pp. ? (in summary section)).

Breeding habitat

During the breeding season, male sage-grouse gather together to perform courtship displays on areas called leks. Areas are often characterized by having bare soil, short-grass steppe, windswept ridges, exposed knolls, or other relatively open sites typically serve as leks (Patterson 1952, p. 83; Connelly *et al*. 2004, p. 3-7 and references therein). Leks are often surrounded by denser shrub-steppe cover, which is used for escape, thermal, and feeding cover. Leks can be formed opportunistically at any appropriate site within or adjacent to nesting habitat (Connelly *et al*. 2000a, p. 970), and therefore lek habitat availability is not considered to be a limiting factor for sage-grouse (Schroeder 1999, p. 4). Leks range in size from less than 0.04 hectare (ha) (0.1 ac) to over 36 ha (90 ac) (Connelly *et al*. 2004, p. 4-3) and can host from ~~several~~ a few to hundreds of males (Johnsgard 2002, p. 112). Males defend individual territories within leks and perform elaborate displays with their specialized plumage and vocalizations to attract females for mating. Numerous researchers have observed that a relatively small number of dominant males account for the majority of copulations on each lek (Schroeder *et al*. 1999, p. 8). ~~Bush *et al*. (2013, p. 33), h~~However, recent genetic analyses found that on average ~~that~~ 45.9 percent (range 14.3 to 54.5 percent) of genetically identified males in a population fathered offspring in a given year (Bush et al. 2013, p. 33). This ~~more recent work~~ suggests that males and females likely engage in off-lek copulations. Males do not participate in incubation of eggs or rearing chicks.

Nesting habitat

The distance ~~F~~females travel to nest locations from leks varies across the range, ranging from 0.14 km (0.087 mi) up to ~~have been documented to travel~~to more than 20 km (12.5 mi) to their nest site after mating (Connelly *et al*. 2000a, p. 970; Connelly et al. 2011, p. 62 and references therein). Distance between the lek and nest site location is influenced by the juxtaposition of habitats, disturbance, and extent of habitat fragmentation (Lyon and Anderson 2003, Connelly et al. 2004, Schroeder and Robb 2003). Females in highly fragmented habitats of Washington moved almost twice (Schroeder et al. 1999) as far to nest as females in relatively intact habitats of southeastern Idaho (Wakkinen et al. 1992, Fischer 1994,). Similarly, females from undisturbed leks in southwestern Wyoming moved an average of 2.1 km to nests while females from disturbed leks moved 4.1 km (Lyon and Anderson 2003).

~~, but~~The d~~d~~istances between a nest site and the lek on which breeding occurred is also variable (Connelly *et al*. 2004, pp. 4-5). Average distance between a female's nest and the lek on which she was first observed ranged from 3.4 km (2.1 miles) to 7.8 km (4.8 miles) in five studies examining 301 nest locations (Schroeder *et al*. 1999 p. 12). Other studies have reported the average lek-to-nest distance was larger for the lek of capture compared with the distance to the nearest lek (Petersen 1980,

Comment [LW 18]:
We can probably update that…
I'll look for a few citations.
AMY: yah, there was a recent presentation, can't remember who?? That had distances for success full nest, renest, etc.

DMD: Connelly et al. 2011 (and references therein) summarizes this on p. 62 in SAB. Davis et al. (2014) reported that the average distance females moved from lek sites of capture to initial nest locations was 4.67 km ± 4.30 SD (n = 59). This distance is within the range reported for other sage-grouse studies (0.40–29.75 km; Schroeder et al. 1999, Aldridge and Brigham 2001, Moynahan et al. 2007).

Wakkinen *et al*. 1992a, Fischer 1994, Schroeder *et al*. 1999, Herman-Brunson 2007). In northeastern California (Davis *et al*. 2014) the average distance between a female's nest and the nearest lek was 3.694.67 km (2.9 mi) ± 2.94 SD (n = 74) and ranged from 0.14(0.087) km to 14.10 km (8.76 mi). These results are consistent with other studies conducted in peripheral populations (Schroeder et al. 1999; Aldridge and Brigham 2001, , Moynahan et al. 2007; Herman-Brunson *et al*. 2009, Wiechman 2013),

Research by Bradbury *et al*. (1989, p. 22) and Wakkinen *et al*. (1992, p. 382) demonstrated that nest sites are selected independent of lek locations, but that the reverse is not true.

Productive nesting areas are typically characterized by sagebrush with an understory of native grasses and forbs, with horizontal and vertical structural diversity that provides an insect prey base, herbaceous forage for pre-laying and nesting hens (Barnett and Crawford 1994, p. 116), and cover for the hen while she is incubating (Gregg 1991, p. 19; Schroeder *et al*. 1999, p. 4; Connelly *et al*. 2000a, p. 971; Connelly *et al*. 2004, pp.4-17, 18). Sage-grouse may also use other shrub or bunchgrass species for nest sites (Klebenow 1969, p. 649; Connelly *et al*. 2000a, p.970; Connelly *et al*. 2004, p. 4-4, Davis *et al*. 2014, p. 5). Shrub canopy and grass cover provide concealment for sage-grouse nests and young (Gregg *et al*. 1994, p. 164; DeLong *et al*.1995, p. 90; Connelly *et al*. 2004, p. 4-4), and forb availability and abundance are critical for reproductive success (Barnett and Crawford 1994, p.116; Gregg *et al*. 2008, p. 539)). Published vegetation characteristics of successful nest sites included a sagebrush canopy cover of 15-25 percent, sagebrush heights of 30 – 80 cm (11.8 – 31.5 in), and grass/forb cover of 18 cm (7.1 in; Connelly *et al*. 2000a, p. 977; Hagen et al. 2007, p. 48).

Sage-grouse clutch size ranges from 6 to 9 eggs with an average of 7 eggs. (Connelly *et al*. 2011a, p.62). The likelihood of a female nesting in a given year averages 82 percent in the eastern

Comment [DMD19]: Davis et al. 2014. Demography, reproductive ecology, and variation in survival of greater sage-grouse in NE California. JWM DOI: 10.1002/jwmg.797

Comment [DMD20]: Gregg et al. (2008) Temporal variation in diet and nutrition of preincubating greater sage-grouse. Rangeland Ecology and Management 61:535-542.

Comment [DMD21]: Also see the meta-analysis by Hagen et al. (2007).

A meta-analysis for greater sage-grouse nesting and brood rearing habitats. Wildlife Biology 13:42-50.

Comment [LW 22]: We can update from SAB…

Comment [DP23]: this is the SAB citation portion of the range and 78 percent in the western portion of the range (Connelly *et al*. 2011a, p. 63). Adult females have higher nest initiation rates than yearling females (Connelly *et al*. 2011a, p. 58). Nest success (one or more eggs hatching from a nest), as reported in the scientific literature, varies widely (reported as 15 to 86 percent of initiated nests Schroeder *et al*. 1999, p. 11; 12 to 71 percent of initiated nests in Connelly *et al*. 2011a, p. 58). Overall, the average nest success for sage-grouse in non-altered habitats is 51 percent and for sage-grouse in altered habitats is 37 percent (Connelly *et al*. 2011a, p. 58). Re-nesting only occurs if the original nest is lost (Schroeder *et al*. 1999, p. 11). Sage-grouse re-nesting rates average 28.9 percent (based on 9 different studies) with a range from 5 to 41 percent (Connelly *et al*. 2004. p. 3-11). Other game bird species have much higher re-nesting rates, often exceeding 75 percent. The impact of re-nesting on annual productivity for most sage-grouse populations is unclear and thought to be limited (Crawford *et al*. 2004, p. 4). In north-central Washington State, re-nesting contributed to 38 percent of the annual productivity of that population (Schroeder 1997, p. 937). However, the author postulated that the re-nesting efforts in this population may be greater than anywhere else in the species' range because environmental conditions allow a longer period of time to successfully rear a clutch (Schroeder 1997, p. 939).

Little information is available on the level of productivity (number of chicks per hen that survive to fall) that is necessary to maintain a stable population (Connelly *et al*. 2000b, p. 970). However, Connelly *et al*. (2000b, p. 970, and references therein) suggest that 2.25 chicks per hen are necessary to maintain stable to increasing populations. Long-term productivity estimates of 1.40 to 2.96 chicks per hen across the species range have been reported (Connelly and Braun 1997, p. 20). ~~Productivity declined slightly after 1985 to 1.21 to 2.19 chicks per hen (Connelly and Braun 1997, p. 20).~~ A recent study assessing the population structure of sage-grouse based on the collection and analysis of over 67,000 wings from hunter harvested birds in Colorado and Oregon during 1973-1998 and 1993-2013 found the average number of juveniles in the harvest per female varied from 1.2 to 2.4 (Braun *et al*.

Comment [LW 24]: Update from SAB

Comment [DP25]: This is the SAB citation

Comment [acn26]: I think we have some new info here, but was transmitter surgically on chicks which really makes me question results, but should mention. Find paper..

DMD: Traditional studies assessing chick survival do not report their findings in terms of number of chicks per hen but as daily survival estimates. Declining populations may be characterized by poor recruitment largely attributed to low chick survival but I'm not sure if that discussion is appropriate here?

2015, p. 10). Despite average clutch sizes of 7 eggs (Connelly *et al*. 2011a, p.62) due to low chick survival and limited re-nesting, there is little evidence that populations of sage-grouse produce large annual surpluses (Connelly *et al*. 2011a, p. 67).

Comment [DMD27]: Braun et al. 2015. Fall population structure of sage-grouse in Colorado and Oregon. Wildlife Technical Report 005-2015.

Brood-rearing habitat

Hens rear their broods in the vicinity of the nest site for the first 2 to 3 weeks following hatching (0.2 to 5 km (0.1 to 3.1 miles), based on two studies in Wyoming (Connelly *et al*. 2004, p. 4-8). Forbs and insects are essential nutritional components for chicks (Klebenow and Gray 1968, p. 81; Johnson and Boyce 1991, p. 90; Connelly *et al*. 2004, p. 4-9). Therefore, early brood-rearing habitat must provide adequate cover ~~(sagebrush canopy cover of 10 to 25 percent; Connelly *et al*. 2000a, p. 977)~~ adjacent to areas rich in forbs and insects to assure chick survival during this period (Connelly *et al*. 2004, p. 4-9).

All sage-grouse gradually move from sagebrush uplands to more mesic areas during the late brood-rearing period (3 weeks post-hatch) in response to summer desiccation of herbaceous vegetation (Connelly *et al*. 2000a, p. 971). Summer use areas can include sagebrush habitats as well as riparian areas, wet meadows, and alfalfa fields (Schroeder *et al*. 1999, p. 4). These areas provide an abundance of forbs and insects for both hens and chicks (Schroeder *et al*. 1999, p. 4; Connelly *et al*. 2000a, p. 971). Sage-grouse will use free water although they do not require it since they obtain their water needs from the food they eat. However, natural water bodies and reservoirs can provide mesic areas for succulent forb and insect production, thereby attracting sage-grouse hens with broods (Connelly *et al*. 2004, p. 4-12). Broodless hens and cocks will also use more mesic areas in close proximity to sagebrush cover during the late summer, often arriving before hens with broods (Connelly *et al*. 2004, p. 4-10).

Comment [DMD28]: Early and late brood-rearing periods have typically been based on observations on habitat use by hens with 6-week-old broods (Martin 1970) and information from Peterson (1970), who found a dietary change in juvenile sage-grouse approximately 6 weeks after Hatching. But see Blomberg et al. 2013

Comment [DP29]: do not have these references – need to follow up

Winter habitat

Sage-grouse are considered a sagebrush obligate and that designation becomes most obvious during the winter when birds depend almost exclusively on sagebrush for both food and cover (Schroeder 1999, p. 5; Thacker *et al*. 2012, p. 588). Winter areas used by sage-grouse are characterized by large expanses of big sagebrush and tall shrubs, predominantly located on relatively gentle south or west-facing slopes that provide more favorable thermal conditions and above snow forage (Beck 1977, p. 22; Hupp and Braun 1987, p. 826; Doherty *et al*. 2008, p. 192; Hagen *et al*. 2011, p. 536; Dzialak *et al*. 2013, p. 16). During the winter, sage-grouse avoid bare ground, conifer and riparian areas, and anthropogenic features (e.g., roads, energy development) (Beck 1977, p. 21; Doherty *et al*. 2008, p. 192; Carpenter *et al*. 2010, p. 1811; Dzialak *et al*. 2012, p. 12; Dzialak *et al*. 2013, p. 16; Smith *et al*. 2014, p. 15; Holloran et al. 2015. p. 9999).

Winter habitats may overlap with or be relatively close to nesting or brood-rearing habitats, or they may be totally separated, requiring significant movement to achieve (Fedy *et al*. 2012, p. 1068). The timing of movement to winter ranges varies considerably, but peaks around mid-October through late November (Schroeder *et al*. 1999, p. 10). Movement has been described as slow and meandering, with birds typically traveling less than 1km (0.6 mi) per day (Connelly *et al* 1988, p. 119). The distance sage-grouse travel (walking and flying) to reach wintering areas is highly variable both within and among populations (Fedy *et al*. 2012, p. 1067). For example, sage-grouse in Idaho on average moved less than 15 km, but some individuals moved greater than 80 km to reach their winter range (Connelly *et al*. 1988, p. 119). The average movement of sage-grouse in Wyoming from summer to winter locations was 17.3 km, but the minimum and maximum distances recorded were 0.33 and 83km, respectively (Fedy *et al* 2012, p. 1067). A population in Canada travels annually to a winter range in Montana, a distance of more than 120 km one way and the longest documented annual migration for sage-grouse (Tack *et al*. 2012, p. 65). The high degree of variability both within and among populations makes generalizations on winter habitat locations in relation to other seasonal habitats difficult (Fedy *et al*. 2012, p. 1067).

Sage-grouse exhibit fidelity to winter sites (Berry and Eng 1985, p. 239). The degree of fidelity, however, may be somewhat more relaxed than for other seasonal habitats, as birds have displayed some ability to shift winter habitat use in response to severe conditions by moving to areas where sagebrush remains above the snow (Beck 1977, p. 24; Smith 2010, p. 8).

Sage-grouse are supremely adapted to the incredibly harsh conditions typical of a winter on the sagebrush steppe which is characterized by periods of sub-zero temperatures, extreme winds, limited shelter, and snow. For example, sage-grouse have feathered legs and feet with small narrow scales adept for walking and burrowing in the snow for shelter and to forage (Patterson 1952, p. 6). All sage-grouse switch from diets containing varying amounts of sagebrush, forbs, and insects to a diet that consists almost entirely of sagebrush (Schroeder *et al*. 1999, p. 5).

Despite these challenging conditions, during the average winter sage-grouse typically experience low overwinter mortality (2 percent, Connelly *et al*. 2000b, p. 229; 0 to 15 percent Wik 2002, p. 40; 2 to 3 percent Sika 2006, p. 90; 4 percent, Bruce *et al*. 2011, p. 421). In fact, sage-grouse not only survive the winter, but actual weight gain over the winter months has been documented (Beck and Braun 1978, p. 243). During notably severe winters, however, even sage-grouse are not immune from the elements and significant population-level mortality has been documented (58 percent, Moynahan *et al*. 2006, p. 1536; 54 percent, Anthony and Willis 2008, p. 544).

The distribution and abundance of suitable winter habitats is limited. In northern Colorado, only 6.8 percent of the area was intensively used by sage-grouse during the winter (Beck 1977, p. 20). In south-central Wyoming, only 7-18 percent of a 4,328 km2 study area was identified as having characteristics suitable for severe winter habitat (Dzialak *et al*. 2013, p. 10). Similarly, winter habitat was limited in northwest Colorado and south-central Wyoming, representing only 17.1 percent of the 6,093 km2 study area (Smith *et al*. 2014, p. 12) In south central Montana, the numbers of males

Comment [DMD30]: Smith et al. 2014. Prioritizing winter habitat quality for greater sage-grouse in a landscape influenced by energy development. Ecosphere 5:15. http://dx.doi.org/10.1890/ES13-00238.

counted on leks declined by 73 percent following a 30 percent loss of winter habitat to cropland conversion (Swenson *et al*. 1987, p. 128). This significant decline happened despite the fact that 84 percent of the total area remained unplowedughed sagebrush-steppe (Swenson *et al*. 1987, p. 128).

The above information highlights the importance of winter habitats to sage-grouse persistence. Clearly loss of these essential winter habitats can have impacts disproportionate to their makeup on the landscape (Swenson *et al*. 1987, p. 128). Winter habitat can be even more limited during severe winters when heavy snow fall further decreases or even eliminates access to sagebrush (as a consequence of increasing snow depth). During such times birds become even more concentrated in the few remaining areas of exposed sagebrush critical for shelter and foraging (Beck 1977, p. 24; Hupp and Braun 1987, p. 828). Thus, areas critical to survival during winters with heavy snowfall, may not be the same areas the birds regularly occupy during an average winter (Caudill *et al*. 2013, p. 256).

Migratory Corridors

The distances sage-grouse move between seasonal habitats are highly variable (Dalke et al. 1960, Connelly et al. 1988). Seasonal habitats may be distinct necessitating movement between areas, or integrated (e.g. sage-grouse may use the same area for breeding and brood-rearing, or winter and breeding, or all three seasonal habitats; Connelly et al. 2000b). Therefore sage-grouse may migrate between two or three distinct seasonal home ranges, or not migrate at all. Sage-grouse tend to have large movements within a season compared with other game birds such as Gray Partridge (*Perdix perdix*) (Weigand 1980, Church and Porter 1990), and ring-necked Pheasants (Hill and Robertson 1988), Non-migratory sage-grouse have seasonal movements of <10 km (6.2 mi) while birds in migratory populations may travel well over 100 km (62 mi; Patterson 1952 p. 189, Hulet 1983, Hagen 1999). Movement patters were defined by Connelly et al. (2000b) as (1) non-migratory—sage-grouse make one-way movements <10 km (6.2 mi) between or among seasonal ranges, (2) one-stage

Comment [LW 31]: Add in description of: nonmigratory, 1-stage, and 2-stage migratory individuals as well as that multiple can be present in any one population.

DMD: See p. 59 of SAB for description of the 3 sage-grouse movement patterns (non-migratory; on-stage; and two-state migration) cited from Connelly et al. 2000.

migration—grouse move ≥10 km (6.2 mi) between two distinct seasonal ranges, and (3) two-stage migration—grouse move ≥10 km (6.2 mi) among three distinct seasonal ranges (Connelly et al. 2001, p. 59). Migration between seasonal ranges is usually in response to seasonal habitat distribution (Schroeder et al. 1999, p. 3; Connelly et al. 2004, p. 3-5). Migration distances for female sage-grouse generally are less than for males (Connelly *et al*. 2004, p. 3-4), but in one study in Colorado, females travelled further than males (Braun and Beck, 1976).

Many populations of sage-grouse migrate between seasonal ranges in response to habitat distribution (Connelly *et al*. 2004, p. 3-5). Migration can occur between winter and breeding/summer areas, between breeding, summer and winter areas, or not at all. Migration distances of up to 161 kilometers (km) (100 mi) have been recorded (Patterson 1952, p.189); however, distances vary depending on the locations of seasonal habitats (Schroeder *et al*. 1999, p. 3). Migration distances for female sage-grouse generally are less than for males (Connelly *et al*. 2004, p. 3-4), but in one study in Colorado, females travelled further than males (Braun and Beck, 1976). Almost no information is available regarding the distribution and characteristics of migration corridors for sage-grouse (Connelly *et al*. 2004, p. 4-19). Sage-grouse dispersal (permanent moves to other areas) is poorly understood (Connelly *et al*. 2004, p. 3-5) and appears to be sporadic (Dunn and Braun 1986, p. 89). Despite the documentation of extensive seasonal movements in this species (Fedy *et al*. 2012, p. 1066; Tack *et al*. 2012, p. 65; Davis *et al*. 2014, pp. 5–7), the dispersal abilities of sage-grouse are assumed to be low (e.g., median natal dispersal distance = 8.8 km for females versus 7.4 km for males [Dunn and Braun 1985, p. 622] and 3.8 ± 1.3 km and 2.7 ± 0.3 km, for males and females, respectively [Thompson 2012, p. 193]). Previous investigations describing space use by sage-grouse have been constrained by highly variable seasonal movement patterns within and among populations, limited sample size, variation in the duration of the study, and variation in methods of home range estimation (e.g., Hagen 1999, Leonard et al. 2000, Hausleitner 2003, Fedy et al. 2012). Moreover, the extensive movements between

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Comment [acn32]: Note for later, we can't use special characters in FR docs, so I was trying to keep them out of report also (to facilitate future cut and paste into FR doc) seasonal ranges and highly clustered distributions of sage-grouse (Hagen et al. 2001) have made estimating home range size and comparisons between studies difficult. Estimating an 'average' home range for sage-grouse is difficult due to the large variation in sage-grouse movements both within and among populations. This variation is related to the spatial availability of habitats required for seasonal use and aAnnual recorded home ranges have varied from 4 - 615 km2 (1.5 – 237.5 mi2; Connelly *et al*. 2011a, p.60).

Comment [DMD33]: Previous investigations describing space use by sage-grouse have been constrained by highly variable seasonal movement patterns within and among populations, limited sample size, variation in the duration of the study, and variation in methods of home range estimation (e.g., Hagen 1999, Leonard et al. 2000, Hausleitner 2003, Fedy et al. 2012). Moreover, the extensive movements between seasonal ranges and highly clustered distributions of sage-grouse (Hagen et al. 2001) have made estimating home range size and comparisons between studies difficult.

Historical and Current Range

Range and Distribution of Sage-Grouse and Sagebrush

Prior to settlement of western North America by European immigrants in the 19th century, greater sage grouse occurred in 13 States and 3 Canadian provinces—Washington, Oregon, California, Nevada, Idaho, Montana, Wyoming, Colorado, Utah, South Dakota, North Dakota, Nebraska, Arizona, British Columbia, Alberta, and Saskatchewan (Schroeder *et al*. 1999, p. 2; Young *et al*. 2000, p. 445; Schroeder *et al*. 2004, p. 369) (Figure X-1). Sagebrush habitats that potentially supported sage-grouse occurred over approximately 1,200,483 km2 (463,509 mi2) before 1800 (Schroeder *et al*. 2004, p. 366). Currently, greater sage-grouse occur in 11 States (Washington, Oregon, California, Nevada, Idaho, Montana, Wyoming, Colorado, Utah, South Dakota, and North Dakota), and 2 Canadian provinces (Alberta and Saskatchewan), occupying approximately 56 percent of their historical range (Schroeder *et al*. 2004, p. 369) (Figure X-1). Approximately 2 percent of the total range of the greater sage-grouse occurs in Canada, with the remainder in the United States (Knick in press2011, p. 14).

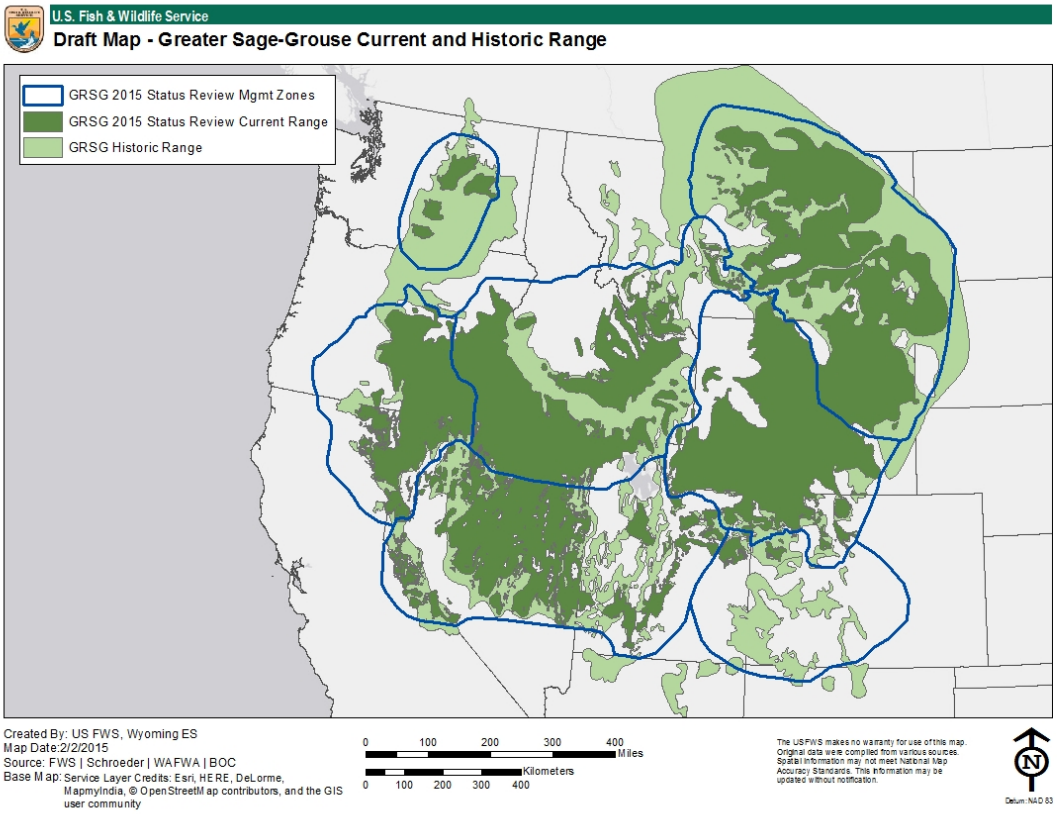


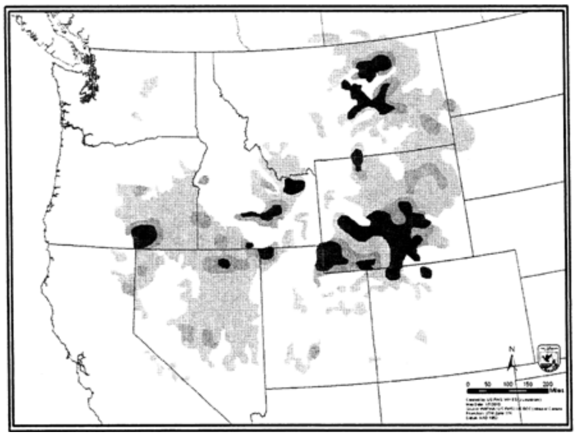
Figure 3-2. Placeholder DRAFT Map

Sage-grouse have been extirpated from Nebraska, British Columbia, and possibly Arizona (Schroeder *et al*. 1999, 2; Young *et al*. 2000 p. 445; Schroeder *et al*. 2004, p. 369). Current distribution of the greater sage-grouse is estimated at 668,412 km2 (258,075 mi2; Connelly *et al*. 2004, p. 6-9; Schroeder *et al*. 2004, 369). Changes in distribution are the result of sagebrush alteration and degradation (Schroeder *et al*. 2004, p. 363; Knick and Connelly 2011, p.).

Comment [acn34]: Use jim's numbers?? Of occupied habitat?

Sage-grouse distribution is associated with sagebrush (Schroeder *et al*. 2004; p. 364), although sagebrush is more widely distributed. However, sagebrush does not always provide suitable habitat due to fragmentation and degradation (Schroeder *et al*. 2004, pp. 369, 372). Very little of the extant sagebrush is undisturbed, with up to 50 to 60 percent having altered understories or having been lost to direct conversion (Knick *et al*. 2003, p. 612). There also are challenges in mapping altered and depleted understories, particularly in semi-arid regions, so maps depicting only sagebrush as a dominant cover type are deceptive in their reflection of habitat quality and, therefore, use by sage-grouse (Knick *et al*. 2003, p. 616). As such, variations in the quality of sagebrush habitats (from either abiotic or anthropogenic events) are reflected by sage-grouse distribution and densities (Figure X-placeholder map below).

Figure 1—Greater sage-grouse population densities based on average number of males per lek (from Stiver *et al.* 2006, p. 1-12). Darker areas indicate higher breeding population densities.



PLACEHOLDER: Get new density layer from Kevin

Sagebrush occurs in two natural vegetation types that are delineated by temperature and patterns of precipitation (Miller *et al*. ~~in press~~2011, p. 7). Sagebrush steppe ranges across the northern portion of sage-grouse range, from British Columbia and the Columbia Basin, through the northern Great Basin, Snake River Plain, and Montana, and into the Wyoming Basin and northern Colorado. Great

Basin sagebrush occurs south of sagebrush steppe, and extends from the Colorado Plateau westward into Nevada, Utah, and California (Miller *et al*. in press, p. 7). Other sagebrush types within greater sage-grouse range include mixed-desert shrubland in the Bighorn Basin of Wyoming, and grasslands in eastern Montana and Wyoming that also support A. cana and A. filifolia (sand sagebrush) (Miller *et al*. in press, p. 7).

Comment [acn35]: Revise using new guidance for plants.

Current Range Distribution-PLACEHOLDER

Greater sage-grouse are disproportionately distributed across their range as a result of variation in habitat quality and abundance. They have been delineated into forty-one populations, defined by geographic or physical barriers to movement (Knick and Connelly 2011, p). Populations at the edge of the current range increasingly are isolated from the larger interior areas (Schroeder et al. 1999, Schroeder et al. 2004). Environmental and stochastic events vs.genetic constraints appear to influence the viability of populations (Knick and Hanser 2011, p.).

Comment [DP36]: placeholder - this describes the reasons for the current range, but not the range itself. May need to combine with above sections for a complete overview.

Fundamental characteristics of sagebrush landscapes have changed from Euro-american settlement (Knick and Connelly 2011, p.). The quantity of area dominated by sagebrush land cover has been reduced by conversion to cropland and other less abundant land uses. The composition of sagebrush communities has changed and in the Great Basin this change has facilitated shifts in fire regimes that are significantly different from historic patterns. In low elevation sagebrush systems fire is more frequent (in part due to the presence *of Bromus tectorum* (cheatgrass; West and Young 2000, p.), whereas fire has been reduced in higher elevations facilitating the expansion of *Juniperus* spp. (junipers) and *Pinus* spp. (pinyon) woodlands. plant species (Miller and Rose 1999, p.). Habitat suitability is also affected by the presence of anthropogenic structures (such as communication towers and power lines(Connelly et al. 2000, Beck et al. 2006). Lastly, the configuration of sagebrush mosaics across the species' range has changed (Knick and Connelly 2011, p.) Increased edges are prevalent due to the high level of infrastructure network, which can change predator movement s (Tewksbury et al. 2002), isolates populations (Saunders et al.1991, Trombulak and Frissell 2000, as cited by Knick and Connelly 2011) and facilitate the spread of exotic species (Gelbard and Belnap 2003) resulting in altering the composition of the surround plant community.

Annual Lek Counts/Surveys-PLACEHOLDER

~~*Management Zone Discussion/Description*~~

~~Basin of Wyoming, and grasslands in eastern Montana and Wyoming that also support A. cana and A. filifolia (sand sagebrush) (Miller *et al.* in press, p. 7).~~

Comment [acn37]: Revise using new guidance for plants.

~~*Current Range Distribution-PLACEHOLDER*~~

~~*Annual Lek Counts/Surveys-PLACEHOLDER*~~

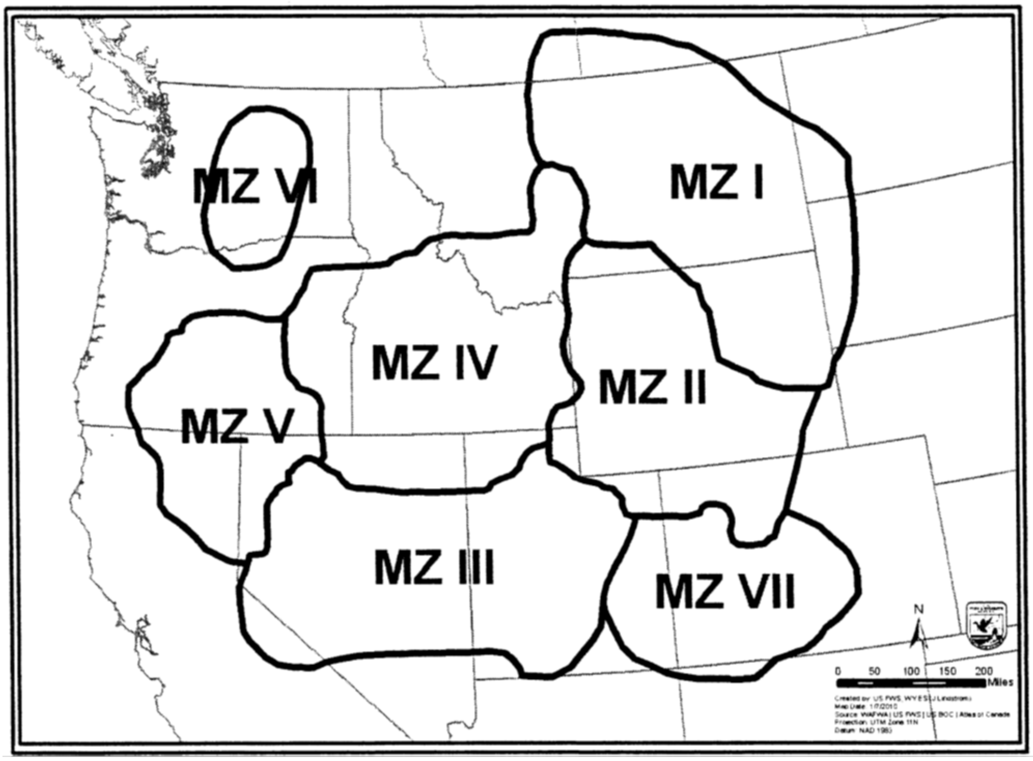
Management Zone Discussion/Description

Due to differences in the ecology of sagebrush across the range of the greater sage-grouse, the Western Association of Fish and Wildlife Agencies (WAFWA) delineated seven Management Zones (MZs I-VII) based primarily on floristic provinces (Figure 2; Table 1; Stiver *et al*. 2006, p. 1-6). The boundaries of these MZs were delineated based on their ecological and biological attributes rather than on arbitrary political boundaries (Stiver *et al*. 2006, p. 1-6). Therefore, vegetation found within a MZ is similar and sage-grouse and their habitats within these areas are likely to respond similarly to environmental factors and management actions. The WAFWA conservation strategy includes the Gunnison sage-grouse, and the boundary for MZ VII includes its range (Stiver *et al*. 2006, pp. 1-1, 1-8), which does not overlap with the range of the greater sage-grouse.

Table 3-1: The Management Zones of the greater sage-grouse as defined by Stiver et al. 2006, pp. 1-7, 1-11.

MZ	STATES AND PROVINCES INCLUDED	FLORISTIC REGION
I	MT, WY, ND, SD, SK, AL	Great Plains
II	ID, WY, UT, CO	Wyoming Basin
III	UT, NV, CA	Southern Great Basin
IV	ID, UT, NV, OR	Snake River Plain
V	OR, CA, NV	Northern Great Basin
VI	WA	Columbia Basin
VII	CO, UT	Colorado Plateau

Figure 2—The Management Zones for sage-grouse as identified by Stiver *et al.* (2006, p. 1-11). (Delineation primarily based on floristic provinces and population boundaries.)



PLACEHOLDER MAP—NEED NEW MAP FROM JIM

MZ I-NORTHERN GREAT PLAINS

Comment [DP38]: Amy developed this as one way to describe MZ and associated populations. It provides a nice summary of the threats, but may be out of order here.

Primary threats identified in 2010 for this MZ include habitat loss, fragmentation, and degradation as a result of conversion of native areas to cropland and energy development with its associated infrastructure. Sage-grouse populations in this MZ also experienced significant negative population impacts from West Nile virus outbreaks beginning in the early 2000s. Garton et al. (2011) predicted an 11.1 percent chance this Management Zone will fall below 200 males by 2037, and a 24.0 percent chance it would fall below 200 males by 2107.

Populations	Description	Information on status in 2010.
Dakotas	Small population centered in southwest North Dakota and northwest South Dakota separated from adjacent populations by 30–40 km and habitat features.	North Dakota portion had a total of 77 males on 18 leks in 2008 (NDGFD 2008, News Release). South Dakota portion had a total of 339 males on 22 leks in 2008 (SDGFP 2008, p. 9)
Northern Montana	Large population north of Missouri River in north central Montana, southeast Alberta, and southwest Saskatchewan separated from adjacent populations by 20 km and Missouri River	
Powder River Basin	Large population in southeast Montana and northeast Wyoming separated from adjacent populations by 20 km and habitat features.	In 2010, Northeast Wyoming has the lowest average male lek attendance in the state, averaging 6 males per active lek in 2011 compared to the statewide average of 17 males per active lek (WGFD 2010 JCR, p. 138)
Yellowstone watershed	Large population in central and southeast Montana separated from adjacent populations by 20–30 km and topography.	

MZ II–WYOMING BASIN

Primary threats identified in 2010 for this MZ include habitat loss, fragmentation, and degradation as a result of energy development with its associated infrastructure. The Wyoming Basin is currently home to the highest breeding of sage-grouse. Garton et al. (2011) predicted a small, 0.3 percent chance, that this zone will fall below 200 males by 2037, and a 16.2 percent chance it would fall below 200 males by 2107.

Populations	Description	Information on status in 2010.
Eagle–south Routt Counties, Colorado	Small population north of the Colorado River separated from adjacent populations by 20–30 km and topography.	The three year average number of males from 2010-2012 is 108.
Middle Park, Colorado	Small population in Middle Park, Colorado, separated from adjacent populations by 20–30 km and terrain.	Since the 1970's, the population counts have been roughly between 200 and 325 males.
Laramie, Wyoming	Small isolated population southwest of Laramie, Wyoming.	Five leks, only one routinely occupied.
Jackson Hole, Wyoming	Small isolated population near Jackson Hole, Wyoming, separated from adjacent populations by 50 km and topography.	Population consists of 16 leks (13 active and 3 inactive in past 10 years) of which only one is considered large (averaging over 40 birds).
Wyoming basin	Large population centered in Wyoming and extending into Montana, Idaho, Utah, and Colorado (areas described below). Is separated from adjacent populations by 20–40 km and topography.	This population is the largest population within the species' range (>20,000 males attending leks annually), and is very robust.
Northwest Colorado	This is Colorado's largest area of sage-grouse occupancy and is considered to be at low risk of extirpation.	

North Park, CO	This portion of the Wyoming Basin population is located in North Park, Jackson County, Colorado.	Long -term data trends (since the early 1970's) indicate this population has fluctuated roughly between 500 and 1,500 males.
Rich-Summit-Morgan, UT	The Rich-Morgan-Summit Sage-grouse Management Area is located in northeastern Utah.	Based on a ten-year average count of males on leks, the area had an estimated 1,223 males as of 2011.
Uintah, UT	The Uintah Sage-grouse Management Area is located in northeastern Utah.	This management area had an estimated 452 males on leks as of 2011

PLACEHOLDER FOR FIGURES BELOW AS PER REVISED OUTLINE

[Figure – WAFWA MZs, populations, and range map]

[Figure – PACs map]

[Figure – Strongholds map]

[Figure - Distribution models by MZ]

[Table - Numbers from Distribution models by MZ]

[Figure – Abundance models by MZ]

[Table - Numbers from Abundance models by MZ]

Population Size

Comment [DP39]: I pulled this from 2010. Other than data received during the data call and the draft Garton report there isn't much to go on for revision. The data call info is sparse. So this is a placeholder, slightly revised to pull out the stuff we don't want to include this time.

Estimates of greater sage-grouse abundance were mostly anecdotal prior to the implementation of systematic surveys in the 1950s (Braun 1998, p. 139). Early reports suggested the birds were abundant throughout their range. However, concerns about extinction were raised in early literature due to market hunting and habitat alteration (Hornaday 1916, pp. 181-185). Following a review of published literature and anecdotal reports, Connelly *et al.* (2004, ES-1-3) concluded that the abundance of sage-grouse has declined from pre-settlement (defined as 1800) numbers. Most of the historical population changes were the result of local extirpations, which has been inferred from a 44 percent reduction in sage-grouse distribution described by Schroeder *et al.* 2004 (Connelly *et al.* 2004, p. 6-9).

Population numbers are difficult to estimate due to the large range of the species, physical difficulty in accessing some areas of habitat, the cryptic coloration and behavior of hens (Garton *et al.* in press, p. 6) and survey protocols. Problems with inconsistent sampling protocols for lek surveys (e.g., number of times a lek is counted, number of leks surveyed in a year, observer bias, observer experience, time counted) were identified by Walsh *et al.* (2006, pp. 61-64) and Garton *et al.* (in press, p. 6), and many of those problems still persist (Stiver *et al.* 2006, p. 3-1). Additionally, estimating population sizes using lek data is difficult as the relationship of those data to actual population size (e.g., ratio of males to females, percent unseen birds) is usually unknown (WAFWA 2008, p. 3). However, the annual counting of males on leks remains the primary approach to monitor long-term trends of populations (WAFWA 2008, p. 3), and standardized techniques are beginning to be implemented throughout the species' range (Stiver *et al.* 2006, pp. 3-1 to 3-16). The use of harvest data for estimating population numbers also is of limited value since both harvest and the population size on which harvest is based are estimates. Given the limitations of these data, States usually rely on a combination of actual counts of birds on leks and harvest data to estimate population size. Estimates of populations by State, generated from a variety of data sources, are provided in Table 4.

TABLE 4. Sage-grouse Population Estimates Based on Data From State Wildlife Agencies.

Lo cation	ata Year	Source	Esti mated Population
CA /NV	004	CA/NV Conservation Assessment (2004, p. 26)	88,0 00
C O	007	2007 CO Conservation plan, based on adjusted male lek counts (count + 1.6 multiplier, sex ratio females:males)	22,6 46
ID	007	Calculated based on assumption of 5% of population is harvested	98,7 00
M T	007	Calculated based on assumption of 5% of population is harvested	62,3 20
N D	007	2008 lek counts adjusted (assumes 75% of males counted at lek, & sex ratio of 2:1) (A. Robinson, NDGFD, pers. comm., 2008)	308

Lo cation	ata Year	Source	Estimated Population
OR	003	2003 Oregon Conservation Plan Estimate (Hagen 2005, p. 27)	40,000
SD	007	SDGF web page (last updated in 2007)	1,500
UT	002	2001 UDOW Management Plan (2002, p. 13)	12,999
WA	003	WDFW Conservation Plan (2004, p. 21)	1,059
WY	007	Calculated based on assumption of 5% of population is harvested	207,560
Canada	008	Environment Canada web page	1,000

Braun (1998, p. 141) estimated that the minimum 1998 rangewide spring population numbered about 157,000 sage-grouse, derived from numbers of males counted on leks. The same year, State wildlife agencies within the range of the species estimated the population was at least 515,000 based on lek counts and harvest data (Warren 2008, pers. comm.). In 2000, we estimated the rangewide abundance of sage-grouse was between a minimum of 100,000 (taken from Braun 1998, p. 141) up to 500,000 birds (based on harvest data from Idaho, Montana, Oregon, and Wyoming, with the assumption that 10 percent of the population is typically harvested) (65 FR 51578). In 2003, based on increased lek survey efforts, Connelly *et al.* (2004, p. 13-5) concluded that rangewide population numbers were likely much greater than the 157,000 estimated by Braun (1998, p. 141), but they were unable to generate a rangewide population estimate. Garton *et al.,* (~~in press~~2011, p. 2) estimated a rangewide minimum of 88,816 males counted on leks in 2007~~, the last year data were formally collated and reported~~This number was XXXX in 2013 (updated Garton report). Estimates of historical populations range from 1,600,000 to 16,000,000 birds (65 FR 51580).

Population Trends

Although population numbers are difficult to estimate, the long-term data collected from counting males on leks provides insight to population trends. Periods of historical decline in sage-grouse abundance occurred from the late 1800s to the early-1900s (Hornaday 1916, pp. 179-221; Crawford 1982, pp. 3-6; Drut 1994, pp. 2-5; WDFW 1995; Braun 1998, p. 140; Schroeder *et al.* 1999, p. 1). Other noticeable declines in sage-grouse populations occurred in the 1920s and 1930s, and then again in the 1960s and 1970s (Connelly and Braun 1997, pp. 3-4; Braun 1998, p. 141). Declines in the 1920s and

1930s were attributed to hunting, and declines in the 1960s and 1970s were primarily as a result of loss of habitat quality and quantity (Connelly and Braun 1997, p. 2). State wildlife agencies were sufficiently concerned with the decline in the 1920s and 1930s that many closed their hunting seasons and others significantly reduced bag limits and season lengths as a precautionary measure (Patterson 1952, pp. 30-33; Autenrieth 1981, p. 10).

Using lek counts as an index for abundance, Connelly *et al.* (2004, p. 6-28) reported rangewide declines from 1965 through 2003. Declines averaged 2 percent per year from 1965 to 2003. The decline was more dramatic from 1965 through 1985, with an average annual change of 3.5 percent. The rate of decline rangewide slowed to 0.37 percent annually during 1986 to 2003, and some populations increased (Connelly *et al.* 2004, p. 6-71). Based on these analyses, Connelly *et al.* 2004 (p. 6-71) estimated that sage-grouse population numbers in the late 1960s and early 1970s were likely two to three times greater than current numbers (Connelly *et al.* 2004, p. 6-71). Using a statistical population reconstruction approach, Garton *et al.* (~~in press~~2011, p. 67) also demonstrated a pattern of significantly higher numbers of sage-grouse in the late 1960s and early 1970s, which was supported by data from several other sources (Garton *et al.* in press, p. 68).

Comment [DP40]: should cite the original sources

In 2008, WAFWA conducted new population trend analyses that incorporated an additional 4 years of data beyond the Connelly *et al.* 2004 analysis. Although the WAFWA analyses used different statistical techniques, lek counts also were used. WAFWA results were similar to Connelly *et al.* (2004) in that a long-term population decline was detected during 1965 to 2007 (3.1 percent; WAFWA 2008, p. 12). WAFWA attributed the decline to the reduction in number of active leks (WAFWA 2008, p. 51).

Comment [DP41]: we are supposed to get a new trend analysis from WAFWA. So this is simply a placeholder

Similar to Connelly *et al.* (2004), the WAFWA analyses determined that the rate of decline lessened during 1985 to 2007 (average annual change of 1.4 percent annually) (WAFWA 2008, p. 58). Garton *et al*. (in press, pp. 68-69) also had similar results.

Although the MZs were not formally adopted by WAFWA until 2006, the population trend analyses conducted by Connelly *et al.* (2004) included trend analyses based on the same floristic provinces used to define the zones. While the average annual rate of change was not presented, the results of those analyses suggested long-term declines in greater sage-grouse for MZs I, II, III, IV and VI. Population trends in MZs V and VII were increasing, but the trends were not statistically significant (Stiver *et al.* 2006, p. 1-7). The WAFWA (2008) and Garton *et al*. (in press) population trend analyses did consider MZs. The WAFWA (2008, pp. 13-27) and Garton *et al* (in press, pp. 22-62) reported that MZs I through VI had negative population trends from 1965 to 2007. All population trend analyses had similar results, with the exception of MZ VII (Table 5). However, this MZ has one of the highest proportion of inactive leks (Garton *et al*. in press, p. 65) which may imply that males numbers on the remaining leks are increasing as birds re-locate. The analysis of this MZ also suffered from small sample sizes and therefore large confidence intervals (Garton *et al*. in press, p. 217), so the treand may not actually reflect the population status.

Comment [BF42]: NW: the narrative leads me to believe neither Garton nor we have any confidence in this estimate for VII – should we say so?

Comment [p43]: Text added to address comment

~~TABLE 5. Long-term Population Trend Estimates for Greater Sage-grouse MZs.~~

~~Z~~	~~States and Provinces Included~~	~~Population Trend Estimates 1965-2003*~~ ~~(Stiver *et al.* 2006)~~	~~Population Trend Estimates Based on Annual Rates of Change 1965-2007 (%)~~ ~~(WAFWA 2008)~~	~~Population Trend Estimates Based on Annual Rates of Change 1965–2007 (%)~~ ~~(Garton *et al.* in press)~~
	~~MT, WY, ND, SD, SK, AL~~	~~Long-term decline~~	~~-2.9~~	~~-2.9~~
~~I~~	~~ID, WY, UT, CO~~	~~Long-term decline~~	~~-2.7~~	~~-3.5~~
~~II~~	~~UT, NV, CA~~	~~Long-term decline~~	~~-2.2~~	~~-10**~~
~~V~~	~~ID, UT, NV, OR~~	~~Long-term decline~~	~~-3.8~~	~~-4**~~
	~~OR, CA, NV~~	~~Change statistically undetectable~~	~~-3.3~~	~~-2**~~

I	WA	Long-term decline	-5.1	-6.5
II	CO, UT	Change statistically undetectable	No detectable trend	+34**

*Average annual rate of change was not reported.

**Due to sample inadequacies for the statistical analyses used, only data from 1995 to 2007 could be used.

Differences in the MZ trends observed between the three analyses are minimal, with the exception of MZs III, V, and VII. While the results of Connelly *et al.* (2004) and WAFWA (2008) were similar for MZ III, Garton *et al.* (in press2011) showed a larger rate of decline. This difference may be due to the shortened time period (12 versus 42 years) Garton *et al.* (in press2011) used for the analyses because some earlier data were not suitable for the statistical procedures used. This increased rate of decline was not observed for MZ IV where Garton *et al.*'s (in press2011) analyses also only spanned 12 years, suggesting that declines in that MZ III may have recently accelerated. No explanation was offered by WAFWA (2008) about the difference between their analyses and Connelly *et al.* (2004) for MZ V. However, Garton *et al*. (in pre2011ss) results are similar to WAFWA for the same area.

Comment [DP44]: this may have changed as per the new Garton analysis

The difference in the annual rate of change between Connelly *et al*. (2004) and WAFWA (2008) versus Garton *et al*. (in press) in MZ VII is significant (Table 5). Garton *et al*. (in press) did not offer an explanation of this difference, but Connelly *et al*. (2004; as cited by (Stiver *et al.* 2006, p. 1-7)) indicated population trends were increasing in this MZ, although those increases were not statistically significant. However, Garton *et al*. (in press, pp. 62-63) reported that the number of leks in MZ VII declined by 39 percent during the same analysis period. The increase in annual rate of change may simply reflect increases on remaining leks as habitat became more limited.

Comment [DP45]: this will all need to be revised with the new Garton report

In addition to calculating annual rates of change by MZ, Garton *et al* (in press) also reported the percent change in number of males per lek from 1965 to 2007, the percent change of active leks from 1965 to 2007, and minimum male population estimates in 2007 (Table 6). The percent change in number of males per lek and the percent change in active leks reflect population declines, and possibly habitat loss in all MZs.

~~TABLE 6. Minimum male greater sage-grouse population estimates in 2007, percent change in number of males per lek and percent change in number of active leks between 1965 and 2007 by MZ (from Garton *et al.* in press, pp. 22-64).~~

~~Z~~	~~Min Population Est in 2007 (# of males)~~	~~Percent Change in # of Males per Lek (1965-2007)~~	~~Percent Change of Active Leks (1965-2007)~~
	~~14,814~~	~~-17~~	~~-22~~
~~I~~	~~42,429~~	~~-30~~	~~-7~~

II	6,851	-24	-16 ***
V	15,761	-54	-11***
	6,925	-17**	-21**
I	315	-76	-57
II	241	-13	-39*

*1995 to 2007 - due to sample sizes, only data from this time period were used.

**1985 to 2007 - due to sample sizes, only data from this time period were used.

***1975 to 2007 – due to sample sizes, only data from this time period were used.

Garton *et al*.'s (in press, p. 71) analyses indicated that estimates of populations of sage-grouse were 20 to 80 percent larger than the estimated carrying capacities (where population size statistically has a growth rate of 0 (Garton *et al*. in press, p. 17)) for those areas. This may be the result of a carrying capacity estimate that is not an absolute upper limit of growth rate, but rather a range of in which growth rates may fluctuate, distribution being skewed or reflect a delayed density-dependent response by the populations (Garton *et al.* in press, p. 71). Several populations analyzed by Garton *et al*. (in press, p. 71) demonstrated a 1- to 2-year delay in population response to habitat conditions. This result is consistent with field observations in Montana and Wyoming where sage-grouse continued to be observed for 3 to 4 years after disturbance resulted in unsuitable habitat conditions (Walker *et al*. 2007a, p. 2652). The delayed response is likely the result of the high site fidelity demonstrated by sage-grouse.

Comment [DP46]: needs revised with new information

In summary, since neither pre-settlement nor current numbers of sage-grouse are accurately known, the actual rate and magnitude of decline since pre-settlement times is uncertain. However, three groups of researchers using different statistical methods (but the same lek count data) concluded that rangewide greater sage-grouse have experienced long-term population declines in the past 43 years, with that decline lessening in the past 22 years. Many of these declines are the result of loss of leks (WAFWA 2008, p. 51), indicating either a direct loss of habitat or habitat function (Connelly and Braun 1997, p. 2). A recent increase in the annual rate of change for MZ VII may simply be an anomaly of small population numbers, as other indicators suggest this area is suffering habitat losses. A delayed response of sage-grouse to changes in carrying capacity was identified by Garton *et al.* (~~in press~~2011, p.71).

~~Connectivity~~