Proposed Rules

Federal Register

This section of the FEDERAL REGISTER contains notices to the public of the proposed issuance of rules and regulations. The purpose of these notices is to give interested persons an opportunity to participate in the rule making prior to the adoption of the final rules.

DEPARTMENT OF THE INTERIOR

Fish and Wildlife Service

50 CFR Part 17

[FWS-R6-ES-2010-0018]
[MO 92210-0-0008-B2]

Endangered and Threatened Wildlife and Plants; 12-Month Findings for Petitions to List the Greater Sage-Grouse (*Centrocercus urophasianus*) as Threatened or Endangered

AGENCY: Fish and Wildlife Service, Interior.

ACTION: Notice of 12–month petition findings.

SUMMARY: We, the U.S. Fish and Wildlife Service (Service), announce three 12–month findings on petitions to list three entities of the greater sage-grouse (*Centrocercus urophasianus*) as threatened or endangered under the Endangered Species Act of 1973, as amended (Act). We find that listing the greater sage-grouse (rangewide) is warranted, but precluded by higher priority listing actions. We will develop a proposed rule to list the greater sage-grouse as our priorities allow.

We find that listing the western subspecies of the greater sage-grouse is not warranted, based on determining that the western subspecies is not a valid taxon and thus is not a listable entity under the Act. We note, however, that greater sage-grouse in the area covered by the putative western subspecies (except those in the Bi-State area (Mono Basin), which are covered by a separate finding) are encompassed by our finding that listing the species is warranted but precluded rangewide.

We find that listing the Bi-State population (previously referred to as the Mono Basin area population), which meets our criteria as a distinct population segment (DPS) of the greater sage-grouse, is warranted but precluded by higher priority listing actions. We will develop a proposed rule to list the Bi-State DPS of the greater sage-grouse as our priorities allow, possibly in conjunction with a proposed rule to list the greater sage-grouse rangewide.

DATES: The finding announced in the document was made on [*insert date of publication in the* **Federal Register**].

ADDRESSES: This finding is available on the Internet at *http://www.regulations.gov* and *www.fws.gov*. Supporting documentation we used to prepare this finding is available for public inspection, by appointment, during normal business hours at the U.S. Fish and Wildlife Service, 5353 Yellowstone Road, Suite 308A, Cheyenne, Wyoming 82009; telephone (307) 772-2374; facsimile (307) 772-2358. Please submit any new information, materials, comments, or questions concerning this species to the Service at the above address.

FOR FURTHER INFORMATION CONTACT: Brian T. Kelly, Field Supervisor, U.S. Fish and Wildlife Service, Wyoming Ecological Services Office (see **ADDRESSES**). If you use a telecommunications device for the deaf (TDD), call the Federal Information Relay Service (FIRS) at (800) 877-8339.

SUPPLEMENTARY INFORMATION:

Background

Section 4(b)(3)(B) of the Act (16 U.S.C. 1531 *et seq.*), requires that, for any petition containing substantial scientific or commercial information that the listing may be warranted, we make a finding within 12 months of the date of the receipt of the petition on whether the petitioned action is (a) not warranted, (b) warranted, or (c) warranted, but that immediate proposal of a regulation implementing the petitioned action is precluded by other pending proposals to determine whether species are threatened or endangered, and expeditious progress is being made to add or remove qualified species from the Lists of Endangered and Threatened Wildlife and Plants. Section 4(b)(3)(C) of the Act requires that we treat a petition for which the requested action is found to be warranted but precluded as though resubmitted on the date of such finding; that is, requiring a subsequent finding to be made within 12 months. We must publish these 12–month findings in the **Federal Register**.

Previous Federal Action

Greater Sage-Grouse

On July 2, 2002, we received a petition from Craig C. Dremann requesting that we list the greater sage-grouse (*Centrocercus urophasianus*) as endangered across its entire range. We received a second petition from the Institute for Wildlife Protection on March 24, 2003, requesting that the greater sage-grouse be listed rangewide. On December 29, 2003, we received a third petition from the American Lands Alliance and 20 additional conservation organizations (American Lands Alliance *et al.*) to list the greater sage-grouse as threatened or endangered rangewide. On April 21, 2004, we announced our 90–day petition finding in the **Federal Register** (69 FR 21484) that these petitions taken collectively, as well as information in our files, presented substantial information indicating that the petitioned actions may be warranted. On July 9, 2004, we published a notice to reopen the period for submitting comments on our 90–day finding, until July 30, 2004 (69 FR 41445). In accordance with section 4(b)(3)(A) of the Act, we completed a status review of the best available scientific and commercial information on the species. On January 12, 2005, we announced our not-warranted 12–month finding in the **Federal Register** (70 FR 2243).

On July 14, 2006, Western Watersheds Project filed a complaint in Federal district court alleging that the Service's 2005 12–month finding was incorrect and arbitrary and requested the finding be remanded to the Service. On December 4, 2007, the U.S. District Court of Idaho ruled that our 2005 finding was arbitrary and capricious, and remanded it to the Service for further consideration. On January 30, 2008, the court approved a stipulated agreement between the Department of Justice and the plaintiffs to issue a new finding in May 2009, contingent on the availability of a new monograph of information on the sage-grouse and its habitat (Monograph). On February 26, 2008, we published a notice to initiate a status review for the greater sage-grouse (73 FR 10218), and on April 29, 2008, we published a notice extending the request for submitting information to June 27, 2008 (73 FR 23172). Publication of the Monograph was delayed due to circumstances outside the control of the Service. An amended joint stipulation, adopted by the court on June 15, 2009, required the Service to submit the 12–month finding to the **Federal Register** by February 26, 2010; this due date was subsequently extended to March 5, 2010.

Western Subspecies of the Greater Sage-Grouse

The western subspecies of the greater sage-grouse (*Centrocercus urophasianus phaios*) was identified by the Service as a category 2 candidate species on September 18, 1985 (50 FR 37958). At the time, we defined Category 2 species as those species for which we possessed information indicating that a proposal to list as endangered or threatened was possibly appropriate, but for which conclusive data on biological vulnerability and threats were not available to support a proposed rule. On February 28, 1996, we discontinued the designation of category 2 species as candidates for listing under the Act (61 FR 7596), and consequently the western subspecies was no longer considered to be a candidate for listing.

We received a petition, dated January 24, 2002, from the Institute for Wildlife Protection requesting that the western subspecies occurring from northern California through Oregon and Washington, as well as any western sage-grouse still occurring in parts of Idaho, be listed under the Act. The petitioner excluded the Mono Basin area populations in California and northwest Nevada since they already had petitioned this population as a distinct population segment (DPS) for emergency listing (see discussion of Bi-State area (Mono Basin) population below). The petitioner also requested that the Service include the Columbia Basin DPS in this petition, even though we had already identified this DPS as a candidate for listing under the Act (66 FR 22984, May 7, 2001) (see discussion of Columbia Basin below).

We published a 90–day finding on February 7, 2003 (68 FR 6500), that the petition did not present substantial information indicating the petitioned action was warranted based on our determination that there was insufficient evidence to indicate that the petitioned western population of sage-grouse is a valid subspecies or DPS. The petitioner pursued legal action, first with a 60–day Notice of Intent to sue, followed by filing a complaint in Federal district court on June 6, 2003, challenging the merits of our 90–day finding. On August 10, 2004, the U.S. District Court for the Western District of Washington ruled in favor of the Service (Case No. C03-1251P). The petitioner appealed and on March 3, 2006, the U.S. Court of Appeals for the Ninth Circuit reversed in part the ruling of the District Court and remanded the matter for a new 90–day finding (*Institute for Wildlife Protection* v. *Norton*, 2006 U.S. App. LEXIS 5428 9th Cir., March 3, 2006). Specifically, the Court of Appeals rejected the Service's conclusion that the petition did not present substantial information indicating that western sage-grouse may be a valid subspecies, but upheld the Service's determination that the petition did not present substantial information indicating that the petitioned population may constitute a DPS. The Court's primary concern was that the Service did not provide a sufficient description of the principles we employed to determine the validity of the subspecies classification. On April 29, 2008, we published in the **Federal Register** (73 FR 23170) a 90–day finding that the petition presented substantial scientific or commercial information indicating that listing western sage-grouse may be warranted and initiated a status review for western sage-grouse.

In a related action, the Service also has made a finding on a petition to list the eastern subspecies of the greater sage-grouse (*Centrocercus urophasianus urophasianus*). On July 3, 2002, we received a petition from the Institute for Wildlife Protection to list the eastern subspecies, identified in the petition as including all sage-grouse east of Oregon, Washington, northern California, and a small portion of Idaho. The petitioners sued the Service in U.S. District Court on January 10, 2003, for failure to complete a 90–day finding. On October 3, 2003, the Court ordered the Service to complete a finding. The Service published its not-substantial 90–day finding in the **Federal Register** on January 7, 2004 (69 FR 933), based on our determination that the eastern sage-grouse was not a valid subspecies. The not-substantial finding was challenged, and on September 28, 2004, the U.S. District Court ruled in favor of the Service, dismissing the plaintiff's case.

Columbia Basin (Washington) Population of the Western Subspecies

On May 28, 1999, we received a petition dated May 14, 1999, from the Northwest Ecosystem Alliance and the Biodiversity Legal Foundation. The petitioners requested that the Washington population of western sage-grouse (*C. u. phaios*) be listed as threatened or endangered under the Act. The petitioners requested listing of the Washington population of western sage-grouse based upon threats to the population and its isolation from the remainder of the taxon. Accompanying the petition was information relating to the taxonomy, ecology, threats, and the past and present distribution of western sage-grouse.

In our documents we have used "Columbia Basin population" rather than "Washington population" because we believe it more appropriately describes the petitioned entity. We published a substantial 90–day finding on August 24, 2000 (65 FR 51578). On May 7, 2001, we published our 12–month finding (66 FR 22984), which included our determination that the Columbia Basin population of the western sage-grouse met the requirements of our policy on DPSs (61 FR 4722) and that listing the DPS was warranted but precluded by other higher priority listing actions. As required by section 4(b)(3)(C) of the Act, we have subsequently made resubmitted petition findings, announced in conjunction with our Candidate Notices of Review, in which we continued to find that listing the Columbia Basin DPS of the western subspecies was warranted but precluded by other higher priority listing actions (66 FR 54811, 67 FR 40663, 69 FR 24887, 70 FR 24893, 74 FR 57803). Subsequent to the March 2006 decision by the court on our 90–day finding on the petition to list the western subspecies of the greater sage-grouse (described above), our resubmitted petition findings stated we were not updating our analysis for the DPS, but would publish an updated finding regarding the petition to list the Columbia Basin population of the western subspecies following completion of the new rangewide status review for the greater sage-grouse.

Bi-State Area (Mono Basin) Population of Sage-grouse

On January 2, 2002, we received a petition from the Institute for Wildlife Protection requesting that the sage-grouse occurring in the Mono Basin area of Mono County, California, and Lyon County, Nevada, be emergency listed as an endangered distinct population segment (DPS) of *Centrocercus urophasianus phaios*, which the petitioners considered to be the western subspecies of the greater sage-grouse. This request was for portions of Alpine and Inyo Counties in California and most of Mono County in California and portions of Carson City, Douglas, Esmeralda, Lyon, and Mineral Counties in Nevada. On December 26, 2002, we published a 90–day finding that the petition did not present substantial scientific or commercial information indicating that the petitioned action may be warranted

(67 FR 78811). Our 2002 finding was based on our determination that the petition did not present substantial information indicating that the population of greater sage-grouse in this area was a DPS under our DPS policy (61 FR 4722; February 7, 1996), and thus was not a listable entity (67 FR 78811; December 26, 2002). Our 2002 finding also included a determination that the petition did not present substantial information regarding threats to indicate that listing the petitioned population may be warranted (67 FR 78811).

On November 15, 2005, we received a petition submitted by the Stanford Law School Environmental Law Clinic on behalf of the Sagebrush Sea Campaign, Western Watersheds Project, Center for Biological Diversity, and Christians Caring for Creation to list the Mono Basin area population of greater sage-grouse as a threatened or endangered DPS of the greater sage-grouse (*C. urophasianus*) under the Act. On March 28, 2006, we responded that emergency listing was not warranted and, due to court orders and settlement agreements for other listing actions, we would not be able to address the petition at that time.

On November 18, 2005, the Institute for Wildlife Protection and Dr. Steven G. Herman sued the Service in U.S. District Court for the Western District of Washington (*Institute for Wildlife Protection et al.* v. *Norton et al.*, No. C05-1939 RSM), challenging the Service's 2002 finding that their petition did not present substantial information indicating that the petitioned action may be warranted. On April 11, 2006, we reached a stipulated settlement agreement with both plaintiffs under which we agreed to evaluate the November 2005 petition and concurrently reevaluate the December 2001 petition (received in January 2002). The settlement agreement required the Service to submit to the **Federal Register** a 90–day finding by December 8, 2006, and if substantial, to complete the 12–month finding by December 10, 2007. On December 19, 2006, we published a 90–day finding that these petitions did not present substantial scientific or commercial information indicating that the petitioned actions may be warranted (71 FR 76058).

On August 23, 2007, the November 2005 petitioners filed a complaint challenging the Service's 2006 finding. After review of the complaint, the Service determined that we would revisit our 2006 finding. The Service entered into a settlement agreement with the petitioners on February 25, 2008, in which the Service agreed to a voluntary remand of the 2006 petition finding, and to submit for publication in the **Federal Register** a new 90–day finding by April 25, 2008. The agreement further stipulated that if the new 90–day finding was positive, the Service would undertake a status review of the Mono Basin area population of the greater sage-grouse and submit for publication in the **Federal Register** a 12–month finding by April 24, 2009.

On April 29, 2008, we published in the **Federal Register** (73 FR 23173) a 90–day petition finding that the petitions presented substantial scientific or commercial information indicating that listing the Mono Basin area population may be warranted and initiated a status review. Based on a joint stipulation by the Service and the plaintiffs to extend the due date for the 12–month finding, on April 23, 2009, the U.S. District Court, Northern District of California, issued an order that if the parties did not agree to a later alternative date, the Service would submit a 12–month finding for the Mono Basin population of the greater sage-grouse to the **Federal Register** no later than May 26, 2009. On May 27, 2009, the U.S. District Court, Northern District of California, issued an order accepting a joint stipulation between the Department of Justice and the plaintiffs, which states that the parties agree that the Service may submit to the **Federal Register** a single document containing the 12–month findings for the Mono Basin area population and the greater sage-grouse no later than by February 26, 2010. Subsequently, the due date for submission of the document to the **Federal Register** was extended to March 5, 2010.

Both the November 2005 and the December 2001 petitions as well as our 2002 and 2006 findings use the term "Mono Basin area" to refer to greater sage-grouse that occur within the geographic area of eastern California and western Nevada that includes Mono Lake. For conservation planning purposes, this same geographic area is referred to as the Bi-State area by the States of California and Nevada (Greater Sage-grouse Conservation Plan for Nevada and Eastern California, 2004, pp. 4–5). For consistency with ongoing planning efforts, we will adopt the "Bi-State" nomenclature hereafter in this finding.

Biology and Ecology of Greater Sage-Grouse

Greater Sage-Grouse 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 speckles, fleshy yellow combs over the eyes, long pointed tails, and dark green toes. Males also have blackish chin and throat feathers, conspicuous phylloplumes (specialized erectile feathers) at the back of the head and neck, and white feathers forming a ruff around the neck and upper belly. During breeding displays, males exhibit olive-green apteria (fleshy bare patches of skin) on their breasts (Schroeder *et al.* 1999, p. 2).

Taxonomy

Greater sage-grouse are members of the Phasianidae family. They are one of two congeneric species; the other species in the genus is the Gunnison sage-grouse (*Centrocercus minimus*). In 1957, the American Ornithologists' Union (AOU) (AOU 1957, p 139) recognized two subspecies of the greater sage-grouse, the eastern (*Centrocercus urophasianus urophasianus)* and western (*C. u. phaios)* based on information from Aldrich (1946, p. 129). The original subspecies designation of the western sage-grouse 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. The last edition of the AOU Check-list of North American Birds to include subspecies was the 5th Edition, published in 1957. Subsequent editions of the Check-list have excluded treatment of subspecies. Richard Banks, who was the AOU Chair of the Committee on Classification and Nomenclature in 2000, indicated that, because the AOU has not published a revised edition at the subspecies level since 1957, the subspecies in that edition, including the western sage-grouse, are still recognized (Banks 2000, pers. comm.). However, in the latest edition of the Check-list (7th Ed., 1998, p. xii), the AOU explained that its decision to omit subspecies, "carries with it our realization that an uncertain number of currently recognized subspecies, especially those formally named early in this century, probably cannot be validated by rigorous modern techniques."

Since the publication of the 1957 Check-list, the validity of the subspecies designations for greater sage-grouse has been questioned, and in some cases dismissed, by several credible taxonomic authorities (Johnsgard 1983, p. 109; Drut 1994, p. 2; Schroeder *et al.* 1999, p. 3; International Union for Conservation of Nature (IUCN) 2000, p. 62; Banks 2000, 2002 pers. comm.; Johnsgard 2002, p. 108; Benedict *et al.* 2003, p. 301). The Western Association of Fish and Wildlife Agencies (WAFWA), an organization of 23 State and provincial agencies charged with the protection and management of fish and wildlife resources in the western part of the United States and Canada, also questioned the validity of the western sage-grouse as a subspecies in its Conservation Assessment of Greater Sage-grouse and Sagebrush Habitats (Connelly *et al.* 2004, pp. 8-4 to 8-5). Furthermore, in its State conservation assessment and strategy for greater sage-grouse, the Oregon Department of Fish and Wildlife (ODFW) stated that "recent genetic analysis (Benedict *et al.* 2003) found little evidence to support this subspecies distinction, and this Plan refers to sage-grouse without reference to subspecies delineation in this document" (Hagen 2005, p. 5).

The Integrated Taxonomic Information System (ITIS), a database representing a partnership of U.S., Canadian, and Mexican agencies, other organizations, and taxonomic specialists designed to provide scientifically credible taxonomic information, lists the taxonomic status of western sage-grouse as "invalid – junior synonym" (ITIS 2010). In an evaluation of the historical classification of the western sage-grouse as a subspecies, Banks stated that it was "weakly characterized" but felt that it would be wise to continue to regard western sage-grouse as taxonomically valid "for management purposes" (Banks, pers. comm. 2000). This statement was made prior to the availability of behavioral and genetic information that has become available since 2000. In addition, Banks' opinion is qualified by the phrase "for Management purposes." Management recommendations and other considerations must be clearly distinguished from scientific or commercial data that indicate whether an entity may be taxonomically valid for the purpose of listing under the Act.

Although the Service had referred to the western sage-grouse in past decisions (for example, in the 12–month finding for a petition to list the Columbia Basin population of western sage-grouse, 66 FR 22984; May 7, 2001), this taxonomic reference was ancillary to the decision at hand and was not the focal point of the listing action. In other words, when past listing actions were focused on some other entity, such as a potential distinct population segment in the State of Washington, we accepted the published taxonomy for western sage-grouse because that taxonomy itself was not the subject of the review and thus not subject to more rigorous evaluation at the time.

Taxonomy is a component of the biological sciences. Therefore, in our evaluation of the reliability of the information, we considered scientists with appropriate taxonomic credentials (which may include a combination of education, training, research, publications, classification and/or other experience relevant to taxonomy) as qualified to provide informed opinions regarding taxonomy, make taxonomic distinctions, and/or question taxonomic classification.

There is no universally accepted definition of what constitutes a subspecies, and the use of subspecies may vary between taxonomic groups (Haig *et al.* 2006, pp. 1584-1594). The Service acknowledges the diverse opinions of the scientific community about species and subspecies concepts. However, to be operationally useful, subspecies must be discernible from one another (i.e., diagnosable); this element of "diagnosability," or the ability to consistently distinguish between populations, is a common thread that runs through all subspecies concepts. The AOU Committee on Classification and Nomenclature offers the following definition of a subspecies: "Subspecies should represent geographically discrete breeding populations that are diagnosable from other populations on the basis of plumage and/or measurements, but are not yet reproductively isolated. Varying levels of diagnosability have been proposed for subspecies, typically ranging from at least 75% to 95% * * * subspecies that are phenotypically but not genetically distinct still warrant recognition if individuals can be assigned to a subspecies with a high degree of certainty" (AOU 2010). In addition, the latest AOU Check-list of North American Birds describes subspecies as: "geographic segments of species' populations that differ abruptly and discretely in morphology or coloration; these differences often correspond with difference in behavior and habitat" (AOU 1998, p. xii).

In general, higher levels of confidence in the classification of subspecies may be gained through the concurrence of multiple morphological, molecular, ecological, behavioral, and/or physiological characters (Haig *et al.* 2006, p. 1591). The AOU definition of subspecies also incorporates this concept of looking for multiple lines of evidence, in referring to abrupt and discrete differences in morphology, coloration, and often corresponding differences in behavior or habitat as well (AOU 1998, p. xii). To assess subspecies diagnosability, we evaluated all the best scientific and commercial information available to determine whether the evidence points to a consistent separation of birds currently purported to be "western sage-grouse" from other populations of greater sage-grouse. This evaluation incorporated information that has become available since the AOU's last subspecies review in 1957, and included data on the geographic separation of the putative eastern and western subspecies, behavior, morphology, and genetics. If the assessment of these multiple characters provided a clear and consistent separation of the putative western subspecies from other populations of sage-grouse, such that any individual bird from the range of the western sage-grouse would likely be correctly assigned to that subspecies on the basis of the suite of characteristics analyzed, that would be considered indicative of a likely valid subspecies.

Geography

The delineation between eastern and western subspecies is vaguely defined and has changed over time from its original description (Aldrich 1946, p. 129; Aldrich and Duvall 1955 p. 12; AOU 1957, p. 139; Aldrich 1963, pp. 539-541). The boundary between the subspecies is generally described along a line starting on the Oregon–Nevada border south of Hart Mountain National Wildlife Refuge and ending near Nyssa, Oregon (Aldrich and Duvall 1955, p. 12; Aldrich 1963, pp. 539-541). Aldrich described the original eastern and western ranges in 1946 (Aldrich 1946, p. 129), while Aldrich and Duvall (1955, p. 12) and Aldrich (1963, pp. 539-541) described an intermediate form in northern California, presumably in a zone of intergradation between the subspecies. All of Aldrich's citations include a portion of Idaho within the western subspecies' range, but the 1957 AOU designation included Idaho as part of the eastern subspecies (AOU 1957, p. 139).

Our evaluation reveals that a boundary between potential western and eastern subspecies may be drawn multiple ways depending on whether one uses general description of historical placement, by considering topographic features, or in response to the differing patterns reported in studying sage-grouse genetics, morphology, or behavior. In their description of greater sage-grouse distribution, Schroeder *et al.* (2004, p. 369) noted the lack of evidence for differentiating between the purported subspecies, stating "We did not quantify the respective distributions of the eastern and western subspecies because of the lack of a clear dividing line (Aldrich and Duvall 1955) and the lack of genetic differentiation (Benedict *et al.* 2003)." Based on this information, there does not appear to be any clear and consistent geographic separation between sage-grouse historically described as "eastern" and "western."

Morphology

As noted above, the original description of the western subspecies of sage-grouse was based solely on differences in coloration (specifically, reduced white markings and darker feathering on western birds) among 11 museum specimens (10 whole birds, 1 head only) collected from 8 locations in Washington, Oregon, and California (Aldrich 1946, p. 129). By today's standards, this represents an extremely small sample size that would likely yield little confidence in the ability to discriminate between populations on the basis of this character. Furthermore, the subspecies designation was based on this single characteristic; no other differences between the western and eastern subspecies of sage-grouse were noted in Aldrich's original description (Aldrich 1946, p. 129; USFWS 2010). Banks (1992) noted plumage color variation in the original specimens Aldrich (1946) used to make his subspecies designation, and agreed that the specimens from Washington, Oregon, and northern California did appear darker than the specimens collected in the eastern portion of the range. However, individual morphological variation in greater sage-grouse, such as plumage coloration, is extensive (Banks 1992). Further, given current taxonomic concepts, Banks (1992) doubted that most current taxonomists would identify a subspecies based on minor color variations from a limited number of specimens, as were available to Aldrich during the mid-1900s (Aldrich 1946, p. 129; Aldrich and Duvall 1955, p. 12; Aldrich 1963, pp. 539-541). Finally, the AOU Committee on Classification has stated that, because of discoloration resulting from age and poor specimen preparation, museum specimens "nearly always must be supplemented by new material for comprehensive systematic studies." (AOU, Check-list of North American Birds, 7th ed., 1998, p. xv.)

Schroeder (2008, pp. 1-19) examined previously collected morphological data across the species' range from both published and unpublished sources. He found statistically significant differences between sexes, age groups, and populations in numerous characteristics including body mass, wing length, tail length, and primary feather length. Many of these differences were associated with sex and age, but body mass also varied by season. There also were substantial morphometric (size and shape) differences among populations. Notably, however, these population differences were not consistent with any of the described geographic delineations between eastern and western subspecies. For example, sage-grouse from Washington and from Northern Colorado up to Alberta appeared to be larger than those in Idaho, Nevada, Oregon, and California (Schroeder 2008, p. 9). This regional variation was not consistent with differences in previously established genetic characteristics (Oyler-McCance *et al.* 2005, as cited in Schroeder 2008, p. 9). Thus our review revealed no clear basis for differentiating between the two described subspecies based on plumage or morphology.

Behavior

The only data available with respect to behavior are for strutting behavior on leks, a key component of mate selection. One recent study compared the male strut behavior between three sage-grouse populations that happen to include populations from both sides of the putative eastern-western line (Taylor and Young 2006, pp. 36-41). However, the classification of these populations changes depending on the description of western sage-grouse used. The Lyon/Mono population falls within the intermediate zone identified by Aldrich and Duvall (1955, p. 12) but would be classified as eastern under Aldrich (1963, p. 541). The Lassen population may be considered either western (Aldrich 1946, p. 129) or intermediate (Aldrich and Duvall 1955, p. 12; Aldrich 1963, p. 541). The Nye population falls within the range of the eastern sage-grouse (Aldrich and Duvall 1955, p. 12; Aldrich 1963, p. 541). The researchers found that male strut rates were not significantly different between populations, but that acoustic components of the display for the Lyon/Mono and Lassen populations (considered intermediate and/or western) were similar to each other, whereas the Nye population (eastern) was distinct. We consider these results inconclusive in distinguishing between eastern and western subspecies because of the inconsistent results and limited geographic scope of the study.

Schroeder (2008, p. 9) also examined previously collected data on strutting behavior on leks, including Taylor and Young (2006). He noted that, although there was regional variation in the strut rate of sage-grouse, it was not clear if this variation reflected population-level effects or some other unexplained variation. Based on the above limited information, we do not consider there to be any strong evidence of a clear separation of the western sage-grouse from other populations on the basis of behavioral differences.

Genetics

Genetic research can sometimes augment or refine taxonomic definitions that are based on morphology or behavior or both (discussed in Haig *et al.* 2006, p. 1586; Oyler-McCance and Quinn in press, p. 19). Benedict *et al.* (2003, p. 309) found no genetic data supporting a subspecies designation. To investigate taxonomic questions and examine levels of gene flow and connectedness among populations, Oyler-McCance *et al.* (2005, p. 1294) conducted a comprehensive examination of the distribution of genetic variation across the entire range of greater sage-grouse, using both mitochondrial and nuclear deoxyribonucleic acid (DNA) sequence data. Oyler-McCance *et al.* (2005, p. 1306) found that the overall distribution of genetic variation showed a gradual shift across the range in both mitochondrial and nuclear DNA data sets. Their results demonstrate that greater sage-grouse populations follow an isolation-by-distance model of restricted gene flow (gene flow resulting from movement between neighboring populations rather than being the result of long distance movements of individuals) (Oyler-McCance *et al.* 2005, p. 1293; Campton 2007, p. 4), and are not consistent with subspecies designations. Oyler-McCance and Quinn (in press, entire) reviewed available studies that used molecular genetic approaches, including Oyler-McCance *et al.* (2005). They examined the genetic data bearing on the delineation of the western and eastern subspecies of greater sage-grouse, and determined that the distinction is not supported by the genetic data (Oyler-McCance and Quinn in press, p. 4). The best available genetic information thus does not support the recognition of the western sage-grouse as a separate subspecies.

Summary: Taxonomic Evaluation of the Subspecies

The AOU has not revisited the question of whether the eastern and western subspecies are valid since their original classification in 1957. We have examined the best scientific information available regarding the putative subspecies of the greater sage-grouse and have considered multiple lines of evidence for the potential existence of western and eastern subspecies based on geographic, morphological, behavioral, and genetic data. In our evaluation, we looked for any consistent significant differences in these characters that might support recognition of the western or eastern sage-grouse as clear, discrete, and diagnosable populations, such that either might be considered a subspecies.

As described above, the boundaries distinguishing the two putative subspecies have shifted over time, and there does not appear to be any clear and consistent geographic separation between sage-grouse historically described as "eastern" and "western." Banks (1992) and Schroeder (2008, p. 9) both found morphological variations between individuals and populations, but Banks stated that the differences would not be sufficient to recognize subspecies by current taxonomic standards, and Schroeder noted that the differences were not consistent with any of the described geographic or genetic delineations between putative subspecies. Schroeder (2008 p. 9) also noted regional behavior differences in strut rate, but stated it was not clear if this variation reflected population-level effects. Finally, the best available genetic information indicates there is no distinction between the putative western and eastern subspecies (Benedict *et al.* 2003, p. 309; Oyler-McCance and Quinn in press, p. 12).

Because the best scientific and commercial information do not support the taxonomic validity of the purported eastern or western subspecies, our analysis of the status of the greater sage-grouse (below) does not address considerations at the scale of subspecies. (See Findings section, below, for our finding on the petition to list the western subspecies of the greater sage-grouse.)

Life History Characteristics

Greater sage-grouse depend on a variety of shrub-steppe habitats throughout their life cycle, and are considered obligate users of several species of sagebrush (e.g., *Artemisia tridentata* ssp. *wyomingensis* (Wyoming big sagebrush), *A. t.* ssp. *vaseyana* (mountain big sagebrush), and *A. t. tridentata* (basin big sagebrush)) (Patterson 1952, p. 48; Braun *et al.* 1976, p. 168; Connelly *et al.* 2000a, pp. 970-972; Connelly *et al.* 2004, p. 4-1; Miller *et al.* in press, p. 1). Greater sage-grouse also use other sagebrush species such as *A. arbuscula* (low sagebrush), *A. nova* (black sagebrush), *A. frigida* (fringed sagebrush), and *A. cana* silver sagebrush (Schroeder *et al.* 1999, pp. 4-5; Connelly *et al.* 2004, p. 3-4). Thus, sage-grouse distribution is strongly correlated with the distribution of sagebrush 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). Adult sage-grouse rarely switch between these habitats once they have been selected, limiting their adaptability to changes.

During the spring breeding season, male sage-grouse gather together to perform courtship displays on areas called leks. Areas of bare soil, short-grass steppe, windswept ridges, exposed knolls, or other relatively open sites typically serve as leks (Patterson 1952, p. 83; Connelly *et al.* 2004, p. 3-7 and references therein). Leks are often surrounded by denser shrub-steppe cover, which is used for escape, thermal, and feeding cover. The proximity, configuration, and abundance of nesting habitat are key factors influencing lek location (Connelly *et al.*, 1981, and Connelly *et al.*, 2000 b, cited in Connelly *et al.*, in press a, p. 11). 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). Nest sites are selected independent of lek locations, but the reverse is not true (Bradbury *et al.* 1989, p. 22; Wakkinen *et al.* 1992, p. 382). Thus, leks are indicative of nesting habitat.

Leks range in size from less than 0.04 hectare (ha) (0.1 acre (ac)) to over 36 ha (90 ac) (Connelly *et al.* 2004, p. 4-3) and can host from several to hundreds of males (Johnsgard 2002, p. 112). Males defend individual territories within leks and perform elaborate displays with their specialized plumage and vocalizations to attract females for mating. Although males are capable of breeding the first spring after hatch, young males are rarely successful in breeding on leks due to the dominance of older males (Schroeder *et al.* 1999, p. 14). 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). However, Bush (2009, p. 106) found 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, which indicates that males and females likely engage in off-lek copulations. Males do not participate in incubation of eggs or rearing chicks.

Females have been documented to travel more than 20 km (12.5 mi) to their nest site after mating (Connelly *et al.* 2000a, p. 970), but distances between a nest site and the lek on which breeding occurred is 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 mi) to 7.8 km (4.8 mi) in five studies examining 301 nest locations (Schroeder *et al.* 1999 p. 12).

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, 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; Connelly *et al.* in press b, p. 12). Sage-grouse also may 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). Shrub canopy and grass cover provide concealment for sage-grouse nests and young, and are critical for reproductive success (Barnett and Crawford 1994, p. 116; Gregg *et al.* 1994, p. 164; DeLong *et al.*1995, p. 90; Connelly *et al.* 2004, p. 4-4). Published vegetation characteristics of successful nest sites included a sagebrush canopy cover of 15–25 percent, sagebrush heights of 30 to 80 cm (11.8 to 31.5 in.), and grass/forb cover of 18 cm (7.1 in.) (Connelly *et al.* 2000a, p. 977).

Sage-grouse clutch size ranges from 6 to 9 eggs with an average of 7 eggs (Connelly *et al.* in press a, pp. 14-15). The likelihood of a female nesting in a given year averages 82 percent in eastern areas of the range (Alberta, Montana, North Dakota, South Dakota, Colorado, Wyoming) and 78 percent in western areas of the range (California, Nevada, Idaho, Oregon, Washington, Utah) (Connelly *et al.* in press a, p. 15). Adult females have higher nest initiation rates than yearling females (Connelly *et al.* in press a, p. 15). Nest success (one or more eggs hatching from a nest), as reported in the scientific literature, varies widely (15–86 percent Schroeder *et al.* 1999, p. 11). Overall, the average nest success for sage-grouse in habitats where sagebrush has not been disturbed is 51 percent and for sage-grouse in disturbed habitats is 37 percent (Connelly *et al.*, in press a, p. 1).

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 1.40–2.96 chicks per hen across the species range have been reported (Connelly and Braun 1997, p. 20). Productivity declined slightly after 1985 to 1.21–2.19 chicks per hen (Connelly and Braun 1997, p. 20). Despite average clutch sizes of 7 eggs (Connelly *et al.* in press a, p. 15) due to low chick survival and limited renesting, there is little evidence that populations of sage-grouse produce large annual surpluses (Connelly *et al.* in press a, p. 24).

Hens rear their broods in the vicinity of the nest site for the first 2–3 weeks following hatching (within 0.2–5 km (0.1–3.1 mi)), 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 ensure chick survival during this period (Connelly *et al.* 2004, p. 4-9).

All sage-grouse gradually move from sagebrush uplands to more mesic areas (moist areas such as streambeds or wet meadows) 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 also will 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).

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

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 and summer areas, between breeding, summer, and winter areas, or not at all. Migration distances of up to 161 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 traveled farther than males (Beck 1977, p. 23). 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). 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 annual recorded home ranges have varied from 4 to 615 square kilometers (km^2) (1.5 to 237.5 square miles (mi^2)) (Connelly *et al.*, in press a, p. 10).

Sage-grouse typically live between 3 and 6 years, but individuals up to 9 years of age have been recorded in the wild (Connelly *et al.* 2004, p. 3-12). Hens typically survive longer due to a disproportionate impact of predation on leks to males (Schroeder *et al.* 1999, p. 14). Juvenile survival (from hatch to first breeding season) is affected by food availability, habitat quality, harvest, and weather. Based on a review of many field studies, juvenile survival rates range from 7 to 60 percent (Connelly *et al.* 2004, p. 3-12). The variation in juvenile mortality rates may be associated with gender, weather, harvest rates, age of brood female (broods with adult females have higher survival), and with habitat quality (rates increase in poor habitats) (Schroeder *et al.* 1999, p. 14; Connelly *et al.*, in press a, p. 20). The average annual survival rate for male sage-grouse (all ages combined) documented in various studies ranged from 38 to 60 percent and 55 to 75 percent for females (Schroeder *et al.* 1999, p. 14). Higher female survival rates account for a female-biased sex ratio in adult birds (Schroeder 1999, p. 14; Johnsgard 2002, p. 621). The sex ratio of sage-grouse breeding populations varies widely with values between 1.2 and 3 females per male being reported (Connelly *et al.*, in press a, p. 23). Although seasonal patterns of mortality have not been thoroughly examined, over-winter mortality appears to be low (Connelly *et al.* 2000b, p. 229; Connelly *et al.* 2004, p. 9-4). While both males and females are capable of breeding the first spring after hatch, young males are rarely successful due to the dominance of older males on the lek (Schroeder *et al.* 1999, p. 14). Nesting rates of yearling females are 25 percent less than adult females (Schroeder *et al.* 1999, p. 13).

Habitat Description and Characteristics

Sage-grouse are dependent on large areas of contiguous sagebrush (Patterson 1952, p. 48; Connelly *et al.* 2004, p. 4-1; Connelly *et al.* in press a, p. 10; Wisdom *et al.* in press, p. 4), and large-scale characteristics within surrounding landscapes influence sage-grouse habitat selection (Knick and Hanser in press, p. 26). 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.* in press,

p. 4, and references therein). Scientists recognize 14 species and 13 subspecies of sagebrush (Connelly *et al.* 2004, p. 5-2; Miller *et al.* in press, p. 8), 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.* in press, pp. 8-11). The degree of dominance by sagebrush varies with local site conditions and disturbance history. Plant associations, typically defined by perennial grasses, further define distinctive sagebrush communities (Miller and Eddleman 2000, pp. 10-14; Connelly *et al.* 2004, p. 5-3), and are influenced by topography, elevation, precipitation, and soil type. These ecological conditions influence the response and resiliency of sagebrush and their associated understories to natural and human-caused changes.

Sagebrush is typically divided into two groups, big sagebrush and low sagebrush, based on their affinities for different soil types (West and Young 2000, p. 259). Big sagebrush species and subspecies, such as *A. tridentata* ssp. *wyomingensis*, are limited to coarse-textured and/or well-drained sediments. Low sagebrush, such as *A. nova*, 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 supersaturated soils, and many low sage sites are partially flooded during spring snowmelt. None of the sagebrush taxa tolerate soils with high salinity (West 1983, p. 333; West and Young 2000, p. 257). Sagebrush that provide important annual and seasonal habitats for sage-grouse include three subspecies of big sagebrush (*A. t.* ssp. *wyomingensis*, *A. t.* ssp. *tridentata* and *A. t.* ssp. *vaseyana*), two low forms of sagebrush (*A. arbuscula* (little sagebrush) and *A. nova*), and *A. cana* ssp. *cana* (Miller *et al.* in press, p. 8).

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. Although seed viability and germination are high, seed dispersal is limited. Sagebrush seeds, depending on the species, remain viable for 1 to 3 years. However, Wyoming big sagebrush seeds do not persist beyond the year of their production (West and Young 2000, p. 260).

Sagebrush is long-lived, with plants of some species surviving up to 150 years (West 1983, p. 340). They produce allelopathic chemicals 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., webworm (*Aroga* spp.); West 1983, p. 341). Most species of sagebrush are killed by fire (West 1983, p. 341; Miller and Eddleman 2000, p. 17; West and Young 2000, p. 259), and historic fire-return intervals were as long as 350 years, depending on sagebrush type and environmental conditions (Baker in press, p. 16). Natural sagebrush recolonization in burned areas depends on the presence of adjacent live plants for a seed source or on the seed bank, if present (Miller and Eddleman 2000, p. 17), and requires decades for full recovery.

Plants associated with the sagebrush understory vary, as does their productivity. Both plant composition and productivity are influenced by moisture availability, soil characteristics, climate, and topographic position (Miller *et al.*, in press, pp. 8-14). 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.* in press, p. 4), 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. Not all areas previously dominated by sagebrush can be restored because alteration of vegetation, nutrient cycles, topsoil, and living (cryptobiotic) soil crusts has exceeded recovery thresholds (Knick *et al.* 2003, p. 620). 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.* in press, p. 5) and may require decades or centuries (Knick *et al.* 2003, p. 620, and references therein). Meaningful restoration for greater 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.* in press, p. 27). Landscape restoration efforts require a broad range of partnerships (private, State, and Federal) due to landownership patterns (Knick *et al.* 2003, p. 623; 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 maintaining the remaining sagebrush (Miller *et al.* in press, p. 5; Wisdom *et al.* in press, pp. 26, 30).

Greater sage-grouse require large, interconnected expanses of sagebrush with healthy, native understories (Patterson 1952, p. 9; Knick *et al.* 2003, p. 623; Connelly *et al.* 2004, pp. 4-15; Connelly *et al.* in press a, p. 10; Pyke in press, p. 7; Wisdom *et al.* in press, p. 4). 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 that influence the distribution of sagebrush and associated understories. Where home ranges have been reported (Connelly *et al.* in press a, p. 10 and references therein), they are extremely variable (4 to 615 km^2 range (1.5 to 237.5 mi^2)). Occupancy of a home range also is based on multiple variables associated with both local vegetation characteristics and landscape characteristics (Knick *et al.* 2003, p. 621). Pyke (in press, p. 18) estimated that greater than 4,000 ha (9,884 ac) was necessary for population sustainability. However, he did not indicate whether this value was for migratory or nonmigratory populations, nor if this included juxtaposition of all seasonal habitats. Large seasonal and annual movements emphasize the landscape nature of the greater sage-grouse (Knick *et al.* 2003, p. 624; Connelly *et al.* in press a, p. 10).

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). 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). Approximately 2 percent of the total range of the greater sage-grouse occurs in Canada, with the remainder in the United States (Knick in press, p. 14).

Sage-grouse have been extirpated from Nebraska, British Columbia, and possibly Arizona (Schroeder *et al.* 1999, p. 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, p. 369). Changes in distribution are the result of sagebrush alteration and degradation (Schroeder *et al.* 2004, p. 363).

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 1).

[INSERT FIGURE 1 HERE]

Sagebrush occurs in two natural vegetation types that are delineated by temperature and patterns of precipitation (Miller *et al.* in press, 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).

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 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

[INSERT FIGURE 2 HERE]

As stated above, due to the variability in habitat conditions, sage-grouse are not evenly distributed across the range (Figure 1). The MZs I, II, IV, and V encompass the core populations of greater sage-grouse and have the highest reported densities (Table 2, Figures 1, 2; Stiver *et al.* 2006, p. 1-12). The MZ III is composed of lower density populations in the Great Basin, while fewer numbers of more dispersed birds occur in MZ VI (Stiver *et al.* 2006, p. 1-7).

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.

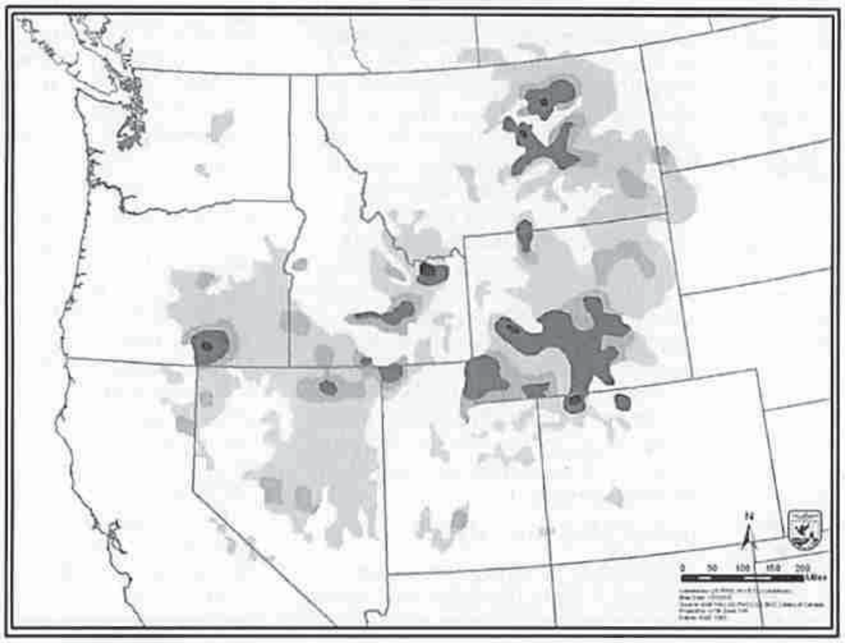

Figure 2—The Management Zones for sage-grouse as identified by Stiver *et al.* (2006, p. 1-11). (Delineation primarily based on floristic provinces and population boundaries.)

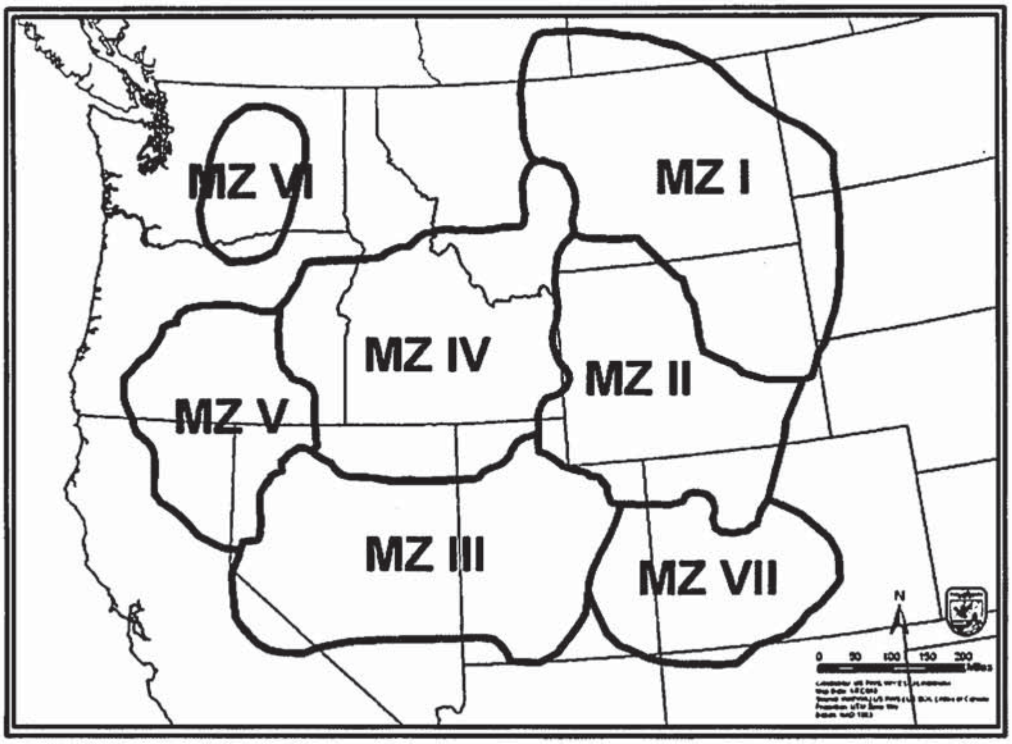

TABLE 2—RELATIVE ABUNDANCE OF GREATER SAGE-GROUSE LEKS, AND NUMBERS OF MALES ATTENDING LEKS BY MANAGEMENT ZONE, BASED ON THE MEAN NUMBER OF INDIVIDUAL LEKS AND MEAN MAXIMUM NUMBER OF MALES ATTENDING LEKS BY MZ DURING 2005–2007.

MZ	Relative Abundance of Leks	Relative Abundance of Males Attending Leks
I	0.17	0.15
II	0.48	0.50
III	0.06	0.07
IV	0.19	0.18
V	0.09	0.10
VI	0.004	0.005
VII	0.003	0.003

Land Ownership of Habitats

Greater sage-grouse extant habitats have multiple surface ownerships, as reflected in Table 3. Most of the habitats occur on Federal surfaces, a reflection of land disposal practices during EuroAmerican settlement of the western United States (Knick in press, pp. 5-10). Lands dominated by sagebrush that were disposed to private ownership typically had deeper soils and greater available water capacity or access to water (valley bottoms), reflecting their capacity for agricultural development or increased grazing activities (Knick in press, p. 15). The lands remaining in Federal ownership were of poorer overall quality. The resulting low productivity on Federal surfaces affects their ability to recover from disturbance (Knick in press, p. 17).

Federal agencies manage almost two-thirds of the sagebrush habitats (Table 3). The Bureau of Land Management (BLM) manages just over half of sage-grouse habitats, while the U.S. Forest Service (USFS) is responsible for management of approximately 8 percent of sage-grouse habitat (Table 3). Other Federal agencies, including the Service, Bureau of Indian Affairs (BIA), Bureau of Reclamation (BOR), National Park Service (NPS), Department of Defense (DOD), and Department of Energy (DOE) also are responsible for sagebrush habitats, but at a much smaller scale (Table 3). State agencies manage approximately 5 percent of sage-grouse habitats.

TABLE 3—PERCENT SURFACE OWNERSHIP OF TOTAL SAGEBRUSH AREA (KM^2 (MI^2)) WITHIN THE SAGE-GROUSE MANAGEMENT ZONES (FROM KNICK IN PRESS, P. 39). OTHER FEDERAL AGENCIES INCLUDE THE SERVICE, BOR, NPS, DOD, AND DOE. MZ VII INCLUDES BOTH GUNNISON AND GREATER SAGE-GROUSE.

Sage-grouse MZ	km^2	mi^2	Sagebrush Management and Ownership					
			BLM Percent	Private Percent	USFS Percent	State Percent	BIA Percent	Other Federal Percent
I Great Plains	50,264	19,407	17	66	2	7	4	3
II Wyoming Basin	108,771	41,996	49	35	4	7	4	1
III Southern Great Basin	92,173	35,588	73	13	10	3	1	0
IV Snake River Plain	134,187	51,810	53	29	11	6	1	0
V Northern Great Basin	65,536	25,303	62	21	10	1	1	6
VI Columbia Basin	12,105	4,674	6	64	2	12	13	3
VII Colorado Plateau	17,534	6,770	42	36	6	6	9	1
TOTALS	480,570	185,549	52	31	8	5	3	1

Population Size

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, with estimates of historical populations ranging from 1,600,000 to 16,000,000 birds (65 FR 51580, August 24, 2000). 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 presettlement (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.

Location	Data Year	Source	Estimated Population
CA/NV	2004	California/Nevada Sage-grouse Conservation Team (2004, p. 26)	88,000
CO	2008	2007 CO Conservation plan, based on adjusted male lek counts (count + 1.6 multiplier, sex ratio females:males) (Colorado Greater Sage-grouse Steering Committee 2008, p. 56)	22,646
ID	2007	Calculated based on assumption of 5% of population is harvested (Service, unpublished data)	98,700
MT	2007	Calculated based on assumption of 5% of population is harvested (Service, unpublished data)	62,320
ND	2007	2008 lek counts adjusted (assumes 75% of males counted at lek, & sex ratio of 2:1) (A. Robinson, NDGFD, pers. comm., 2008)	308
OR	2003	2003 Oregon Conservation Plan Estimate (Hagen 2005, p. 27)	40,000
SD	2007	South Dakota Game and Fish web page (last updated in 2007)	1,500
UT	2002	Utah Division of Wildlife Resources (2002, p. 13)	12,999
WA	2003	Washington Division of Fish and Wildlife (Stinson *et al.* 2004, p. 21)	1,059
WY	2007	Calculated based on assumption of 5% of population is harvested (Service, unpublished data)	207,560
Canada	2006	Government of Canada 2010	450

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, August 24, 2000). 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, p. 2) estimated a rangewide minimum of 88,816 males counted on leks in 2007, the last year data were formally collated and reported. 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. 6-71) 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, p. 67) also demonstrated a pattern of 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).

In 2008, WAFWA conducted new population trend analyses that incorporated an additional 4 years of data beyond the Connelly *et al.* 2004 analysis (WAFWA 2008, entire). 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 (average 3.1 percent annually; WAFWA 2008, p. 12). WAFWA attributed the decline to the reduction in number of active leks (WAFWA 2008, p. 51). 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. While the average annual rate of decline has lessened since 1985 (3.1 to 1.4 percent), population declines continue and populations are now at much lower levels than in the early 1980's. Therefore, these continuing negative trends at such low relative numbers are concerning regarding long-term population persistence. Similarly, short-term increases or stable trends, while on the surface seem encouraging, do not indicate that populations are recovering but may instead be a function of losing leks and not increases in numbers (WAFWA 2008, p.51). Population stability may also be compromised if cycles in sage-grouse populations (Schroeder *et al.* 1999, p. 15; Connelly *et al.* 2004, p.6-71) are lost, which current analyses suggest, minimizing the opportunities for population recovery if habitat were available (Garton 2009, pers. comm.).

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 indicated 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 (Connelly *et al.* 2004, p. 6-71; Stiver *et al.* 2006, p. 1-7). 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 proportions of inactive leks (Garton *et al.* in press, p. 65), which may imply that male numbers on the remaining leks are increasing as birds relocate. 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 trend may not actually reflect the population status.

TABLE 5—LONG-TERM POPULATION TREND ESTIMATES FOR GREATER SAGE-GROUSE MANAGEMENT ZONES.

MZ	States and Provinces Included	Population Trend Estimates 1965-2003* (Connelly *et al.* 2004)	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)
I	MT, WY, ND, SD, SK, AL	Long-term decline	-2.9	-2.9
II	ID, WY, UT, CO	Long-term decline	-2.7	-3.5
III	UT, NV, CA	Long-term decline	-2.2	-10**
IV	ID, UT, NV, OR	Long-term decline	-3.8	-4**
V	OR, CA, NV	Change statistically undetectable	-3.3	-2**
VI	WA	Long-term decline	-5.1	-6.5
VII	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 press) showed a larger rate of decline. This difference may be due to the shortened time period (12 versus 42 years) Garton *et al.* (in press) 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 press) analyses also spanned only 12 years, suggesting that declines in 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 press) results are similar to WAFWA for the same area.

The difference in the annual rate of change between Connelly *et al.* (2004) and WAFWA (2008) as compared to Garton *et al.* (in press) for MZ VII is substantial (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.

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 MANAGEMENT ZONE (FROM GARTON *et al.* IN PRESS, PP. 22-64).

MZ	Min Population Est in 2007 (# of males)	Percent Change in # of Males per Lek (1965–2007)	Percent Change of Active Leks (1965–2007)
I	14,814	-17	-22
II	42,429	-30	-7
III	6,851	-24	-16 ***
IV	15,761	-54	-11***
V	6,925	-17**	-21**
VI	315	-76	-57
VII	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.

In summary, since neither presettlement nor current numbers of sage-grouse are accurately known, the actual rate and magnitude of decline since presettlement 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, p.71).

Connectivity

Greater sage-grouse are a landscape-scale species, requiring large expanses of sagebrush to meet all seasonal habitat requirements. The loss of habitat from fragmentation and conversion decreases the connectivity between seasonal habitats potentially resulting in the loss of the population (Doherty *et al.* 2008, p. 194). Loss of connectivity also can increase population isolation (Knick and Hanser in press, p. 4, and references therein) and, therefore, the probability of loss of genetic diversity and extirpation from stochastic events.

Analyses of connectivity of greater sage-grouse across the sagebrush landscape were conducted by Knick and Hanser (in press, entire). Knick and Hanser (in press, p. 29) found that the average movement between population centers (leks) of sage-grouse rangewide was 16.6 km (10.3 mi), with a standard deviation of 7.3 km (4.5 mi). Leks within 18 km (11.2 mi) of each other had common features when compared to leks further than this distance (Knick and Hanser in press, p. 17). Therefore, they used a distance of 18 km (11.2 mi) between leks to assess connectivity (movement between populations), but cautioned that this distance may not accurately reflect genetic flow, or lack thereof, between populations (Knick and Hanser in press, p. 28). Genetic evidence suggests that exchange of individual birds has not been restricted, although there is a gradation of allelic frequencies across the species' range (Oyler-McCance and Quinn, in press, p. 14). This result suggests that widespread movements (e.g., across several States) are not occurring.

Population linkages primarily occurred within MZs, and connectivity between MZs was limited, with the exception of MZs I (Great Plains) and II (Wyoming Basin). Within MZs, the Wyoming Basin (MZ II) had the highest levels of connectivity, followed by MZ IV (Snake River Plain) and MZ I (Great Plains) (Knick and Hanser in press, p. 18). The MZ VI (Columbia Basin) and VII (Colorado Plateau) had the least internal connectivity, suggesting there was limited dispersal between leks and an existing relatively high degree of isolation (Knick and Hanser in press, p. 18). Areas along the edges of the sage-grouse range (e.g., Columbia Basin, Bi-State area) are currently isolated from other sage-grouse populations (Knick and Hanser in press, p. 28).

Connectivity between sage-grouse MZs and the populations within them declined across all three analysis periods examined: 1965–1974, 1980–1989, and 1998–2007. The decline in connectivity was due to the loss of leks and reduced population size (Knick and Hanser in press, p. 29). Historic leks with low connectivity also were lost

(Knick and Hanser in press, p. 20), suggesting that current isolation of leks by distance (including habitat fragmentation) will likely result in their future loss (Knick and Hanser in press, p. 28). Small decreases in lek connectivity resulted in large increases in probability of lek abandonment (Knick and Hanser, in press, p. 29). Therefore, maintaining habitat connectivity and sage-grouse population numbers are essential for sage-grouse persistence.

Sagebrush distribution was the most important factor in maintaining connectivity (Knick and Hanser in press, p. 32). This result suggests that any activities that remove or fragment sagebrush habitats will contribute to loss of connectivity and population isolation. This conclusion is consistent with research from both Aldridge *et al.* (2008, p. 988) and Wisdom *et al.* (in press, p. 13), which independently identified the proximity of sagebrush patches and area in sagebrush cover as the best predictors for sage-grouse presence.

Summary of Information Pertaining to the Five Factors

Section 4 of the Act (16 U.S.C. 1533) and implementing regulations (50 CFR part 424) set forth procedures for adding species to the Federal Lists of Endangered and Threatened Wildlife and Plants. In making this finding, we summarize below information regarding the status and threats to the greater sage-grouse in relation to the five factors provided in section 4(a)(1) of the Act. Under section (4) of the Act, we may determine a species to be endangered or threatened on the basis of any of the following five factors: (A) Present or threatened destruction, modification, or curtailment of habitat or range; (B) overutilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) inadequacy of existing regulatory mechanisms; or (E) other natural or manmade factors affecting its continued existence. Our evaluation of threats is based on information provided in the petition, available in our files, and other sources considered to be the best scientific and commercial information available, including published and unpublished studies and reports.

Differences in ecological conditions within each MZ affect the susceptibility of these areas to the various threats facing sagebrush ecosystems and its potential for restoration. For example, *Centaurea diffusa* (diffuse knapweed), an exotic annual weed, is most competitive within shrub-grassland communities where antelope bitterbrush is dominant (MZ VI), and *Bromus tectorum* (cheatgrass) is more dominant in areas with minimal summer precipitation (MZs III and V) (Miller *et al.*, in press, pp. 20-21). Therefore, we stratify our analyses by these MZs because they represent zones within which ecological variation is less than what it would be across the range of the species. This approach allows us to better assess the impact and benefits of actions occurring across the species' range and in turn more accurately assess the status of the species.

Factor A. The Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range.

Several factors are contributing to the destruction, modification, or curtailment of the greater sage-grouse's habitat or range. Several recent studies have demonstrated that sagebrush area is one of the best landscape predictors of greater sage-grouse persistence (Aldridge *et al.* 2008, p. 987; Doherty *et al.* 2008, p. 191; Wisdom *et al.*, in press, p. 17). Sagebrush habitats are becoming increasingly degraded and fragmented due to the impacts of multiple threats, including direct conversion, urbanization, infrastructure such as roads and powerlines built in support of several activities, wildfire and the change in wildfire frequency, incursion of invasive plants, grazing, and nonrenewable and renewable energy development. Many of these threat factors are exacerbated by the effects of climate change, which may influence long-term habitat trends.

Habitat Conversion for Agriculture

Sagebrush is estimated to have covered roughly 120 million ha (296 million ac; Schroeder *et al.* 2004, p. 365) in western North America, but large portions of that area have been cultivated for the production of agricultural crops (e.g., potatoes, wheat; Schroeder *et al.* 1999, p. 16; 2000, p. 11). Western rangelands were converted to agricultural lands on a large scale beginning with the series of Homestead Acts in the 1800s (Braun 1998, p. 142, Hays *et al.* 1998, p. 26; Knick in press, p. 4; Knick *et al.* in press, p. 11), especially where suitable deep soil terrain and water were available (Rogers 1964, p.13, Schroeder and Vander Haegen, 2009, in press, p. 3). Connelly *et al.* (2004, p. 5-55) estimated that 24.9 million ha (61.5 million ac) within the sage-grouse conservation area (SGCA) used for their assessment area (historic range of Gunnison and greater sage-grouse plus a 50-km (31-mi) buffer) for sage-grouse is now comprised of agricultural lands, although some areas within the species' range are not sagebrush habitat, and the SGCA is larger than the sage-grouse current distribution. An estimated 10 percent of sagebrush steppe that existed prior to EuroAmerican settlement has been converted to agriculture (Knick *et al.* in press, p. 13). The remaining 90 percent is largely unsuited for agriculture because irrigation is not considered to be feasible, topography and soils are limiting, or temperatures are too extreme for many crops (West 1996 cited in Knick *et al.* in press, p. 13).

Habitat conversion results in loss of habitat available for sage-grouse use. The actual effect of this loss depends on the amount of sagebrush lost, the type of seasonal habitat affected, and the arrangement of habitat lost (large blocks or small patches) (Knick *et al.* in press, p. 15). Direct impacts to sage-grouse depend on the timing of conversion (e.g., loss of nests, eggs). Indirect effects of agricultural activities adjoining sagebrush habitats include increased predation with a resulting reduced sage-grouse nest success (Connelly *et al.* 2004, p. 7-23), increased human presence, and habitat fragmentation.

To estimate the area possibly influenced by these indirect effects, Knick *et al.* (in press, p. 13) applied a "high effective buffer" out to 6.9 km (4.3 mi) from agricultural lands, based on foraging distances of synathropic (ecologically associated with humans) predators (e.g. red foxes (*Vulpes vulpes*) and ravens (*Corvus corax*)). Given the distribution of agricultural activities across the sagebrush range, nearly three quarters of all sagebrush within range of sage-grouse has been influenced by agricultural activities (falls within the high effective buffer) (Knick *et al.* in press, p. 13). This influence includes foraging distances for synathropic predators (Leu *et al.* 2008, p. 1120; Knick *et al.* in press, p. 13), and associated features such as irrigation ditches. Extensive conversion of sagebrush to agriculture within a landscape has decreased abundance of sage-grouse in many portions of their range (Knick and Hanser in press, p. 30, and references therein).

Soil associations have resulted in disproportionate levels of habitat conversion across different sagebrush communities. For example, *Artemisia tridentata* ssp. *vaseyana* is found at lower elevations, in soils that retain moisture 2 to 4 weeks longer than in well-drained, but dry and higher elevation soils typical of *A. t.* ssp. *wyomingensis* locations. Therefore, sagebrush communities dominated by basin big sagebrush (*A. t.* ssp. *tridentata*) have been converted to agriculture more extensively than have communities on poorer soil sites (Winward 2004, p. 29) (also see discussion below).

Large losses of sagebrush shrub-steppe habitats due to agricultural conversion have occurred in some areas within the range of the greater sage-grouse. This loss has been especially apparent in the Columbia Basin of the Northwest (MZ VI), the Snake River Plain of Idaho (MZ IV) (Schroeder *et al.* 2004, p. 370), and the Great Plains (MZ I) (Knick *et al.* in press, p. 13). Hironaka *et al.* (1983, p. 27) estimated that 99 percent of basin big sagebrush habitat in the Snake River Plain has been converted to cropland. Between 1975 and 1992 alone, 29,762 ha (73,543 ac) of sagebrush habitat were converted to cropland on the Upper Snake River Plain, a 74-percent increase in cropland (Leonard *et al.* 2000, p. 268). The loss of this primarily winter sage-grouse habitat is significantly related to subsequent sage-grouse declines (Leonard *et al.* 2000, p. 268).

Prior to EuroAmerican settlement in the 19th century, Washington had an estimated 42 million ha (103.8 million ac) of shrub-steppe (Connelly *et al.* 2004, p. 7-22). Approximately 60 percent of the original shrub-steppe habitat in Washington has been converted to primarily agricultural uses (Dobler 1994, p. 2). Deep soils supporting shrub-steppe communities in Washington within sage-grouse range continue to be converted to agricultural uses (Vander Haegen *et al.* 2000, p. 1156), resulting in habitat loss. Agriculture is the dominant land cover within sagebrush areas of Washington (42 percent) and Idaho (19 percent) (Miller *et al.*, in press, p. 18). In north-central Oregon (MZ V), approximately 2.6 million ha (6.4 million ac) of habitat were converted for agricultural purposes, essentially eliminating sage-grouse from this area (Willis *et al.* 1993, p. 35). More broadly, across the interior Columbia Basin of southern Idaho, northern Utah, northern Nevada, eastern Oregon (MZ IV), and Washington, approximately 6 million ha (14.8 million ac) of shrub-steppe habitat has been converted to agricultural crops (Altman and Holmes 2000, p. 10).

Braun concluded that development of irrigation projects to support agricultural production in areas where soils were sufficient to support agriculture, in some cases conjointly with hydroelectric dam construction, has resulted in additional sage-grouse habitat loss (Braun 1998, p. 142). The reservoirs formed by these projects impacted native shrub-steppe habitat adjacent to the rivers in addition to supporting the irrigation and direct conversion of shrub-steppe lands to agriculture. The projects precipitated conversion of large expanses of upland shrub-steppe habitat in the Columbia Basin for irrigated agriculture (65 FR 51578). The creation of these reservoirs also inundated hundreds of kilometers of riparian habitats used by sage-grouse broods (Braun 1998, p. 144). However, other small and isolated reclamation projects (4,000 to 8,000 ha (10,000 to 20,000 ac)) were responsible for three-fold localized increases in sage-grouse populations (Patterson 1952, pp. 266-274) by providing water in a semiarid environment, which provided additional insect and forb food resources (e.g., Eden Reclamation Project in Wyoming). Benefits of providing water through agricultural activities may now be negated due to the threat of West Nile virus (WNv) (Walker *et al.* 2004, p. 4).

Five percent of the areas occupied by Great Basin sagebrush have been converted to agriculture, urban or industrial areas (MZs III and IV) (Miller *et al.* in press, p. 18). Five percent has also been converted in the wheatgrass-needlegrass-shrubsteppe (MZ II, primarily in north-central Wyoming) (Miller *et al.*, in press, p. 18). In sagebrush-steppe habitats, 14 percent of sagebrush habitats had been converted to agriculture, urban or industrial activities (MZs II, IV, V, and VI) (Miller *et al.*, in press, pp. 17-18). Nineteen percent of the Great Plains area (MZ I) has been converted to agriculture (Knick *et al.* in press, p. 13). Conversions for sagebrush habitat types by State are detailed in Table 7.

TABLE 7—CURRENT SAGEBRUSH-STEPPE HABITAT AND AGRICULTURAL LANDS WITHIN GREAT BASIN SAGEBRUSH (AS DERIVED FROM LANDFIRE 2006 VEGETATION COVERAGE) (FROM MILLER *et al.* IN PRESS, PP. 17-18).

State	Percent Sagebrush	Percent Agriculture
Washington	23.7	42.4
Montana	56.2*	7.5*
Wyoming	66.0*	3.4*
Idaho	55.0	18.6
Oregon	64.5	8.6
Nevada	58.7	1.3
Utah	37.6	9.7
California	49.8	8.0
Colorado	40.6*	11.8*
TOTAL	55.4	10.0

*Analyses did not include sagebrush lands in the eastern portions of Colorado, Montana, and Wyoming.

Aldridge *et al.* (2008, pp. 990-991) reported that sage-grouse extirpations were more likely to occur in areas where cultivated crops exceeded 25 percent. Their results supported the conclusions of others (e.g., Schroeder 1997, p. 934; Braun 1998, p. 142; Aldridge and Brigham 2003, p. 30) that extensive cultivation and fragmentation of native habitats have been associated with sage-grouse population declines. Wisdom *et al.* (in press, p. 4) identified environmental factors associated with the regional extirpation of sage-grouse. Areas still occupied by sage-grouse have three times less area in agriculture and a mean human density 26 times lower than extirpated areas (Wisdom *et al.*, in press, p. 13). While sage-grouse may forage on agricultural crops (see discussion below), they avoid landscapes dominated by agriculture (Aldridge *et al.* 2008, p. 991). Conversions to croplands in southern Idaho have resulted in isolation of sagebrush-dominated landscapes into less productive regions north and south of the Snake River Plain (Knick *et al.* 2003, p. 618). Therefore, formerly continuous populations in this area are now disconnected (Knick and Hanser in press, p. 52).

Sagebrush habitat continues to be converted for both dryland and irrigated crop production (Montana Farm Services Agency (FSA) in litt. 2009; Braun 1998, p. 142; 65 FR 51578, August 24, 2000). The increasing value of wheat and corn crops has driven new conversions in recent years. For example, the acres of sagebrush converted to tilled agriculture in Montana increased annually from 2005 to 2009, with approximately 10,259 ha (25,351 ac) converted, primarily in the eastern two-thirds of the State (MZ I) (Montana FSA in litt. 2009). In addition, in 2008, a single conversion in central Montana totaled between 3,345 and 10,000 ha (10,000 and 30,000 ac) (MZ I) (Hanebury 2008a, pers. comm.). Other large conversions occurred in the same part of Montana in 2008, although these were unquantified (Hanebury 2008b, pers. comm.). We were unable to gather any further information on crop conversions of sagebrush habitats as there are no systematic efforts to collect State or local data on conversion rates in the majority of the greater sage-grouse range (GAO 2007, p. 16).

In addition to crop conversion for traditional crops, recent interest in the development of crops for use as biofuels could potentially impact sage-grouse. For example, the 2008 Farm Bill authorized the Biomass Crop Assistance Program (BCAP), which provides financial incentives to agricultural producers that establish and produce eligible crops for conversion to bioenergy products (U.S. Department of Agriculture (USDA) 2009b, p. 1). Further loss of sagebrush habitats due to BCAP will negatively impact sage-grouse populations. However, currently we have no way of predicting the magnitude of BCAP impacts to sage-grouse (see discussion under Factor D, below).

Although conversion of shrub-steppe habitat to agricultural crops impacts sage-grouse through the loss of sagebrush on a broad scale, some studies report the use of agricultural crops (e.g., alfalfa) by sage-grouse. When alfalfa fields and other croplands are adjacent to extant sagebrush habitat, sage-grouse have been observed feeding in these fields, especially during brood-rearing (Patterson 1952, p. 203; Rogers 1964, p. 53; Wallestad 1971, p. 134; Connelly *et al.* 1988, p.120; Fischer *et al.* 1997, p. 89). Connelly *et al.* (1988, p. 120) reported seasonal movements of sage-grouse to agricultural crops as sagebrush habitats desiccated during the summer. However, use of irrigated crops may not be beneficial to greater sage-grouse if it increases exposure to pesticides (Knick *et al.* in press, p. 16) and WNv (Walker *et al.* 2004, p. 4).

Some conversion of cropland to sagebrush has occurred in former sage-grouse habitats through the USDA's voluntary Conservation Reserve Program (CRP) which pays landowners a rental fee to plant permanent vegetation on portions of their lands, taking them out of agricultural production. In Washington State (Columbia Basin, MZ VI), sage-grouse have declined precipitously in the Columbia Basin largely due to conversion of sagebrush habitats to cropland (Schroeder and Vander Haegen, in press, p. 4). Approximately 599,314 ha (1,480,937 ac) of converted farmland had been enrolled in the CRP, almost all of which was historically shrub-steppe (Schroeder and Vander Haegen in press, p. 5). Schroeder and Vander Haegen (in press, p. 20) found that CRP lands that have been out of production long enough to allow re-establishment of sagebrush and was juxtaposed to a relatively intact shrub-steppe landscape was most beneficial to sage-grouse. There appears to be some correlation with sage-grouse use of CRP and a slight increase in population size in north-central Washington (Schroeder and Vander Haegen in press, p. 21). Schroeder and Vander Haegen (in press, p. 21) concluded that the loss of CRP due to expiration of the program or incentives to produce biofuels would likely severely impact populations in the Columbia Basin.

Although estimates of the numbers of acres enrolled rangewide in CRP (and the number of acres soon to expire from CRP) are available, the extent of cropland conversion to habitats beneficial to sage-grouse (i.e., CRP lands planted with native grasses, forbs, and shrubs) is not known for any other area barring the Columbia Basin. Thus, outside this area, we cannot judge the overall impact of CRP land to sage-grouse persistence.

Direct habitat loss and conversion also occurs via numerous other landscape uses, including urbanization, livestock forage production, road building, and oil pads. These activities are described in greater detail below. Although we were unable to obtain an estimate of the total amount of sagebrush habitats that have been lost due to these activities, they have resulted in habitat fragmentation, as well as habitat loss.

Urbanization

Low densities of indigenous peoples have been present for more than 12,000 years in the historical range of sage-grouse. By 1900, less than 1 person per km² (1 person per 0.4 mi²) resided in 51 percent of the 325 counties within the SGCA, and densities greater than 10 persons per km² (10 persons per 0.4 mi²) occurred in 4 percent of the counties (Connelly *et al.* 2004, p. 7-24). By 2000, counties with less than 1 person per km² (1 person per 0.4 mi²) occurred in 31 percent of the 325 counties and densities greater than 10 persons per km² (10 persons per 0.4 mi²) occurred in 22 percent of the counties (Connelly *et al.* 2004, p. 7-25). Today, the Columbia Basin (MZ VI) has the highest density of humans while the Great Plains (MZ I) and Wyoming Basin (MZ II) have the lowest (Knick *et al.* in press, p. 19). Growth in the Great Plains (MZ I) continues to be slower than other areas. For example, population densities have increased since 1990 by 7 percent in the Great Plains (MZ I), by 19 percent in the Wyoming Basin (MZ II), and by 31 percent in the Colorado Plateau (MZ VII) (Knick *et al.* in press, p. 19).

The dominant urban areas in the sage-grouse range are located in the Bear River Valley of Utah, the portion of Bonneville Basin southeast of the Great Salt Lake, the Snake River Valley of southern Idaho, and the Columbia River Valley of Washington (Rand McNally Road Atlas 2003; Connelly *et al.* 2004, p. 7-25). Overall, approximately 1 percent of the amount of potential sagebrush (estimated historic range) is now covered by lands classified as urban (Miller *et al.*, in press, p. 18).

Knick *et al* (in press, p. 107) examined the influence of urbanization on greater sage-grouse MZs by adding a 6.9-km (4.3-mi) buffer (an estimate of the foraging distances of mammalian and corvid predators of sage-grouse) to the total area of urban land use. Based the estimates using this approach, the Columbia Basin (MZ VI) was influenced the most by urbanization with 48.4 percent of the sagebrush area affected. The Northern Great Basin (MZ V) was influenced least with 12.5 percent affected. Wyoming Basin (MZ II), which has the majority of sage-grouse in the range, was at 18.4 percent affected.

Since 1950, the western U.S. population growth rate has exceeded the national average (Leu and Hanser in press, p. 4). This growth has led to increases in urban, suburban, and rural development. Rural development has increased especially rapidly in recent decades. For example, the amount of uninhabited area in the Great Basin ecoregion has decreased from 90,000 km² (34,749 mi²) in 1990 to less than 12,000 km² (4,633 mi²) in 2004 (Knick *et al.* in press, p. 20). Urbanization has directly eliminated some sage-grouse habitat (Braun 1998, p. 145). Interrelated effects from urbanization include construction of associated infrastructure (e.g., roads, powerlines, and pipelines) and predation threats from the introduction of domestic pets and increases in predators subsidized by human activities. In particular, municipal solid waste landfills (landfills) and roads have been shown to contribute to increases in common raven (*Corvus corax*) populations (Knight *et al.* 1993 p. 470; Restani *et al.* 2001, p. 403; Webb *et al.* 2004, p. 523). Ravens are known to be an important predator on sage-grouse nests and have been considered a restraint on sage-grouse population growth in some locations (Batterson and Morse 1948, p. 14; Autenrieth 1981, p. 45; Coates 2007, p. 26). Landfills (and roads) are found in every State within the greater sage-grouse range and a number of these are located within or adjacent to sage-grouse habitat.

Recent changes in demographic and economic trends have resulted in greater than 60 percent of the Rocky Mountain West's counties experiencing rural sprawl where rural areas are outpacing urban areas in growth (Theobald 2003, p. 3). In some Colorado counties, up to 50 percent of sage-grouse habitat is under rural subdivision development, and an estimated 3 to 5 percent of all sage-grouse historical habitat in Colorado has already been converted into urban areas (Braun 1998, p. 145). We are unaware of similar estimates for other States within the range of the greater sage-grouse and, therefore, cannot determine the effects of this factor on a rangewide basis. Rural development has increasingly taken the form of low-density (approximately 6 to 25 homes per km² (6 to 25 homes per 0.4 mi²)) home development or exurban growth (Hansen *et al.* 2005, p. 1894). Between 1990 and 2000, 120,000 km² (46,332 mi²) of land were developed at exurban densities nationally (Theobald 2001, p. 553). However, this value includes development nationwide, and we are unable to report values specifically for sagebrush habitats. However, within the Great Basin (including California, Idaho, Nevada, and Utah), human populations have increased 69 percent and uninhabited areas declined by 86 percent between 1990 and 2004 (Leu and Hanser in press, p. 19). Similar to higher density urbanization, exurban development has the potential to negatively affect sage-grouse populations through fragmentation or other indirect habitat loss, increased infrastructure, and increased predation.

In modeling sage-grouse persistence, Aldridge *et al.* (2008, pp. 991-992) found that the density of humans in 1950 was the best predictor of sage-grouse extirpation among the human population metrics considered (including increasing human population growth). Sage-grouse extirpation was more likely in areas having a moderate human population density of at least 4 people per km² (4 people per 0.4 mi²). Increasing human populations were not a good predictor of sage-grouse persistence, most likely because much of the growth occurred in areas that are already no longer suitable for sage-grouse. Aldridge *et al.* (2008, p. 990) also reported that, based on their models, sage-grouse require a minimum of 25 percent sagebrush for persistence in an area. A high probability of persistence required 65 percent sagebrush or more. This result is similar to the results by Wisdom *et al.* (in press, p. 18) who reported that human density was 26 times greater in extirpated sage-grouse areas than in currently occupied range. Therefore, human population growth that results in exurban development in sagebrush habitats will reduce the likelihood of sage-grouse persistence in the area. Given the current demographic and economic trends in the Rocky Mountain West, we believe that rates of urbanization will continue increasing, resulting in further habitat fragmentation and degradation and decreasing the probability of long-term sage-grouse persistence.

Infrastructure in Sagebrush Habitats

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

Sagebrush communities exhibit a high degree of variation in their resistance and resilience to change, beyond natural variation. Resistance (the ability to withstand disturbing forces without changing) and resilience (the ability to recover once altered) generally increase with increasing moisture and decreasing temperatures, and also can be linked to soil characteristics (Connelly *et al.* 2004, p. 13-6). However, most extant sagebrush habitat has been altered since European immigrant settlement of the West (Baker *et al.* 1976, p. 168; Braun 1998, p. 140; Knick *et al.* 2003, p. 612; Connelly *et al.* 2004, p. 13-6), and sagebrush habitat continues to be fragmented and lost (Knick *et al.* 2003, p. 614) through the factors described below. The cumulative effects of habitat fragmentation have not been quantified over the range of sagebrush and most fragmentation cannot be attributed to specific land uses (Knick *et al.* 2003, p. 616). However, in large-scale analysis of the collective effect of anthropogenic features (or the "human footprint") in the western United States, Leu *et al.* (2008, p. 1130) found that 13 percent of the area was affected in some way by anthropogenic features (i.e., fragmentation). Areas with the lowest "human footprint" (i.e., no to slight development or use) experienced above-average human population growth between 1990 and 2000. There is significant evidence these areas will experience increasing habitat fragmentation in the future (Leu *et al.* 2008, p. 1133). Although the area covered by these estimates includes all western states, we believe the general points regarding effects of anthropogenic features apply to sage-grouse habitat.

Fragmentation of sagebrush habitats has been cited as a primary cause of the decline of sage-grouse populations because the species requires large expanses of contiguous sagebrush (Patterson 1952, pp. 192-193; Connelly and Braun 1997, p. 4; Braun 1998, p. 140; Johnson and Braun 1999, p. 78; Connelly *et al.* 2000a, p. 975; Miller and Eddleman 2000, p. 1; Schroeder and Baydack 2001, p. 29; Johnsgard 2002, p. 108; Aldridge and Brigham 2003, p. 25; Beck *et al.* 2003, p. 203; Pedersen *et al.* 2003, pp. 23-24; Connelly *et al.* 2004, p. 4-15; Schroeder *et al.* 2004, p. 368; Leu *et al.* in press, p. 19). The negative effects of habitat fragmentation have been well documented in numerous bird species, including some shrub-steppe obligates (Knick and Rotenberry 1995, pp. 1068-1069). However, prior to 2005, detailed data to assess how fragmentation influences specific greater sage-grouse life-history parameters such as productivity, density, and home range were not available. More recently, several studies have documented negative effects of fragmentation as a result of oil and gas development and its associated infrastructure (see discussion of Energy Development below) on lek persistence, lek attendance, winter habitat use, recruitment, yearling annual survival rate, and female nest site choice (Holloran 2005, p. 49; Aldridge and Boyce 2007, pp. 517-523; Walker *et al.* 2007a, pp. 2651-2652; Doherty *et al.* 2008, p. 194). Wisdom *et al.* (in press, p. 18) reported that a variety of human developments, including roads, energy development, and other factors that contribute to habitat fragmentation have contributed to or been associated with sage-grouse extirpation. Estimating the impact of habitat fragmentation on sage-grouse is complicated by time lags in response to habitat changes (Garton *et al.*, in press, p. 71), particularly since these long-lived birds will continue to return to altered breeding areas (leks, nesting areas, and early brood-rearing areas) due to strong site fidelity despite nesting or productivity failures (Wiens and Rotenberry 1985, p. 666).

Powerlines

Power grids were first constructed in the United States in the late 1800s. The public demand for electricity has grown as human population and industrial activities have expanded (Manville 2002, p. 5), resulting in more than 804,500 km (500,000 mi) of transmission lines (lines carrying greater than 115,000 volts (115 kilovolts (kV)) by 2002 within the United States (Manville 2002, p. 4). A similar estimate is not available for distribution lines (lines carrying less than 69,000volts (69kV)), and we are not aware of data for Canada. Within the SGCA, Knick *et al.* (*in press*, p. 21) showed that powerlines cover a minimum of 1,089km² (420.5 mi).

Due to the potential spread of invasive species and predators as a result of powerline construction the impact from the powerline is greater than the actual footprint. Knick *et al.* (in press, p. 111) estimated these impacts may influence up to 39 percent of all sagebrush in the SGCA. Powerlines can directly affect greater sage-grouse by posing a collision and electrocution hazard (Braun 1998, pp. 145-146; Connelly *et al.* 2000a, p. 974), and can have indirect effects by decreasing lek recruitment (Braun *et al.* 2002, p. 10), increasing predation (Connelly *et al.* 2004, p. 13-12), fragmenting habitat (Braun 1998, p. 146), and facilitating the invasion of exotic annual plants (Knick *et al.* 2003, p. 612; Connelly *et al.* 2004, p. 7-25). In 1939, three adult sage-grouse died as a result of colliding with a telegraph line in Utah (Borell 1939, p. 85). Both Braun (1998, p. 145) and Connelly *et al.* (2000a, p. 974) report that sage-grouse collisions with powerlines occur, although no specific instances were presented. There was also an unpublished observation reported by Aldridge and Brigham (2003, p. 31). In 2009, two sage-grouse died from electrocution after colliding with a powerline in the Mono Basin of California (Gardner 2009, pers. comm.). We were unable to find any other documentation of other collisions or electrocution of sage-grouse resulting from powerlines.

In areas where the vegetation is low and the terrain relatively flat, power poles provide an attractive hunting and roosting perch, as well as nesting stratum for many species of raptors and corvids (Steenhof *et al.* 1993, p. 27; Connelly *et al.* 2000a, p. 974; Manville 2002, p. 7; Vander Haegen *et al.* 2002, p. 503). Power poles increase a raptor's range of vision, allow for greater speed during attacks on prey, and serve as territorial markers (Steenhof *et al.* 1993, p. 275; Manville 2002, p. 7). Raptors may actively seek out power poles where natural perches are limited. For example, within 1 year of construction of a 596-km (372.5-mi) transmission line in southern Idaho and Oregon, raptors and common ravens began nesting on the supporting poles (Steenhof *et al.* 1993, p. 275). Within 10 years of construction, 133 pairs of raptors and ravens were nesting along this stretch (Steenhof *et al.* 1993, p. 275). Raven counts have increased by approximately 200 percent along the Falcon-Gondor transmission line corridor in Nevada within 5 years of construction (Atamian *et al.* 2007, p. 2). The increased abundance of raptors and corvids within occupied sage-grouse habitats can result in increased predation. Ellis (1985, p. 10) reported that golden eagle (*Aquila chryrsaetos*) predation on sage-grouse on leks increased from 26 to 73 percent of the total predation after completion of a transmission line within 200 meters (m) (220 yards (yd)) of an active sage-grouse lek in northeastern Utah. The lek was eventually abandoned, and Ellis (1985, p. 10) concluded that the presence of the powerline resulted in changes in sage-grouse dispersal patterns and caused fragmentation of the habitat.

Leks within 0.4 km (0.25 mi) of new powerlines constructed for coalbed methane development in the Powder River Basin of Wyoming had significantly lower growth rates, as measured by recruitment of new males onto the lek, compared to leks further from these lines, which were presumed to be the result of increased raptor predation (Braun *et al.* 2002, p. 10). Within the SGCA, Connelly *et al.* (2004, p. 7-26) estimated that the area potentially influenced by additional perches for corvids and raptors provided by powerlines, assuming a 5- to 6.9-km (3.1- to 4.3-mi) radius buffer around the perches based on the average foraging distance of these predators, was 672,644 to 837,390 km² (259,641 to 323,317 mi²), or 32 to 40 percent of the SGCA. The actual impact on the area would depend on corvid and raptor densities within the area, the amount of cover to reduce predation risk at sage-grouse nests, and other factors (see discussion in Factor C, below).

The presence of a powerline may fragment sage-grouse habitats even if raptors are not present. Braun (1998, p. 146) found that use of otherwise suitable habitat by sage-grouse near powerlines increased as distance from the powerline increased for up to 600 m (660 yd) and, based on that unpublished data, reported that the presence of powerlines may limit sage-grouse use within 1 km (0.6 mi) in otherwise suitable habitat. Similar results were recorded for other grouse species. Pruett *et al.* (2009, p. 6) found that lesser and greater prairie-chickens (*Tympanuchus pallidicinctus* and *T. cupido*, respectively) avoided otherwise suitable habitat near powerlines. Additionally, both species also crossed powerlines less often than nearby roads, which suggests that powerlines are a particularly strong barrier to movement (Pruett *et al.* 2009, p. 6).

Sage-grouse also may avoid powerlines as a result of the electromagnetic fields (Wisdom *et al.* in press, p. 19). Electromagnetic fields have been demonstrated to alter the behavior, physiology, endocrine systems, and immune function in birds, with negative consequences on reproduction and development (Fernie and Reynolds 2005, p. 135). Birds are diverse in their sensitivities to electromagnetic field exposures, with domestic chickens being very sensitive. Many raptor species are less affected (Fernie and Reynolds 2005, p. 135).

Linear corridors through sagebrush habitats can facilitate the spread of invasive species, such as *Bromus tectorum* (Gelbard and Belnap 2003, pp. 424-426; Knick *et al.* 2003, p. 620;

Connelly *et al.* 2004, p. 1-2). However, we were unable to find any information regarding the amount of invasive species incursion as a result of powerline construction.

Powerlines are common to nearly every type of anthropogenic habitat use, except perhaps some forms of agricultural development (e.g., livestock grazing) and fire. Although we were unable to find an estimate of all future proposed powerlines within currently occupied sage-grouse habitats, we anticipate that powerlines will continue to increase into the foreseeable future, particularly given the increasing development of energy resources and urban areas. For example, up to 8,579 km (5,311 mi) of new powerlines are predicted for the development of the Powder River Basin coal-bed methane field in northeastern Wyoming (BLM 2003) in addition to the approximately 9,656 km (6,000 mi) already constructed in that area. In November 2009, nine Federal agencies signed a Memorandum of Understanding to expedite the building of new transmission lines on Federal lands. If these lines cross sage-grouse habitats, sage-grouse will likely be negatively affected.

Communication Towers

Within sage-grouse habitats, 9,510 new communication towers have been constructed within recent years (Connelly *et al.* 2004, p. 13-7). While millions of birds are killed annually in the United States through collisions with communication towers and their associated structures (e.g., guy wires, lights) (Shire *et al.* 2000, p. 5; Manville 2002, p. 10), most documented mortalities are of migratory songbirds. We were unable to determine if any sage-grouse mortalities occur as a result of collision with communication towers or their supporting structures, as most towers are not monitored and those that are lie outside the range of the species (Kerlinger 2000, p. 2; Shire *et al.* 2000 p. 19). Cellular towers have the potential to cause sage-grouse mortality via collisions, to influence movements through avoidance of a tall structure (Wisdom *et al.* in press, p. 20), or to provide perches for corvids and raptors (Steenhof *et al.* 1993, p. 275; Connelly *et al.* 2004, p. 13-7).

In a comparison of sage-grouse locations in extirpated areas of their range (as determined by museum species and historical observations) and currently occupied habitats, the distance to cellular towers was nearly twice as far from grouse locations in currently occupied habitats than extirpated areas (Wisdom *et al.* in press, p. 13). The results may have been influenced by location as many cellular towers are close to intensive human development. However, such associations with other indicators of development and cellular towers were low (Wisdom *et al.* in press, p. 20). High levels of electromagnetic radiation within 500 m (547 yd) of all towers have been linked to decreased populations and reproductive performance of some bird and amphibian species (Wisdom *et al.* in press, p. 19, and references therein). We do not know if greater sage-grouse are negatively impacted by electromagnetic radiation, or if their avoidance of these structures is a response to increased predation risk.

Fences

Fences are used to delineate property boundaries and for livestock management (Braun 1998, p. 145; Connelly *et al.* 2000a, p. 974). The effects of fencing on sage-grouse include direct mortality through collisions, creation of predator (raptor) and corvid perch sites, the potential creation of predator corridors along fences (particularly if a road is maintained next to the fence), incursion of exotic species along the fencing corridor, and habitat fragmentation (Call and Maser 1985, p. 22; Braun 1998, p. 145; Connelly *et al.* 2000a, p. 974; Beck *et al.* 2003, p. 211; Knick *et al.* 2003, p. 612; Connelly *et al.* 2004, p. 1-2).

More than 1,000 km (625 mi) of fences were constructed annually in sagebrush habitats from 1996 through 2002, mostly in Montana, Nevada, Oregon, and Wyoming (Connelly *et al.* 2004, p. 7-34). Over 51,000 km (31,690 mi) of fences were constructed on BLM lands supporting sage-grouse populations between 1962 and 1997 (Connelly *et al.* 2000a, p. 974). Sage-grouse frequently fly low and fast across sagebrush flats, and fences can create a collision hazard (Call and Maser 1985, p. 22). Thirty-six carcasses of sage-grouse were found near Randolph, Utah, along a 3.2-km (2-mi) fence within 3 months of its construction (Call and Maser 1985, p. 22). Twenty-one incidents of mortality through fence collisions near Pinedale, Wyoming, were reported in 2003 to the BLM (Connelly *et al.* 2004, p. 13-12). A recent study in Wyoming confirmed 146 sage-grouse fence strike mortalities over a 31–month period along a 7.6-km (4.6-mi) stretch of 3-wire BLM range fence (Christiansen 2009).

Not all fences present the same mortality risk to sage-grouse. Mortality risk appears to be dependent on a combination of factors including design of fencing, landscape topography, and spatial relationship with seasonal habitats (Christiansen 2009, unpublished data). Although the effects of direct strike mortality on populations are not understood, fences are ubiquitous across the landscape. In many parts of the sage-grouse range (primarily Montana, Nevada, Oregon, Wyoming) fences exceed densities of more than 2 km/km^2 (1.2 mi/0.4 mi^2; Knick *et al.* in press, p. 32). Fence collisions continue to be identified as a source of mortality for sage-grouse, and we expect this source of mortality to continue into the foreseeable future (Braun 1998, p. 145; Connelly *et al.* 2000a, p. 974; Oyler-McCance *et al.* 2001, p. 330; Connelly *et al.* 2004, p. 7-3).

Fence posts create perching places for raptors and corvids, which may increase their ability to prey on sage-grouse (Braun 1998, p. 145; Oyler-McCance *et al.* 2001, p. 330; Connelly *et al.* 2004, p. 13-12). We anticipate that the effect on sage-grouse populations through the creation of new raptor perches and predator corridors into sagebrush habitats is similar to that of powerlines discussed previously (Braun 1998, p. 145; Connelly *et al.* 2004, p. 7-3). Fences and their associated roads also facilitate the spread of invasive plant species that replace sagebrush plants upon which sage-grouse depend (Braun 1998, p. 145; Connelly *et al.* 2000a, p. 973; Gelbard and Belnap 2003, p. 421; Connelly *et al.* 2004, p. 7-3). Greater sage-grouse avoidance of habitat adjacent to fences, presumably to minimize the risk of predation, effectively results in habitat fragmentation even if the actual habitat is not removed (Braun 1998, p. 145).

Roads

Interstate highways and major paved roads cover approximately 2,500 km^2 (965 mi^2) or 0.1 percent of the SGCA (Knick *et al.* in press, p. 21). Based on applying a 7-km (4.3-mi) buffer to estimate the potential impact of secondary effects from roads, interstates and highways are estimated to influence 851,044 km^2 (328,590 mi^2) or 41 percent of the SGCA. Additionally, secondary paved roads are heavily distributed throughout most of the SGCA, existing at densities of up to greater than 5 km/km^2 (3.1 mi/mi^2). Taken together, 95 percent of all sage-grouse habitats were within 2.5 km (1.5 mi) of a mapped road, and almost no area of sagebrush was greater the 6.9 km (4.3 mi) from a mapped road (Knick *et al.* in press, p. 21).

Impacts from roads may include direct habitat loss, direct mortality, barriers to migration corridors or seasonal habitats, facilitation of predators and spread of invasive vegetative species, and other indirect influences such as noise (Forman and Alexander 1998, pp. 207-231). Sage-grouse mortality resulting from collisions with vehicles does occur (Patterson 1952, p. 81), but mortalities are typically not monitored or recorded. Therefore, we are unable to determine the importance of this factor on sage-grouse populations. Data regarding how roads affect seasonal habitat availability for individual sage-grouse populations by creating barriers and the ability of greater sage-grouse to reach these areas were not available. Road development within Gunnison sage-grouse (*C. minimus*) habitats impeded movement of local populations between the resultant patches, with grouse road avoidance presumably being a behavioral means to limit exposure to predation (Oyler-McCance *et al.* 2001, p. 330).

Roads can provide corridors for predators to move into previously unoccupied areas. For some mammalian species, dispersal along roads has greatly increased their distribution (Forman and Alexander 1998, p. 212; Forman 2000, p. 33). Corvids also use linear features such as primary and secondary roads as travel routes, expanding their movements into previously unused regions (Knight and Kawashima 1993, p. 268; Connelly *et al.* 2004, p. 12-3). In an analysis of anthropogenic impacts, at least 58 percent of the SGCA had a high or medium estimated presence of corvids (Connelly *et al.* 2004, p. 12-6). Corvids are important sage-grouse nest predators and in a study in Nevada were positively identified via video recorder as responsible for more than 50 percent of nest predations in the study area (Coates 2007, pp. 26-30). Bui (2009, p. 31) documented ravens following roads in oil and gas fields during foraging. Additionally, highway rest areas provide a source of food and perches for corvids and raptors, and facilitate their movements into surrounding areas (Connelly *et al.* 2004, p. 7-25).

The presence of roads increases human access and resulting disturbance effects in remote areas (Forman and Alexander 1998, p. 221; Forman 2000, p. 35; Connelly *et al.* 2004, pp. 7-6 to 7-25). Increases in legal and illegal hunting activities resulting from the use of roads built into sagebrush habitats have been documented (Hornaday 1916, p. 183; Patterson 1952, p. vi). However, the actual current effect of these increased activities on sage-grouse populations has not been determined. Roads also may facilitate access for rangeland habitat treatments, such as disking or mowing (Connelly *et al.* 2004, p. 7-25), resulting in subsequent direct habitat losses. New roads are being constructed to support development activities within the greater sage-grouse extant range. In the Powder River Basin of Wyoming, up to 28,572 km (17,754 mi) of roads to support coalbed methane development are proposed (BLM 2003).

The expansion of road networks contributes to exotic plant invasions via introduced road fill, vehicle transport, and road maintenance activities (Forman and Alexander 1998, p. 210; Forman 2000, p. 32; Gelbard and Belnap 2003, p. 426; Knick *et al.* 2003, p. 619; Connelly *et al.* 2004, p. 7-25). Invasive species are not limited to roadsides, but also encroach into surrounding habitats (Forman and Alexander 1998, p. 210; Forman 2000, p. 33; Gelbard and Belnap 2003, p. 427). In their study of roads on the Colorado Plateau of southern Utah, Gelbard and Belnap (2003, p. 426) found that improving unpaved four-wheel drive roads to paved roads resulted in increased cover of exotic plant species within the interior of adjacent plant communities. This effect was associated with road construction and maintenance activities and vehicle traffic, and not with differences in site characteristics. The incursion of exotic plants into native sagebrush systems can negatively affect greater sage-grouse through habitat losses and conversions (see further discussion in Invasive Plants, below).

Additional indirect effects of roads may result from birds' behavioral avoidance of road areas because of noise, visual disturbance, pollutants, and predators moving along a road. The absence of vegetation in arid and semiarid regions that may buffer these impacts further exacerbates the problem (Suter 1978, p. 6). Male sage-grouse lek attendance was shown to decline within 3 km (1.9 mi) of a methane well or haul road with traffic volume exceeding one vehicle per day (Holloran 2005, p. 40). Male sage-grouse depend on acoustical signals to attract females to leks (Gibson and Bradbury 1985, p. 82; Gratson 1993, p. 692). If noise interferes with mating displays, and thereby female attendance, younger males will not be drawn to the lek and eventually leks will become inactive (Amstrup and Phillips 1977, p. 26; Braun 1986, pp. 229-230).

Dust from roads and exposed roadsides can damage vegetation through interference with photosynthetic activities. The actual amount of potential damage depends on winds, wind direction, the type of surrounding vegetation and topography (Forman and Alexander 1998, p. 217). Chemicals used for road maintenance, particularly in areas with snowy or icy precipitation, can affect the composition of roadside vegetation (Forman and Alexander 1998, p. 219). We were unable to find any data relating these potential effects directly to impacts on sage-grouse population parameters.

In a study on the Pinedale Anticline in Wyoming, sage-grouse hens that bred on leks within 3 km (1.9 mi) of roads associated with oil and gas development traveled twice as far to nest as did hens bred on leks greater than 3 km (1.9 mi) from roads. Nest initiation rates for hens bred on leks close to roads also were lower (65 versus 89 percent) affecting population recruitment (33 versus 44 percent) (Lyon 2000, p. 33; Lyon and Anderson 2003, pp. 489-490). Lyon and Anderson (2003, p. 490) suggested that roads may be the primary impact of oil and gas development to sage-grouse, due to their persistence and continued use even after drilling and production have ceased. Braun *et al.* (2002, p. 5) suggested that daily vehicular traffic along road networks for oil wells can impact sage-grouse breeding activities based on lek abandonment patterns.

In a study of 804 leks within 100 km (62.5 mi) of Interstate 80 in southern Wyoming and northeastern Utah, Connelly *et al.* (2004, p. 13-12) found that there were no leks within 2 km (1.25 mi) of the interstate and only 9 leks were found between 2 and 4 km (1.25 and 2.5 mi) along this same highway. The number of active leks increased with increasing distance from the interstate. Lek persistence and activity relative to distance from the interstate also were measured. The distance of a lek from the interstate was a significant predictor of lek activity, with leks further from the interstate more likely to be active. An analysis of long-term changes in populations between 1970 and 2003 showed that leks closest (within 7.5 km (4.7 mi)) to the interstate declined at a greater rate than those further away (Connelly *et al.* 2004, p. 13-13). Extirpated sage-grouse range was 60 percent closer to highways (Wisdom *et al.* in press, p. 18). What is not clear from these studies is what specific factor relative to roads (e.g., noise, changes in vegetation, etc.) sage-grouse are responding to. Connelly *et al.* (2004, p. 13-13) caution that they have not included other potential sources of indirect disturbance (e.g., powerlines) in their analyses.

Aldridge *et al.* (2008, p. 992) did not find road density to be an important factor affecting sage-grouse persistence or rangewide patterns in sage-grouse extirpation. However, the authors did not consider the intensity of human use of roads in their modeling efforts. They also indicated that their analyses may have been influenced by inaccuracies in spatial road data sets, particularly for secondary roads (Aldridge *et al.* 2008, p. 992). However, Wisdom *et al.* (in press, p. 18) found that extirpated range has a 25 percent higher density of roads than occupied range. Wisdom *et al.*'s (in press) rangewide analysis supports the findings of numerous local studies showing that roads can have both direct and indirect impacts on sage-grouse distribution and individual fitness (e.g., Lyon and Anderson 2003, Aldridge and Boyce 2007).

Railroads

Railroads presumably have the same potential impacts to sage-grouse as do roads because they create linear corridors within sagebrush habitats. Railways and the cattle they transport were primarily responsible for the initial spread of *Bromus tectorum* in the intermountain region (Connelly *et al.* 2004, p. 7-25). *B. tectorum*, an exotic species that is unsuitable as sage-grouse habitat, readily invaded the disturbed soils adjacent to railroads. Fires created by trains facilitated the spread of *B. tectorum* into adjacent areas. Knick *et al.* (in press, p. 109) found that railroads cover 487 km^2 (188 mi^2) or less than 0.1 percent of the SGCA, but they estimated railroads could influence 10 percent of the SGCA based adding a 3-km (1.9-mi) buffer to estimate potential impacts from the exotic plants they can spread. Avian collisions with trains occur, although no estimates of mortality rates are documented in the literature (Erickson *et al.* 2001, p. 8).

Summary: Habitat Conversion for Agriculture; Urbanization; Infrastructure

Large losses of sagebrush shrub-steppe habitats due to agricultural conversion have occurred range wide, but have been especially significant in the Columbia Basin of Washington (MZ VI), the Snake River Plain of Idaho (MZ IV), and the Great Plains (MZ I). Conversion of sage brush habitats to cropland continues to occur, although quantitative data is available only for Montana. We do not know the current rate of conversion, but most areas suitable for agricultural production were converted many years ago. The current rate of conversion is likely to increase in the future if incentives for crop production for use as biofuels continue to be offered. Urban and exurban development also have direct and indirect negative effects on sage-grouse, including direct and indirect habitat losses, disturbance, and introduction of new predators and invasive plant species. Given current trends in the Rocky Mountain west, we expect urban and exurban development to continue. Infrastructure such as powerlines, roads, communication towers, and fences continue to fragment sage-grouse habitat. Past and current trends lead us to believe this source of fragmentation will increase into the future.

Fragmentation of sagebrush habitats through a variety of mechanisms including those listed above has been cited as a primary cause of the decline of sage-grouse populations (Patterson 1952, pp. 192-193; Connelly and Braun 1997, p. 4; Braun 1998, p. 140; Johnson and Braun 1999, p. 78; Connelly *et al.* 2000a, p. 975; Miller and Eddleman 2000, p. 1; Schroeder and Baydack 2001, p. 29; Johnsgard 2002, p. 108; Aldridge and Brigham 2003, p. 25; Beck *et al.* 2003, p. 203; Pedersen *et al.* 2003, pp. 23-24; Connelly *et al.* 2004, p. 4-15; Schroeder *et al.* 2004, p. 368; Leu *et al.* in press, p. 19). The negative effects of habitat fragmentation on sage-grouse are diverse and include reduced lek persistence, lek attendance, winter habitat use, recruitment, yearling annual survival, and female nest site choice (Holloran 2005, p. 49; Aldridge and Boyce 2007, pp. 517-523; Walker *et al.* 2007a, pp. 2651-2652; Doherty *et al.* 2008, p. 194). Since fragmentation is associated with most anthropogenic activities, the effects are ubiquitous across the species range (Knick *et al.* in press, p. 24). We agree with the assessment that habitat fragmentation is a primary cause of sage-grouse decline and in some areas has already led to population extirpation. We also conclude that habitat fragmentation will continue into the foreseeable future and will continue to threaten the persistence of greater sage-grouse.

Fire

Many of the native vegetative species of the sagebrush-steppe ecosystem are killed by wildfires, and recovery requires many years. As a result of this loss of habitat, fire has been identified as a primary factor associated with greater sage-grouse population declines (Hulet 1983, *in* Connelly *et al.* 2000a, p. 973; Crowley and Connelly 1996, *in* Connelly *et al.* 2000c, p. 94; Connelly and Braun 1997, p. 232; Connelly *et al.* 2000a, p. 973; Connelly *et al.* 2000c, p. 93; Miller and Eddlemen 2000, p. 24; Johnson *et al.*, in press, p. 12; Knick and Hanser, in press, pp. 29-30). In nesting and wintering sites, fire causes direct loss of habitat due to reduced cover and forage (Call and Maser 1985, p. 17). For example, prescribed fires in mountain big sagebrush at Hart Mountain National Antelope Refuge caused a short-term increase in certain forbs, but reduced sagebrush cover, making habitat less suitable for nesting (Rowland and Wisdom 2002, p. 28). Similarly, Nelle *et al.* (2000, p. 586) and Beck *et al.* (2009, p. 400) reported nesting habitat loss from fire, creating a long-term negative impact that will require 25 to 150 years of sagebrush regrowth before sufficient canopy cover becomes available for nesting birds.

In southeastern Idaho, sage-grouse populations were generally declining across the entire study area, but declines were more severe in post-fire years (Connelly *et al.* 2000c, p. 93). Further, Fischer *et al.* (1997, p. 89) concluded that habitat fragmentation caused by fire may influence distribution or migratory patterns in sage-grouse. Hulet (1983, in Connelly *et al.* 2000a, p. 973) documented the loss of leks from fire.

Fire within 54 km (33.6 mi) of a lek is one of two primary factors in predicting lek extirpation (Knick and Hanser in press, p. 26). Small increases in the amount of burned habitat surrounding a lek had a large influence on the probability of lek abandonment (Knick and Hanser, in press, pp. 29-30). Additionally, fire had a negative effect on lek trends in the Snake River Plain (MZ IV) and Southern Great Basin (MZ III) (Johnson *et al.* in press, p.12). Several recent studies have demonstrated that sagebrush area is one of the best landscape predictors of greater sage-grouse persistence (Aldridge *et al.* 2008, p. 987; Doherty *et al.* 2008, p. 191; Wisdom *et al.*, in press, p. 17). While there may be limited instances where burned habitat is beneficial, these gains are lost if sagebrush habitat is not readily available (Woodward 2006, p. 65).

Herbaceous understory vegetation plays a critical role throughout the breeding season as a source of forage and cover for sage-grouse females and chicks. The response of herbaceous understory vegetation to fire varies with differences in species composition, pre-burn site condition, fire intensity, and pre- and post-fire patterns of precipitation. In general, when not considering the synergistic effects of invasive species, any short-term flush of understory grasses and forbs is lost after only a few years and little difference is apparent between burned and unburned sites (Cook *et al.* 1994, p. 298; Fischer *et al.* 1996, p. 196; Crawford 1999, p. 7; Wrobleski 1999, p. 31; Nelle *et al.* 2000, p. 588; Paysen *et al.* 2000, p. 154; Wambolt *et al.* 2001, p. 250). Independent of the response of perennial grasses and forbs to fire, the most important and widespread sagebrush species for greater sage-grouse (i.e., big sagebrush) are killed by fire and require decades to recover. Prior to recovery, these sites are of limited to no use to sage-grouse (Fischer *et al.* 1996, p. 196; Connelly *et al.* 2000c, p. 90; Nelle *et al.* 2000, p. 588; Beck *et al.* 2009, p. 400). Therefore, fire results in direct, long-term habitat loss.

In addition to altering plant community structure, fires can influence invertebrate food sources (Schroeder *et al.* 1999, p. 5). Ants (Hymenoptera), grasshoppers (Orthoptera), and beetles (Coleoptera) are an essential component of juvenile greater sage-grouse diets, especially in the first 3 weeks of life (Johnson and Boyce 1991, p. 90). Crawford and Davis (2002, p. 56) reported that the abundance of arthropods did not decline following wildfire. Pyle (1992, p. 14) reported no apparent effect of prescribed burning to beetles. However, Fischer *et al.* (1996, p. 197) found that the abundance of insects was significantly lower 2–3 years post-burn. Additionally, grasshopper abundance declined 60 percent in burned plots versus unburned plots 1 year post-burn, but this difference disappeared the second year (Bock and Bock 1991, p. 165). Conversely, Nelle *et al.* (2000, p. 589) reported the abundance of beetles and ants was significantly greater in 1–year-old burns, but returned to pre-burn levels by years 3 to 5. The effect of fire on insect populations likely varies due to a host of environmental factors. Because few studies have been conducted and the results of those available vary, the specific magnitude and duration of the effects of fire on insect communities is still uncertain, as is the effect any changes may have on greater sage-grouse populations.

The few studies that have suggested fire may be beneficial for greater sage-grouse were primarily conducted in mesic areas used for brood-rearing (Klebenow 1970, p. 399; Pyle and Crawford 1996, p. 323; Gates 1983, *in* Connelly *et al.* 2000c, p. 90; Sime 1991, *in* Connelly *et al.* 2000a, p. 972). In this habitat, small fires may maintain a suitable habitat mosaic by reducing shrub encroachment and encouraging understory growth. However, without available nearby sagebrush cover, the utility of these sites is questionable. For example, Slater (2003, p. 63) reported that sage-grouse using burned areas were rarely found more than 60 m (200 ft) from the edge of the burn and may preferentially use the burned and unburned edge habitat. However, Byrne (2002, p. 27) reported avoidance of burned habitat by nesting, brood-rearing, and broodless females. Both Connelly *et al.* (2000c, p. 90) and Fischer *et al.* (1996, p. 196) found that prescribed burns did not improve brood-rearing habitat in Wyoming big sagebrush, as forbs did not increase and insect populations declined. Hence, fires in these locations may negatively affect brood-rearing habitat rather than improve it (Connelly and Braun 1997, p. 11).

The nature of historical fire patterns in sagebrush communities, particularly in *Artemisia tridentata* var. *wyomingensis*, is not well understood and a high degree of variability likely occurred (Miller and Eddleman 2000, p. 16; Zouhar *et al.* 2008, p. 154; Baker in press, p. 16). However, as inferred by several lines of reasoning, fire in sagebrush systems was historically infrequent (Baker in press, pp. 15-16). This conclusion is evidenced by the fact that most sagebrush species have not developed evolutionary adaptations such as re-sprouting and heat-stimulated seed germination found in other shrub-dominated systems, like chaparral, exposed to relatively frequent fire events. Baker (in press, p. 17) suggests natural fire regimes and landscapes were typically shaped by a few infrequent large fire events that occurred at intervals approaching the historical fire rotation (50 to 350 years – see discussion below). The researcher concludes that the historical sagebrush systems likely consisted of extensive sagebrush habitat dotted by small areas of grassland and that this condition was maintained by long interludes of numerous small fires, accounting for little burned area, punctuated by large fire events that consumed large expanses. In general, fire extensively reduces sagebrush within burned areas, and big sagebrush varieties, the most widespread species of sagebrush, can take up to 150 years to reestablish an area (Braun 1998, p. 147; Cooper *et al.* 2007, p. 13; Lesica *et al.* 2007, p. 264; Baker, in press, pp. 15-16).

Fire rotation, or the average amount of time it takes to burn once through a particular landscape, is difficult to quantify in large sagebrush expanses. Because sagebrush is killed by fire, it does not record evidence of prior burns (i.e., fire scars) as do forested systems. As a result, a clear picture of the complex spatial and temporal pattern of historical fire regimes in most sagebrush communities is not available. Widely variable estimates of historical fire rotation have been described in the literature. 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 in press, pp. 15-16). In general, mean fire return intervals in low-lying, xeric, big sagebrush communities range from over 100 to 350 years, and return intervals decrease from 50 to over 200 years in more mesic areas, at higher elevations, during wetter climatic periods, and in locations associated with grasslands (Baker 2006, p. 181; Mensing *et al.* 2006, p. 75; Baker, in press, pp. 15-16; Miller *et al.*, in press, p. 35).

The invasion of exotic annual grasses, such as *Bromus tectorum* and *Taeniatherum asperum* (medusahead), has been shown to increase fire frequency within the sagebrush ecosystem (Zouhar *et al.* 2008, p. 41; Miller *et al.* in press, p. 39). *B. tectorum* readily invades sagebrush communities, especially disturbed sites, and changes historical fire patterns by providing an abundant and easily ignitable fuel source that facilitates fire spread. While sagebrush is killed by fire and is slow to reestablish, *B. tectorum* recovers within 1 to 2 years of a fire event (Young and Evans 1978, p. 285). This annual recovery leads to a readily burnable fuel source and ultimately a reoccurring fire cycle that prevents sagebrush reestablishment (Eiswerth *et al.* 2009, p. 1324). In the Snake River Plain (MZ IV), for example, Whisenant (1990, p. 4) suggests fire rotation due to *B. tectorum* establishment is now as low as 3–5 years. It is difficult and usually ineffective to restore an area to sagebrush after annual grasses become established (Paysen *et al.* 2000, p. 154; Connelly *et al.* 2004, pp. 7-44 to 7-50; Pyke, in press, p. 25). Habitat loss from fire and the subsequent invasion by nonnative annual grasses have negatively affected sage-grouse populations in some locations (Connelly *et al.* 2000c, p. 93).

Evidence exists of a significant relationship between an increase in fire occurrence caused by *Bromus tectorum* invasion in the Snake River Plain and Northern Great Basin since the 1960s (Miller *et al.*, in press, p. 39) and in northern Nevada and eastern Oregon since 1980 (MZs IV and V). The extensive distribution and highly invasive nature of *B. tectorum* poses substantial increased risk of fire and permanent loss of sagebrush habitat, as areas disturbed by fire are highly susceptible to further invasion and ultimately habitat conversion to an altered community state. For example, Link *et al.* (2006, p. 116) show that risk of fire increases from approximately 46 to 100 percent when ground cover of *B. tectorum* increases from 12 to 45 percent or more. In the Great Basin

Ecoregion (defined as east-central California, most of Nevada, and western Utah, MZs IV and V), approximately 58 percent of sagebrush habitats are at moderate to high risk of *B. tectorum* invasion during the next 30 years (Suring *et al.* 2005, p. 138). The BLM estimated that approximately 11.9 million ha (29 million ac) of public lands in the western distribution of the greater sage-grouse (Washington, Oregon, Idaho, Nevada, Utah) were infested with weeds as of 2000 (BLM 2007a, p. 3-28). The most dominant invasive plants consist of grasses in the *Bromus* genus, which represent nearly 70 percent of the total infested area (BLM 2007a, p. 3-28).

Conifer woodlands have expanded into sagebrush ecosystems over the last century (Miller *et al.* in press, p. 34). Woodlands can encroach into sagebrush communities when the interval between fires becomes long enough for seedlings to establish and trees to mature and dominate a site (Miller *et al.* in press, p. 36). However, historical fire rotation appears to have been sufficiently long to allow woodland invasion, and yet extensive stands of mature sagebrush were evident during settlement times (Vale 1975, p. 33; Baker, in press, pp. 15-16). This suggests that causes other than active fire suppression must largely explain recent tree invasions into sagebrush habitats (Baker in press, p. 21, 24). Baker (in press, p. 24) and Miller *et al.* (in press, p. 37) offer a suite of causes, acting in concert with fire exclusion that may better explain the dramatic expansion of conifer woodlands over the last century. These causes include alterations due to domestic livestock grazing (such as reduced competition from native grasses and forbs and facilitation of tree regeneration by increased shrub cover and enhanced seed dispersal), climatic fluctuations favorable to tree regeneration, enhanced tree growth due to increased water use efficiency associated with carbon dioxide fertilization, and recovery from past disturbance (both natural and anthropogenic). Regardless of the cause of conifer woodland encroachment, the rate of expansion is increasing and is resulting in the loss and fragmentation of sagebrush habitats (see discussion in Pinyon-juniper section below).

Between 1980 and 2007, the number of fires and total area burned increased in all MZs across the greater sage-grouse's range except the Snake River Plain (MZ IV) (Miller *et al.*, in press, p. 39). Additionally, average fire size increased in the Southern Great Basin (MZ III) during this same period. However, predicting the amount of habitat that will burn during an "average fire" year is difficult due to the highly variable nature of fire seasons. For example, the approximate area burned on or adjacent to BLM-managed lands varied from 140,000 ha (346,000 ac) in 1998 to a 6-fold increase in 1999 (814,200 ha; 2 million ac) returning back down to approximately the 1998 level in 2002 (157,700 ha; 384,743 ac) before rising again 10-fold in 2006 (1.4 million ha; 3.5 million ac) (Miller *et al.*, in press, pp. 39-40).

From 1980 to 2007, wildfires have burned approximately 8.7 million ha (21.5 million ac) of sagebrush, or approximately 18 percent of the estimated 47.5 million ha (117.4 million ac) of sagebrush habitat occurring within the delineated MZs (Baker, in press, p. 43). Additionally, the trend in total acreage burned since 1980 has primarily increased (Miller *et al.*, in press, p. 39). Although fire alters sagebrush habitats throughout the greater sage-grouse's range, fire disproportionately affects the Great Basin (Baker *et al.* in press, p. 20) (i.e., Utah, Nevada, Idaho, and eastern Oregon; MZ III, IV, and V) and will likely influence the persistence of greater sage-grouse populations in the area. In these three MZs combined, nearly 27 percent of sagebrush habitat has burned since 1980 (Baker, in press, p. 43). A primary reason for this disproportionate influence in this region is due to the presence of burned sites and their subsequent susceptibility to invasion by exotic annual grasses.

According to one review, range fires destroyed 30 to 40 percent of sage-grouse habitat in southern Idaho (MZ IV) in a 5–year period (1997–2001) (Signe Sather-Blair, BLM, *in* Healy 2001). This amount included about 202,000 ha (500,000 ac), which burned between 1999 and 2001, significantly altering the largest remaining contiguous patch of sagebrush in the State (Signe Sather-Blair, BLM, *in* Healy 2001). Between 2003 and 2007, Idaho lost an additional 267,000 ha (660,000 ac) of sage-grouse habitat, or approximately 7 percent of the total estimated remaining habitat in the State. Over nine fire seasons in Nevada (1999–2007), about 1 million ha (2.5 million ac) of sagebrush were burned, representing approximately 12 percent of the State's extant sagebrush habitat (Espinosa and Phenix 2008, p. 3). Most of these fires occurred in northeast Nevada (MZ IV) within quality habitat that has traditionally supported high densities of sage-grouse, which also is highly susceptible to *Bromus tectorum* invasion.

Baker (in press, p. 20) calculated recent fire rotation by MZ and compared these to estimates of historical fire rotations. Based on this analysis, the researcher suggests that increased fire rotations since 1980 are presumably outside the historic range of variability and far shorter in floristic regions where Wyoming big sagebrush is common (Baker in press, p. 20). This analysis included MZs III, IV, V, and VI, all of which have extensive *Bromus tectorum* invasions.

In addition to wildfire, land managers are using prescribed fire as well as mechanical and chemical treatments to obtain desired management objectives for a variety of wildlife species and domestic ungulates in sagebrush habitats throughout the range of the greater sage-grouse. While the efficacy of treatments in sagebrush habitats to enhance sage-grouse populations is questionable (Peterson 1970, p. 154; Swensen *et al.* 1987, p. 128; Connelly *et al.* 2000c, p. 94; Nelle *et al.* 2000, p. 590; WAFWA 2009, p. 12; Connelly *et al.* in press c, p. 8), as with wildland fire, an immediate and potentially long-term result is the loss of habitat (Beck *et al.* 2009, p. 400).

Knick *et al.* (in press, p. 33) report that more than 370,000 ha (914,000 ac) of public lands were treated with prescribed fire to address management objectives for many different species between 1997 and 2006, mostly in Oregon and Idaho, and an additional 124,200 ha (306,900 ac) were treated with mechanical means over this same time period, primarily in Utah and Nevada. However, these acreages represent all habitat types and thus overestimate negative impacts to greater sage-grouse. Quantifying the amount of sagebrush-specific habitat treatments is difficult due to the fact that centralized reporting is not typically categorized by habitat. However, agencies under the Department of the Interior (DOI) report species of special interest, including greater sage-grouse, which may occur in proximity to a prescribed treatment. Between 2003 and 2008, approximately 133,500 ha (330,000 ac) of greater sage-grouse habitat have been burned by land managers within the DOI or approximately 22,000 ha (55,000 ac) annually. This acreage does not reflect lands burned by agencies under the USDA (e.g., USFS). Although much of the land under USFS jurisdiction lies outside greater sage-grouse range, this agency manages approximately 8 percent of sagebrush habitats. Ultimately, the amount of sagebrush habitat treated by land managers appears to represent a relatively minor loss when compared to loss incurred by wildfire. However, in light of the significant habitat loss due to wildfire, and the preponderance of evidence that suggests these treatments are not beneficial to sage-grouse, the rationale for using such treatments to improve sage-grouse habitat deserves further scrutiny.

Sagebrush recovery rates are highly variable, and precise estimates are often hampered by limited data from older burns. Factors contributing to the rate of shrub recovery include the amount of and distance from unburned habitat, abundance and viability of seed in soil seed bank (depending on species, sagebrush seeds are typically viable for one to three seasons), rate of seed dispersal, and pre- and post-fire weather, which influences seedling germination and establishment (Young and Evans 1989, p. 204; Maier *et al.* 2001, p. 701; Ziegenhagen and Miller 2009, p. 201). Based on a review of existing literature, Baker (in press, pp. 14-15) reports that full recovery to pre-burn conditions in *Artemisia tridentata* ssp. *vaseyana* communities ranges between 25 and 100 years and in *A. t.* ssp. *wyomingensis* communities between 50 and 120 years. However, the researcher cautions that data pertaining to the latter community is sparse. What is known is that by 25 years post-fire, *A. t.* ssp. *wyomingensis* typically has less than 5 percent pre-fire canopy cover (Baker in press, p. 15).

A variety of techniques have been employed to restore sagebrush communities following a fire event (Cadwell *et al.* 1996, p. 143; Quinney *et al.* 1996, p. 157; Livingston 1998, p. 41). The extent and efficacy of restoration efforts is variable and complicated by limitations in capacity (personnel, equipment, funding, seed availability, and limited seeding window), incomplete knowledge of appropriate methods, invasive plant species, and abiotic factors, such as weather, that are largely outside the control of land managers (Hemstrom *et al.* 2002, pp. 1250-1251; Pyke, in press, p. 29). While post-fire rehabilitation efforts have benefited from additional resources in recent years, resulting in an increase of treated acres from 28,100 ha (69,436 ac) in 1997 to 1.6 million ha (3.9 million ac) in 2002 (Connelly *et al.* 2004, p. 7-35), acreage treated annually remains far outpaced by acreage disturbed. For example, of the more than 1 million ha (2.5 million ac) of sage-grouse habitat burned during the 2006 and 2007 fire seasons on BLM-managed lands, about 40 percent or 384,000 ha (950,000 ac) had some form of active post-fire restoration such as reseeding. More specifically, Eiswerth *et al.* (2009, p. 1321) report that over the past 20 years within the BLM's Winnemucca District in Nevada, approximately 12 percent of burned areas have been actively reseeded.

The main purpose of the Burned Area Emergency Stabilization and Rehabilitation program (BLM 2007b, pp. 1-2), designed to rehabilitate areas following fire, is to stabilize soils and maintain site productivity rather than to regain site suitability for wildlife (Pyke, in press, p. 24). Consequently, in areas that experience active post-fire restoration efforts, an emphasis is often placed on introduced grasses that establish quickly. Only recently has a modest increase in the use of native species for burned area rehabilitation been reported (Richards *et al.* 1998, p. 630; Pyke, in press, p. 24). Further complicating our understanding of the effectiveness of these treatments is that most managers do not keep track of monitoring data in a routine or systematic fashion (GAO 2003, p. 5). Assuming complete success of restoration efforts on targeted areas, however unlikely, the return of a shrub-dominated community will still require several decades, and landscape restoration may require centuries or longer (Knick 1999, p. 55; Hemstrom *et al.* 2002, p. 1252). Even longer periods may be required for greater sage-grouse to use recovered or restored landscapes (Knick *et al.*, in press, p. 65).

The loss of habitat due to wildland fire is anticipated to increase due to the intensifying synergistic interactions among fire, people, invasive species, and climate change (Miller *et al.*, in press, p. 50). The recent past- and present-day fire regimes across the greater sage-grouse distribution have changed with a demonstrated increase in the more arid Wyoming big sagebrush communities and a decrease across many mountain big sagebrush communities. Both scenarios of altered fire regimes have caused significant losses to greater sage-grouse habitat through facilitating conifer expansion at high-elevation interfaces and exotic weed encroachment at lower elevations (Miller *et al.*, in press, p. 47). In the face of climate change, both of these scenarios are anticipated to worsen (Baker, in press, p. 24; Miller *et al.*, in press, p. 48). Predicted changes in temperature, precipitation, and carbon dioxide are all anticipated to influence vegetation dynamics and alter fire patterns resulting in the increasing loss and conversion of sagebrush habitats (Neilson *et al.* 2005, p. 157). Further, many climate scientists suggest that in addition to the predicted change in climate toward a warmer and generally wetter Great Basin, variability of interannual and interdecadal wet-dry cycles will increase and likely act in concert with fire, disease, and invasive species to further stress the sagebrush ecosystem (Neilson *et al.* 2005, p. 152). The anticipated increase in suitable conditions for wildland fire will likely further interact with people and infrastructure. Human-caused fires have reportedly increased and been shown to be correlated with road presence (Miller *et al.*, in press. p. 40). Given the popularity of off-highway vehicles (OHV) and the ready access to lands in the Great Basin, the increasing trend in both fire ignitions by people and loss of habitat will likely continue.

While multiple factors can influence sagebrush persistence, fire is the primary cause of recent large-scale losses of habitat within the Great Basin, and this stressor is anticipated to intensify. In addition to loss of habitat and its influence on greater sage-grouse population persistence, fragmentation and isolation of populations presents a higher probability of extirpation in disjunct areas (Knick and Hanser, in press, p. 20; Wisdom *et al.*, in press, p. 22). Knick and Hanser (in press, p. 31) suggest extinction is currently more probable than colonization for many great sage-grouse populations because of their low abundance and isolation coupled with fire and human influence. As areas become isolated through disturbances such as fire, populations are exposed to additional stressors and persistence may be hampered by the limited ability of individuals to disperse into areas that are otherwise not self-sustaining. Thus, while direct loss of habitat due to fire has been shown to be a significant factor associated with population persistence, the indirect effect posed by loss of connectivity among populations may greatly expand the influence of this threat beyond the physical fire perimeter.

Summary: Fire

Fire is one of the primary factors linked to population declines of greater sage-grouse because of long-term loss of sagebrush and conversion to monocultures of exotic grasses (Connelly and Braun 1997, p. 7; Johnson *et al.*, in press, p. 12; Knick and Hanser, in press, pp. 29-30). Loss of sagebrush habitat to wildfire has been increasing in western areas of the greater sage-grouse range for the past three decades. The change in fire frequency has been strongly influenced by the presence of exotic annual grasses and significantly deviates from extrapolated historical regimes. Restoration of these communities is challenging, requires many years, and may, in fact, never be achieved in the presence of invasive grass species. Greater sage-grouse are slow to recolonize burned areas even if structural features of the shrub community may have recovered (Knick *et al.*, in press, p. 46). While it is not currently possible to predict the extent or location of future fire events, the best scientific and commercial information available indicates that fire frequency is likely to increase in the foreseeable future due to increases in cover of *Bromus tectorum* and the projected effects of climate change (see Invasive plants (annual grasses and other noxious weeds), below, and also Climate Change, below).

An analysis of previously extirpated sage-grouse habitats has shown that the extent and abundance of sagebrush habitats, proximity to burned habitat, and degree of connectivity among sage-grouse groups strongly affects persistence (Aldridge *et al.* 2008, p. 987; Knick and Hanser, in press, pp. 29-30; Wisdom *et al.*, in press, p. 17). The loss of habitat caused by fire and the functional barrier burned habitat can pose to movement and dispersal compounds the influence this stressor can have on populations and population dynamics. Barring alterations to the current fire pattern, as well as the difficulties associated with restoration, the concerns presented by this threat will continue and likely strongly influence persistence of the greater sage-grouse, especially in the western half of its range within the foreseeable future.

Invasive Plants (Annual Grasses and Other Noxious Weeds)

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

Invasives alter plant community structure and composition, productivity, nutrient cycling, and hydrology (Vitousek 1990, p. 7) and may cause declines in native plant populations through competitive exclusion and niche displacement, among other mechanisms (Mooney and Cleland 2001, p. 5446). Invasive plants reduce and, in cases where monocultures occur, eliminate vegetation that sage-grouse use for food and cover. Invasives do not provide quality sage-grouse habitat. Sage-grouse depend on a variety of native forbs and the insects associated with them for chick survival, and sagebrush, which is used exclusively throughout the winter for food and cover. Invasives impact the entire range of sage-grouse, although not all given species are distributed across the entire range. Leu *et al.* (2008, pp. 1119-1139) modeled the risk of invasion by exotic plant species for the entire range of sage-grouse. Areas at high risk for invasion were distributed throughout the range, but were especially concentrated in eastern Washington (MZ VI), southern Idaho (MZ IV), central Utah (MZ III), and northeast Montana (MZ I).

Along with replacing or removing vegetation essential to sage-grouse, invasives fragment existing sage-grouse habitat. They can create long-term changes in ecosystem processes, such as fire-cycles (see discussion under Fire above) and other disturbance regimes that persist even after an invasive plant is removed (Zouhar *et al.* 2008, p. 33). A variety of nonnative annuals and perennials are invasive to sagebrush ecosystems (Connelly *et al.* 2004, pp. 7-107 and 7-108; Zouhar *et al.* 2008, p 144). *Bromus tectorum* is considered most invasive in *Artemisia tridentata* ssp. *wyomingensis* communities, while *Taeniatherum asperum* fills a similar niche in more mesic communities with heavier clay soils (Connelly *et al.* 2004, p. 5-9). Some other problematic rangeland weeds include *Euphorbia esula* (leafy spurge), *Centaurea solstitialis* (yellow starthistle), *Centaurea maculosa* (spotted knapweed), *Centaurea diffusa* (diffuse knapweed), and a number of other *Centaurea* species (DiTomaso 2000, p. 255; Davies and Svejcar 2008, pp. 623-629).

Nonnative annual grasses (e.g., *Bromus tectorum* and *Taeniatherum asperum*) have caused extensive sagebrush habitat loss in the Intermountain West and Great Basin (Connelly *et al.* 2004, pp. 1-2 and 4-16). They impact sagebrush ecosystems by shortening fire intervals to as low as 3 to 5 years, perpetuating their own persistence and intensifying the role of fire (Whisenant 1990, p. 4). Connelly *et al.* (2004, p. 7-5) suggested that fire intervals are shortened to less than 10 years. Although nonnative annual grasses occur throughout the sage-grouse's range, they are more problematic in western States (MZs III, IV, V, and VI) than Rocky Mountain States (MZs I and II) (Connelly *et al.* 2004, p. 5-9).

Quantifying the total amount of sage-grouse habitat impacted by invasives is problematic due to differing sampling methodologies, incomplete sampling, inconsistencies in species sampled, and varying interpretations of what constitutes an infestation (Miller *et al.*, in press, p. 19). Widely variable estimates of the total acreage of weed infestations have been reported. BLM (1996, p. 6) estimated invasives (which may or may not have included *Bromus tectorum* in their estimate) covered at least 3.2 million ha (8 million ac) of BLM lands as of 1994, and predicted 7.7 million ha (19 million ac) would be infested by 2000. However, a qualitative 1991 BLM survey covering 40 million ha (98.8 million ac) of all BLM-managed land in Washington, Oregon, Idaho, Nevada, and Utah (MZs III, IV, V, and VI) reported that introduced annual grasses were a dominant or significant presence on 7 million ha (17.2 million ac) of sagebrush ecosystems (Connelly *et al.* 2004, p. 5-10). An additional 25.1 million ha (62 million ac) had less than 10 percent *B. tectorum* in the understory, but were considered to be at risk of *B. tectorum* invasion (Zouhar 2003, p. 3, in reference to the same survey). More recently, BLM reported that as of 2000, noxious weeds and annual grasses occupied 11.9 million ha (29.4 million ac) of BLM lands in Washington, Oregon, Idaho, Nevada, and Utah (BLM 2007a, p. 3-28). However, when considering all States within the current range of sage-grouse, this number increases to 14.8 million ha (36.5 million ac). Although estimates of the total area infested by *B. tectorum* vary widely, it is clear that *B. tectorum* is a significant presence in western rangelands.

The Landscape Fire and Resource Management Planning Tools Project (LANDFIRE) has a rangewide dataset documenting annual grass distribution. Based on 1999–2002 imagery, at least 885,990 ha (2.2 million ac) of annual grasses occur within the current range of sage-grouse (LANDFIRE 2007). Satellite data only map annual grass monocultures, and not areas where they occur in lower densities or even dominate the sagebrush understory (which is mapped as sagebrush).

Therefore, the LANDFIRE dataset is a gross underestimate of the total acres of infestation. However, this dataset provides a rangewide comparison of annual grass monocultures and identifies the large extent of these monocultures in both the western and eastern part of the sage-grouse's range.

Approximately 80 percent of land in the Great Basin Ecoregion (MZs III, IV, and V) is susceptible to displacement by *Bromus tectorum* (including over 58 percent of sagebrush that is moderately or highly susceptible) within 30 years (Connelly *et al.* 2004, p. 7-17, Suring *et al.* 2005, p. 138). Due to the disproportionate abundance of *B. tectorum* in the Great Basin, suggesting an increased susceptibility to *B. tectorum* invasion than other parts of the sage-grouse's range, Connelly *et al.* (2004, p. 7-8) cautioned that a formal analysis of the risk of *B. tectorum* invasion in other areas was needed before such inferences are made. Also, while nonnative annual grasses are usually associated with lower elevations and drier climates (Connelly *et al.* 2004, p. 5-5), the ecological range of *B. tectorum* continues to expand at low and high elevations (Ramakrishnan *et al.* 2006, pp. 61-62), both southward and eastward (Miller *et al.*, in press, p. 21). Local infestations of *B. tectorum* and other annual grasses occur in Montana, Wyoming, and Colorado (MZs I and II) (Miller *et al.*, in press, p. 21), and there is evidence that *B. tectorum* is impacting fire intervals in Wyoming. For example, 40,469 ha (100,000 ac) of sagebrush that burned in a wildfire southeast of Worland, Wyoming (MZ II), became infested with *B. tectorum*, accelerating the fire interval in this area (Wyoming Big Horn Basin Sage-grouse Local Working Group 2007, pp. 39-40).

Noxious weeds spread about 931 ha (2,300 ac) per day on BLM land and 1,862 ha (4,600 ac) per day on all public land in the West (BLM 1996, p. 1), or increase about 8 to 20 percent annually (*Federal Interagency Committee for the Management of Noxious and Exotic Weeds* 1997, p. v). Invasions are often associated with ground disturbances caused by wildfire, grazing, infrastructure, and other anthropogenic activity (Rice and Mack 1990, p. 84; Gelbard and Belnap 2003, p. 420; Zouhar *et al.* 2008, p. 23), but disturbance is not required for invasives to spread (Young and Allen 1997, p. 531; Roundy *et al.* 2007, p. 614). Invasions also may occur sequentially, where initial invaders (e.g., *Bromus tectorum*) are replaced by new exotics (Crawford *et al.* 2004, p 9; Miller *et al.*, in press, p. 20).

Based on data collected in the western half of the range, Bradley *et al.* (2009, pp. 1511-1521; Bradley 2009, pp. 196-208) predicted favorable conditions for *Bromus tectorum* across much of the sage-grouse's range under current and future (2100) climate conditions. A strong indicator for future *B. tectorum* locations is the proximity to current locations (Bradley and Mustard 2006, p. 1146) as well as summer, annual, and spring precipitation, and winter temperature (Bradley 2009, p. 196). Bradley *et al.* (2009, p. 1517) predicted that in the future some areas will become unfavorable for *B. tectorum* while others will become favorable. Specifically, Bradley *et al.* (2009, p. 1515) predicted that climatically suitable *B. tectorum* habitat will shift northwards, leading to expanded risk in Idaho, Montana, and Wyoming, but reduced risk in southern Nevada and Utah. Despite the potential for future retreat in Nevada and Utah, there will still be climatically suitable *B. tectorum* habitat in these States, well within the range of sage-grouse (see Figure 4b in Bradley *et al.* 2009, p. 1517). Bradley *et al.* (2009, p. 1511) noted that changes in climatic suitability may create restoration opportunities in areas that are currently dominated by invasives. We anticipate that *B. tectorum* will eventually disappear from areas that become climatically unsuitable for this species, but this transition is unlikely to occur suddenly. Also, Bradley *et al.* (2009, p. 1519) cautioned that areas that become unfavorable to *B. tectorum* may become favorable to other invasives, such as *B. rubens* (red brome) in the southern Great Basin, which is more tolerant of higher temperatures. Therefore, areas that become unsuitable for *B. tectorum* will not necessarily be returned to pre-invaded habitat conditions without significant effort. Bradley *et al.* (2009, p. 1519) suggested that modeling and experimental work is needed to assess whether native species could occupy these sites if invasives are reduced or eliminated by climate change.

LANDFIRE also has a rangewide dataset documenting other exotic grasses and forbs, including perennial grasses and annual, perennial, and biennial forbs. Like annual grasses, other invasive plants are grossly underestimated in the LANDFIRE dataset because the dataset only includes monocultures of these species. Based on 1999–2002 imagery, at least 1.3 million ha (3.3 million ac) of other exotic plants occur within the current range of sage-grouse (LANDFIRE 2007). Aside from LANDFIRE, the only other information documenting the specific distribution of invasives within the sage-grouse's range is at a presence–absence scale at the county level. DiTomaso (2000, p. 257) estimated that western rangelands are infested with 2,900,000 ha (7,166,027 ac) of *C. maculosa*, 1,300,000 ha (3,212,357 ac) of *C. diffusa*, 8,000,000 ha (19,768,352 ac) of *C. solstitialis*, and 1,100,000 ha (2,718,148 ac) of *Euphorbia esula*, but this estimate did not describe the distribution of invasives across the landscape. These estimates, combined with estimates of acres infested by *Bromus tectorum*, and the fact that LANDFIRE detected more acres of other noxious weeds than annual grasses, illustrate the severity of the invasives problem.

Invasives that are not annual grasses impact the entire range of sage-grouse, although not all given species are distributed across the entire range. Leu *et al.* (2008, pp. 1119-1139) modeled the risk of invasion by exotic plant species (which also would include annual grasses), for the entire range of sage-grouse. Areas at high risk for invasion were distributed throughout the range, but were especially concentrated in eastern Washington (MZ VI), southern Idaho (MZ IV), central Utah (MZ III), and northeastern Montana (MZ I). Like *Bromus tectorum*, the distribution of other invasives will likely shift with climate change. Bradley *et al.* (2009, p. 1518) predicts that the range of *C. maculosa* will expand in some areas, mainly in parts of Oregon, Idaho, western Wyoming, and Colorado, and will contract in other areas (e.g., eastern Montana). She also predicts that the range of *C. solstitialis* will expand eastward (Bradley *et al.* 2009, p. 1514) and that the invasion risk of *Euphorbia esula* will likely decrease in several States, including parts of Colorado, Oregon, and Idaho (Bradley *et al.* 2009, pp. 1516-1518).

Many efforts are ongoing to restore or rehabilitate sage-grouse habitat affected by invasive species. Common rehabilitation techniques include first reducing the density of invasives using herbicides, defoliation via grazing, pathogenic bacteria and other forms of biocontrol, or prescribed fire (Tu *et al.* 2001; Larson *et al.* 2008, p. 250; Pyke, in press, pp. 25-26). Sites are then typically reseeded with grass and forb mixes, and sometimes planted with sagebrush plugs. Despite ongoing efforts to transform lands dominated by invasive annual grasses into quality sage-grouse habitat, restoration and rehabilitation techniques are considered to be mostly unproven and experimental

(Pyke, in press, pp. 25-28, and see discussion on fire above).

Several components of the restoration process are being investigated with varying success (Pyke, in press, p. 25). Some techniques show promise, such as use of the herbicide Imazapic to control *Bromus tectorum*. However, further analyses of the benefit of this method still need to be conducted (Pyke, in press, p. 27). Also, it will take time for sagebrush to establish and mature in areas currently dominated by annual grasses. Rehabilitation and restoration efforts also are hindered by cost and the ability to procure the equipment and seed needed for projects (Pyke, in press, pp. 29-30). Furthermore, while restoration projects for other species may depend on a single site or landowner, restoration of sage-grouse habitat requires partnerships across multiple ownerships in order to restore and maintain a connective network of intact vegetation (Pyke, in press, pp. 33-34).

Treatment success also depends on factors which are not controllable, such as precipitation received at the treatment site (Pyke, in press, p. 30). For example, only 3.3 to 33.6 percent of recent vegetation treatments conducted by the BLM in annual grassland monocultures were reported as successful (Carlson 2008b, pers. comm.). Areas with established annual grasses that receive less than 22.9 cm (9 in.) of annual precipitation are less likely to benefit from restoration (Connelly *et al.* 2004, p. 7-17, Carlson 2008b, pers. comm.). Consequently, BLM focuses most (98 percent) of their restoration efforts in areas receiving more than 22.9 cm (9 in.) of annual precipitation where there is greater chance of success. Of the BLM treatments in annual grasslands, only 10 percent of acres treated in areas receiving less than 22.9 cm (9 in.) of annual precipitation were considered to be effectively treated. In areas receiving between 22.9 cm (9 in.) and 30.5 cm (12 in.) of annual precipitation, 33.6 percent of the acres were treated effectively, and 3.3 percent of the acres were treated effectively in areas receiving greater than 30.5 cm (12 in.) of annual precipitation (Carlson 2008b, pers. comm.). Since the BLM treatments in annual grassland monocultures included both the reestablishment of native shrub and grass species and greenstripping efforts to reduce the frequency of fires in annual grassland monocultures, it is unclear how many of these successfully treated acres are attributed to restoration versus prevention.

A variety of regulatory mechanisms and nonregulatory measures to control invasive plants exist. However, the extent to which these mechanisms effectively ameliorate the current rate of invasive expansion is unclear. If noxious weeds are spreading at a rate of 931 ha (2,300 ac) per day on BLM lands (BLM 1996, p. 1), this amounts to 339,815 ha (839,500 ac) per year, which includes both suitable and nonsuitable habitat for sage-grouse. It is unclear whether this estimate is limited to noxious weeds or if it includes other invasives (e.g., *Bromus tectorum*). Still, we can compare this estimate to the area of all invasives (excluding conifers) treated by the BLM between October 2005 and September 2007, which totaled 259,897 ha (642,216 ac), i.e., approximately 86,632 ha (214,072 ac) treated annually.

The number of acres treated annually (86,632 ha; 214,072 ac) is not keeping pace with the rate of spread (339,815 ha; 839,500 ac) especially when considering the inability to treat the problem. We acknowledge that the rate of spread on BLM lands also includes areas that are not sage-grouse habitat. However, the rate of spread may not have included *B. tectorum* and only part of the invasive treatments completed by BLM (23.6 percent of treatments in annual grassland monocultures and 7.5 percent of treatments in sagebrush with annual grassland understories) were considered to be effective by the BLM (Carlson 2008b, pers. comm.). Also, treatments are typically considered to be successful based on whether native vegetation was reestablished, maintained, or enhanced, and not based on a positive population response of sage-grouse to the treatment. Therefore, the effectiveness of treatments for sage-grouse is likely much less than reported for vegetation.

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

Invasives are a serious rangewide threat, and one of the highest risk factors for sage-grouse based on the plants' ability to out-compete sagebrush, the inability to effectively control them once they become established, and the synergistic interaction between them and other risk factors on the landscape (e.g., wildfire, infrastructure construction). Invasives reduce and eliminate vegetation that is essential for sage-grouse to use as food and cover. Their presence on the landscape has removed and fragmented sage-grouse habitat. Because invasives are widespread, have the ability to spread rapidly, occur near areas susceptible to invasion, and are difficult to control, we anticipate that invasives will continue to replace and reduce the quality of sage-grouse habitat across the range in the foreseeable future. There have been many studies addressing effective invasive control methods, as well as conservation actions to control invasives, with varied success. While some efforts appear successful at smaller scales, prevention (e.g., early detection and fire prevention) appears to be the only known effective tool to preclude or minimize large-scale habitat loss from invasive species in the future.

Pinyon-Juniper Encroachment

Pinyon-juniper woodlands are a native habitat type dominated by pinyon pine (*Pinus edulis*) and various juniper species (*Juniperus* spp.) that can encroach upon, infill, and eventually replace sagebrush habitat. These two woodland types are often referred to collectively as pinyon-juniper; however, some portions of the sage-grouse's range are only impacted by juniper encroachment. Commons *et al.* (1999, p. 238) found that the number of male Gunnison sage-grouse (*C. minimus*) on leks in southwestern Colorado doubled after pinyon-juniper removal and mechanical treatment of mountain sagebrush and deciduous brush. Hence, we infer that some greater sage-grouse populations have been negatively affected by pinyon-juniper encroachment and that some populations will decline in the future due to projected increases in the pinyon-juniper type, especially in areas where pinyon-juniper encroachment is a large-scale threat (parts of MZs III, IV, and V). Doherty *et al.* (2008, p. 187) reported a strong avoidance of conifers by female greater sage-grouse in the winter, further supporting our previous inference. Also, Freese's (2009, pp. 84-85, 89-90) 2–year telemetry study in central Oregon found that sage-grouse used areas with less than 5 percent juniper cover more often in the breeding and summer seasons than similar habitat that had greater than 5 percent juniper cover. Therefore, pinyon-juniper encroachment into occupied sage-grouse habitat reduces, and likely eventually eliminates, sage-grouse occupancy in these areas.

Pinyon-juniper woodlands are often associated with sagebrush communities and currently occupy at least 18 million ha (44.6 million ac) of the Intermountain West within the sage-grouse's range (Crawford *et al.* 2004, p. 8; Miller *et al.* 2008, p. 1). Pinyon-juniper extent has increased 10-fold in the Intermountain West since European settlement causing the loss of many bunchgrass and sagebrush-bunchgrass communities (Miller and Tausch 2001, pp. 15-16). This expansion has been attributed to the reduced role of fire, the introduction of livestock grazing, increases in global carbon dioxide concentrations, climate change, and natural recovery from past disturbance (Miller and Rose 1999, pp. 555-556; Miller and Tausch 2001, p. 15; Baker, in press, p. 24; see also discussion under Fire above).

Connelly *et al.* (2004, pp. 7-8 to 7-14) estimated that approximately 60 percent of sagebrush in the Great Basin was at low risk of displacement by pinyon-juniper in 30 years, 6 percent at moderate risk, and 35 percent at high risk. Mountain big sagebrush appears to be most at risk of pinyon-juniper displacement (Connelly *et al.* 2004, pp. 7-13). When juniper increases in mountain big sagebrush communities, shrub cover declines and the season of available succulent forbs is shortened due to soil moisture depletion (Crawford *et al.* 2004, p. 8). As with *Bromus tectorum*, the Great Basin appears more susceptible to pinyon-juniper invasion than other areas of the sage-grouse's range; however, Connelly *et al.* (2004, pp. 7-8) cautioned that a formal analysis of the risks posed in other locations was needed before such inferences could be made.

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

Pinyon-juniper expansion into sagebrush habitats, with subsequent replacement of sagebrush communities, has been well documented (Miller *et al.* 2000, p. 575; Connelly *et al.* 2004, p. 7-5; Crawford *et al.* 2004, p. 2; Miller *et al.* 2008, p. 1). However, few studies have documented woodland dynamics at the landscape level across different ecological provinces, creating some uncertainty regarding the total amount of expansion that has occurred in sagebrush communities (Miller *et al.* 2008, p. 1). Regardless, we know that up to 90 percent of existing woodlands in the sagebrush-steppe and Great Basin sagebrush vegetation types were previously dominated by sagebrush vegetation prior to the late 1800s (Miller *et al.*, in press, pp. 23-24). Based on past trends and the current distribution of pinyon-juniper relative to sagebrush habitat, we anticipate that expansion will continue at varying rates across the landscape and cause further loss of sagebrush habitat within the western part of the sage-grouse's range, especially in parts of MZs III, IV, and V.

While pinyon-juniper expansion appears less problematic in the eastern portion of the range (MZs I, II and VII) and silver sagebrush areas (primarily MZ I), woodland encroachment is a threat mentioned in Wyoming, Montana, and Colorado State sage-grouse conservation plans, indicating that this is of some concern in these States as well (Stiver *et al.* 2006, p. 2-23). Colorado's State plan mapped areas threatened by pinyon-juniper encroachment in northwestern Colorado, and specifically attributed some sage-grouse habitat loss in Colorado to pinyon-juniper expansion (Colorado Greater Sage-grouse Steering Committee 2008, pp. 179, 182). Furthermore, LANDFIRE (2007) data illustrates extensive coverage of pinyon-juniper woodlands in parts of northwestern Colorado within the range of sage-grouse. These data also show limited pinyon-juniper coverage in Montana and Wyoming; however, LANDFIRE data could be a major underestimate of juniper because it is difficult to classify pinyon-juniper woodlands with satellite imagery when the trees occur at low densities (Hagen 2005, p. 142).

Recently, many conservation actions have addressed this threat using a variety of techniques (e.g., mechanical, herbicide, cutting, burning) to remove conifers in sage-grouse habitat. The effectiveness of these treatments varies with the technique used and proximity of the site to invasive plant infestations, among other factors. We are not aware of any study documenting a direct correlation between these treatments and increased greater sage-grouse productivity; however, we infer some level of positive response based on Commons *et al.*'s (1999) Gunnison sage-grouse study and the documented avoidance, or reduced use, by sage-grouse of areas where pinyon-juniper has encroached upon sagebrush communities (Doherty *et al.* 2008, p. 187; Freese 2009, pp. 84-85, 89-90). However, since the effectiveness of treatments for sage-grouse is usually based on a short-term, anecdotal evaluation of whether pinyon-juniper was successfully removed from a site, it is unclear whether pinyon-juniper removal has a positive long-term population-level impact for sage-grouse. In most cases it is still too early to measure a population response to these treatments (Oregon Department of Fish and Wildlife (ODFW) 2008, p. 3). Consequently, we do not know if these efforts are effectively ameliorating the threat of pinyon-juniper expansion at the site-level.

Furthermore, while many acres have been treated since 2004, treatments are not likely keeping pace with the current rate of pinyon-juniper encroachment, at least in parts of the range. For example, while Oregon has treated approximately 8,094 ha (20,000 ac) of juniper to restore native sagebrush habitat between 2003 and early 2008 (about 1,619 ha or 4,000 ac per year; ODFW 2008, p. 3), LANDFIRE data show at least 106,882 ha (264,110 ac) of juniper occur within 4.8 km (3 mi) of Oregon leks. This distance (4.8 km; 3 mi) reflects the upper estimate of a typical pinyon seed dispersal event, although seeds may be dispersed shorter distances and up to at least 10 km (6.2 mi) (Chambers *et al.* 1999, p. 12). At this rate, it would take approximately 60 years to remove the threat of juniper encroachment within 3 miles of sage-grouse leks in Oregon, assuming expansion does not continue.

Again, LANDFIRE data provides a gross underestimate of pinyon-juniper since it misses single, large trees. This underestimate suggests that it will take longer than 60 years to fully address the threat of juniper encroachment in

Oregon, if conservation actions continue to occur at the current rate. Furthermore, not all treatments are effective. Of the 38,780 ha (95,826 ac) treated by BLM in Fiscal Year (FY) 2006 and FY 2007, only 21,598 ha (53,369 ac), or 55.7 percent were considered to be effective by the BLM (Carlson 2008b, pers. comm.). Again, the measure of effectiveness typically refers to whether vegetation was treated successfully, and not whether sage-grouse use an area that has been treated.

Summary: Invasive Plants and Pinyon-Juniper Encroachment

Invasives plants negatively impact sage-grouse primarily by reducing or eliminating native vegetation that sage-grouse require for food and cover, resulting in habitat loss and fragmentation. A variety of nonnative annuals and perennials (e.g., Bromus tectorum, Euphorbia esula) and native conifers (e.g., pinyon pine, juniper species) are invasive to sagebrush ecosystems. Nonnative invasives, including annual grasses and other noxious weeds, continue to expand their range, facilitated by ground disturbances such as wildfire, grazing, and infrastructure. Pinyon and juniper and some other native conifers are expanding and infilling their current range mainly due to decreased fire return intervals, livestock grazing, and increases in global carbon dioxide concentrations associated with climate change, among other factors.

Collectively, invasives plants impact the entire range of sage-grouse, although they are most problematic in the Intermountain West and Great Basin (MZs III, IV, V, and VI). A large portion of the Great Basin is at risk of *B. tectorum* invasion or pinyon-juniper encroachment within the next 30 years. Approximately 80 percent of land in the Great Basin Ecoregion (MZs III, IV, and V) is susceptible to displacement by *B. tectorum* within 30 years (Connelly *et al.* 2004, p. 7-17, Suring *et al.* 2005, p. 138). Connelly *et al.* (2004, pp. 7-8 to 7-14) estimated that approximately 35 percent of sagebrush in the Great Basin was at high risk of displacement by pinyon-juniper in 30 years. *Bromus tectorum* is widespread at lower elevations and pinyon-juniper woodlands tend to expand into higher elevation sagebrush habitats, creating an elevational squeeze from both low and high elevations. Climate change will likely alter the range of individual invasive species, increasing fragmentation and habitat loss of sagebrush communities. Despite the potential shifting of individual species, invasive plants will persist and continue to spread rangewide in the foreseeable future.

A variety of restoration and rehabilitation techniques are used to treat invasive plants, but they can be costly and are mostly unproven and experimental. The success of treatments, particularly for annual grassland restoration, depends on uncontrollable factors (e.g., precipitation). While some efforts appear successful at smaller scales, prevention appears to be the only known effective tool to preclude large-scale habitat loss from invasive annuals and perennials in the future. Pinyon-juniper treatments, particularly when done in the early stages of encroachment when sagebrush and forb understory is still intact, have the potential to provide an immediate benefit to sage-grouse. However, studies have not yet documented a correlation between pinyon-juniper treatments and increased greater sage-grouse productivity.

Grazing

Native herbivores, such as pronghorn antelope (*Antilocapra americana*), mule deer (*Odocoileus hemionus*), bison (*Bison bison*), and other ungulates were present in low numbers on the sagebrush-steppe region prior to European settlement of western States (Osborne 1953, p. 267; Miller *et al.* 1994, p. 111), and sage-grouse co-evolved with these animals. However, mass extinction of the majority of large herbivores occurred 10,000 to 12,000 years ago (Knick *et al.* 2003, p. 616; Knick *et al.*, in press, p. 40). From that period up until European settlement, many areas of sagebrush-steppe still did not support herds of large ungulates and grazing pressure was likely sporadic and localized (Miller *et al.* 1994, p. 113; Plew and Sundell 2000, p. 132; Grayson 2006, p. 921). Additionally, plants of the sagebrush-steppe lack traits that reflect a history of large ungulate grazing pressure (Mack and Thompson 1982, pp. 757). Therefore, native vegetation communities within the sagebrush ecosystem evolved in the absence of significant grazing presence (Mack and Thompson 1982, p. 768). With European settlement of western States (1860 to the early 1900s), unregulated numbers of cattle, sheep, and horses rapidly increased, peaking at the turn of the century (Oliphant 1968, p. vii; Young *et al.* 1976, pp. 194-195, Carpenter 1981, p. 106; Donahue 1999, p. 15) with an estimated 19.6 million cattle and 25 million sheep in the West (BLM 2009a, p. 1).

Excessive grazing by domestic livestock during the late 1800s and early 1900s, along with severe drought, significantly impacted sagebrush ecosystems (Knick *et al.* 2003, p. 616). Long-term effects from this overgrazing, including changes in plant communities and soils, persist today (Knick *et al.* 2003, p.116). Currently, livestock grazing is the most widespread type of land use across the sagebrush biome (Connelly *et al.* 2004, p. 7-29); almost all sagebrush areas are managed for livestock grazing (Knick *et al.* 2003, p. 616; Knick *et al.*, in press, p. 27).

Although little direct experimental evidence links grazing practices to population levels of greater sage-grouse (Braun 1987, p. 137; Connelly and Braun 1997, p. 231), the impacts of livestock grazing on sage-grouse habitat and on some aspects of the life cycle of the species have been studied. Sage-grouse need significant grass and shrub cover for protection from predators, particularly during nesting season, and females will preferentially choose nesting sites based on these qualities (Hagen *et al.* 2007, p. 46). The reduction of grass heights due to livestock grazing in sage-grouse nesting and brood-rearing areas has been shown to negatively affect nesting success when cover is reduced below the 18 cm (7 in.) needed for predator avoidance (Gregg *et al.* 1994, p. 165). Based on measurements of cattle foraging rates on bunchgrasses both between and under sagebrush canopies, the probability of foraging on under-canopy bunchgrasses depends on sagebrush morphology, and consequently, the effects of grazing on nesting habitats might be site specific (France *et al.* 2008, pp. 392-393).

Several authors have noted that grazing by livestock could reduce the suitability of breeding and brood-rearing habitat, negatively affecting sage-grouse populations (Braun 1987, p. 137; Dobkin 1995, p. 18; Connelly and Braun 1997, p. 231; Beck and Mitchell 2000, pp. 998-1000). Exclosure studies have demonstrated that domestic livestock grazing reduces water infiltration rates and cover of herbaceous plants and litter, as well as compacting soils and increasing soil erosion (Braun 1998, p. 147; Dobkin *et al.* 1998, p. 213). These impacts result in a change in the proportion of shrub, grass, and forb components in the affected area, and an increased invasion of exotic plant species that do not provide suitable habitat for sage-grouse (Mack and Thompson 1982, p. 761; Miller and Eddleman 2000, p. 19; Knick *et al.*, in press, p. 41).

Livestock also may compete directly with sage-grouse for rangeland resources. Cattle are grazers, feeding mostly on grasses, but they will make seasonal use of forbs and shrub species like sagebrush (Vallentine 1990, p. 226). Domestic sheep are intermediate feeders making high use of forbs, but also using a large volume of grass and shrub species like sagebrush (Vallentine 1990, pp. 240-241). Sheep consume rangeland forbs in occupied sage-grouse habitat (Pederson *et al.* 2003, p. 43) and, in general, forb consumption may reduce food availability for sage-grouse. This impact is particularly important for pre-laying hens, as forbs provide essential calcium, phosphorus, and protein (Barnett and Crawford 1994, p. 117). A hen's nutritional condition affects nest initiation rate, clutch size, and subsequent reproductive success (Barnett and Crawford 1994, p.117; Coggins 1998, p. 30).

Other effects of direct competition between livestock and sage-grouse depend on condition of the habitat and the grazing practices. Thus, the effects vary across the range of the greater sage-grouse. For example, Aldridge and Brigham (2003, p. 30) suggest that poor livestock management in mesic sites, which are considered limited habitats for sage-grouse in Alberta (Aldridge and Brigham 2002, p. 441), results in a reduction of forbs and grasses available to sage-grouse chicks, thereby affecting chick survival.

Other consequences of grazing include several related to livestock trampling of grouse and habitat. Although the effect of trampling at a population level is unknown, outright nest destruction has been documented and the presence of livestock can cause sage-grouse to abandon their nests (Rasmussen and Griner 1938, p. 863; Patterson 1952, p. 111; Call and Maser 1985, p. 17; Holloran and Anderson 2003, p. 309; Coates 2007, p.28). Coates (2007, p. 28) documented nest abandonment following partial nest depredation by a cow. In general all recorded encounters between livestock and grouse nests resulted in hens flushing from nests, which could expose the eggs to predation; there is strong evidence that visual predators like ravens use hen movements to locate sage-grouse nests (Coates 2007, p.33). Livestock also may trample sagebrush seedlings, thereby removing a source of future sage-grouse food and cover (Connelly *et al.* 2004, p. 7-31). Trampling of soil by livestock can reduce or eliminate biological soil crusts making these areas susceptible to *Bromus tectorum* invasion (Mack 1981 as cited in Miller and Eddleman 2000, p. 21; Young and Allen 1997, p. 531).

Some livestock grazing effects may have positive consequences for sage-grouse. Evans (1986, p. 67) found that sage-grouse used grazed meadows significantly more during late summer than ungrazed meadows because grazing had stimulated the regrowth of forbs. Klebenow (1981, p. 121) noted that sage-grouse sought out and used openings in meadows created by cattle grazing in northern Nevada. Also, both sheep and goats have been used to control invasive weeds (Mosley 1996 as cited in Connelly *et al.* 2004, p. 7-49; Merritt *et al.* 2001, p. 4; Olsen and Wallander 2001, p. 30) and woody plant encroachment (Riggs and Urness 1989, p. 358) in sage-grouse habitat.

Sagebrush plant communities are not adapted to domestic grazing disturbance. Grazing changed the functioning of systems into less resilient, and in some cases, altered communities (Knick *et al.*, in press, p. 39). The ability to restore or rehabilitate areas depends on the condition of the area relative to its site potential (Knick *et al.*, in press, p. 39). For example, if an area has a balanced mix of shrubs and native understory vegetation, a change in grazing management can restore the habitat to its potential vigor (Pyke, in press, p. 11). Wambolt and Payne (1986, p. 318) found that rest from grazing had a better perennial grass response than other treatments. Active restoration would be required where native understory vegetation is much reduced (Pyke, in press, p. 15). But, if an area has soil loss and/or invasive species, returning the site to the native historical plant community may be impossible (Daubenmire 1970, p. 82; Knick *et al.*, in press, p. 39; Pyke, in press, p. 17). Aldridge *et al.* (2008, p. 990) did not find any relationship between sage-grouse persistence and livestock densities. However, the authors noted that livestock numbers do not necessarily correlate with range condition. They concluded that the intensity, duration, and distribution of livestock grazing are more influential on rangeland condition than the livestock density values used in their modeling efforts (Aldridge *et al.* 2008, p. 990).

Extensive rangeland treatment has been conducted by federal agencies and private landowners to improve conditions for livestock in the sagebrush-steppe region (Connelly *et al.* 2004, p. 7- 28; Knick *et al.*, in press, p. 28). By the 1970s, over 2 million ha (5 million ac) of sagebrush are estimated to have been mechanically treated, sprayed with herbicide, or burned in an effort to remove sagebrush and increase herbaceous forage and grasses (Crawford *et al.* 2004, p. 12). The BLM treated over 1,800,000 ha (4,447,897 ac) from 1940 to 1994, with 62 percent of the treatment occurring during the 1960s (Miller and Eddleman 2000, p. 20). Braun (1998, p. 146) concluded that, since European settlement of western North America, all sagebrush habitats used by greater sage-grouse have been treated in some way to reduce shrub cover. The use of chemicals to control sagebrush was initiated in the 1940s and intensified in the 1960s and early 1970s (Braun 1987, p. 138). Crawford *et al.* (2004, p. 12) hypothesized that reductions in sage-grouse habitat quality (and possibly sage-grouse numbers) in the 1970s may have been associated with extensive rangeland treatments to increase forage for domestic livestock.

Greater sage-grouse response to herbicide treatments depends on the extent to which forbs and sagebrush are killed. Chemical control of sagebrush has resulted in declines of sage-grouse breeding populations through the loss of live sagebrush cover (Connelly *et al.* 2000a, p. 972). Herbicide treatment also can result in sage-grouse emigration from affected areas (Connelly *et al.* 2000a, p. 973), and has been documented to have a negative effect on nesting, brood carrying capacity (Klebenow 1970, p. 399), and winter shrub cover essential for food and thermal cover (Pyrah 1972 and Higby 1969 as cited in Connelly *et al.* 2000a, p. 973). Conversely, small treatments interspersed with nontreated sagebrush habitats did not affect sage-grouse use, presumably due to minimal effects on food or cover (Braun 1998, p. 147). Also, application of herbicides in early spring to reduce sagebrush cover may enhance some brood-rearing habitats by increasing the coverage of herbaceous plant foods (Autenrieth 1981, p. 65).

Mechanical treatments are designed to either remove the aboveground portion of the sagebrush plant (mowing, roller chopping, and roto-beating), or to uproot the plant from the soil (grubbing, bulldozing, anchor chaining, cabling, railing, raking, and plowing; Connelly *et al.* 2004, p. 17-47). These treatments were begun in the 1930s and continued at relatively low levels to the late 1990s (Braun 1998, p. 147). Mechanical treatments, if carefully designed and executed, can be beneficial to sage-grouse by improving herbaceous cover, forb production, and sagebrush resprouting (Braun 1998, p. 147). However, adverse effects also have been documented (Connelly *et al.* 2000a, p. 973). For example, in Montana, the number of breeding males declined by 73 percent after 16 percent of the 202-km^2 (78- mi^2) study area was plowed (Swenson *et al.* 1987, p. 128). Mechanical treatments in blocks greater than 100 ha (247 ac), or of any size seeded with exotic grasses, degrade sage-grouse habitat by altering the structure and composition of the vegetative community (Braun 1998, p. 147).

The current extent to which mechanical, chemical, and prescribed fire methods are used to remove or control sagebrush is not known, particularly with regard to private lands. However, BLM has stated that with rare exceptions, they no longer are involved in actions that convert sagebrush to other habitat types, and that mechanical or chemical treatments in sagebrush habitat on BLM lands currently focus on improving the diversity of the native plant community, reducing conifer encroachment, or reducing the risk of a large wildfire (see discussion of Fire above; BLM 2004, p. 15).

Historically, the elimination of sagebrush followed with rangeland seedings was encouraged to improve forage for livestock grazing operations (Blaisdell 1949, p. 519). Large expanses of sagebrush removed via chemical and mechanical methods have been reseeded with nonnative grasses, such as crested wheatgrass (*Agropyron cristatum*), to increase forage production on public lands (Pechanec *et al.* 1965 as cited in Connelly *et al.* 2004, p.7-28). These treatments reduced or eliminated many native grasses and forbs present prior to the seedings (Hull 1974, p. 217). Sage-grouse are affected indirectly through the loss of native forbs that serve as food and loss of native grasses that provide concealment or hiding cover (Connelly *et al.* 2004, p. 4-4).

Water developments for the benefit of livestock and wild ungulates on public lands are common (Connelly *et al.* 2004, p. 7-35). Development of springs and other water sources to support livestock in upland shrub-steppe habitats can artificially concentrate domestic and wild ungulates in important sage-grouse habitats, thereby exacerbating grazing impacts in those areas such as heavy grazing and vegetation trampling (Braun 1998, p. 147; Knick *et al.*, in press, p. 42). Diverting the water sources has the secondary effect of changing the habitat present at the water source before diversion. This impact could result in the loss of either riparian or wet meadow habitat important to sage-grouse as sources of forbs or insects. Water developments for livestock and wild ungulates also could be used as mosquito breeding habitat, and thus have the potential to facilitate the spread of West Nile virus (see discussion under Factor C: Disease and Predation).

Another indirect negative impact to sage-grouse from livestock grazing occurs due to the placement of thousands of miles of fences for livestock management purposes (see discussion above under Infrastructure). Fences cause direct mortality through collision and indirect mortality through the creation of predator perch sites, the potential creation of predator corridors along fences (particularly if a road is maintained next to the fence), incursion of exotic species along the fencing corridor, and habitat fragmentation (Call and Maser 1985, p. 22; Braun 1998, p. 145; Connelly *et al.* 2000a, p. 974; Beck *et al.* 2003, p. 211; Knick *et al.* 2003, p. 612; Connelly *et al.* 2004, p. 1-2).

The impacts of livestock operations on sage-grouse depend upon stocking levels, season of use, and utilization levels. Cattle and sheep Animal Unit Months (AUMs) (the amount of forage required to feed one cow with calf, one horse, five sheep, or five goats for 1 month) on all Federal land have declined since the early 1900s (Laycock *et al.* 1996, p. 3). By the 1940s, AUMs on all Federal lands (not just areas occupied by sage-grouse) were estimated to be 14.6 million, increasing to 16.5 million in the 1950s, and gradually declining to 10.2 million by the 1990s (Miller and Eddleman 2000, p. 19). Although AUMs have decreased over time, we cannot assume that the net impact of grazing has decreased because the productivity of those lands has decreased (Knick *et al.*, in press, p. 42). As of 2007, the number of permitted AUMs for BLM lands in States where sage-grouse occur totaled 7,118,989 (Beever and Aldridge, in press, p. 19-20). We estimate that those permitted AUMs occur in approximately 18,783 BLM grazing allotments in sage-grouse habitat (Stoner 2008). Since 2005, 644 (3.4 percent) of those allotments have decreased the permitted AUMs (Service 2008a). However, BLM tracks the number of AUMs permitted rather than the number of AUMs actually used. The number permitted typically is higher than what is used, thus we do not know how the decrease on paper corresponds to the actual number of AUMs for the last four years.

Wild Horse and Burro Grazing

Free-roaming horses and burros have been a component of sagebrush and other arid communities since they were brought to North America at the end of the 16th century (Wagner 1983, p. 116; Beever 2003, p. 887). About 31,000 wild horses occur in 10 western States (including 2 states outside the range of the greater sage-grouse), with herd sizes being largest in Nevada, Wyoming, and Oregon, which are the States with the most extensive sagebrush cover (Connelly *et al.* 2004, p. 7-37). Of about 5,000 burros occur in five western States approximately 700 occur within the SGCA (Connelly *et al.* 2004, p.7-37). Beever and Aldridge (2009, in press, p. 7) estimate that about 12 percent (78, 389 km^2, 30,266 mi^2) of sage-grouse habitat is managed for free-roaming horses and burros. However, the extent to which the equids use land outside of designated management areas is difficult to quantify but may be considerable.

We are unaware of any studies that directly address the impact of wild horses or burros on sagebrush and sage-grouse. However, some authors have suggested that wild horses could negatively impact important meadow and spring brood-rearing habitats used by sage-grouse (Crawford *et al.* 2004, p. 11; Connelly *et al.* 2004, p. 7-37). Horses are generalists, but seasonally their diets can be almost wholly comprised of grasses (Wagner 1983, pp. 119-120). A comparison of areas with and without horse grazing showed 1.9 to 2.9 times more grass cover and higher grass density in areas without horse grazing (Beever *et al.* 2008 as cited Beever and Aldridge in press, p. 11). Additionally, sites with horse grazing had less shrub cover and more fragmented shrub canopies (Beever and Aldridge in press, p. 12). As noted above, sage-grouse need significant grass and shrub cover for protection from predators particularly during nesting season, and females will preferentially choose nesting sites based on these qualities (Hagen *et al.* 2007, p. 46). Sites with grazing also generally showed less plant diversity, altered soil characteristics, and 1.6 to 2.6 times greater abundance of nonnative *Bromus tectorum* (Beever *et al.* 2008 as cited in Beever and Aldridge 2009, in press, p. 13). These impacts combined indicate that horse grazing has the potential to result in an overall decrease in the quality and quantity of sage-grouse habitat in areas where such grazing occurs.

Currently, free-roaming equids consume an estimated 315,000 to 433,000 AUMs as compared to over 7 million AUMs for domestic livestock within the range of greater sage-grouse (Beever and Aldridge, in press, p. 21). Cattle typically outnumber horses by a large degree in areas where both occur; however, locally ratios of 2:1 (horse:cow) have been reported (Wagner 1983, p.126). The local effects of ungulate grazing depend on a host of abiotic and biotic factors (e.g., elevation, season, soil composition, plant productivity, and composition). Additional significant biological and behavioral differences influence the impact of horses as compared to cattle grazing on habitat (Beever 2003, pp.

888-890). For example, due to physiological differences, a horse must forage longer and consumes 20 to 65 percent more forage than would a cow of equivalent body mass (Wagner 1983, p. 121; Menard *et al.* 2002, p.127). Unlike cattle and other ungulates, horses can crop vegetation close to the ground, potentially limiting or delaying recovery of plants (Menard *et al.* 2002, p.127). In addition, horses seasonally move to higher elevations, spend less time at water, and range farther from water sources than cattle (Beever and Aldridge in press, pp. 20, 21). Given these differences, along with the confounding factor of past range use, it is difficult to assess the overall magnitude of the impact of horses on the landscape in general, or on sage-grouse habitat in particular. In areas grazed by both horses and cattle, whether the impacts are synergistic or additive is currently unknown (Beever and Aldridge, in press, p. 21).

Wild Ungulate Herbivory

Native herbivores, such as elk (*Cervus elaphus*), mule deer, and pronghorn antelope coexist with sage-grouse in sagebrush ecosystems (Miller *et al.* 1994, p. 111). These ungulates are present in sagebrush ecosystems during various seasons based on dietary needs and forage availability (Kufeld 1973, p. 106-107; Kufeld *et al.* 1973 as cited in Wallmo and Regelin 1981, p. 387-396; Allen *et al.* 1984, p. 1). Elk primarily consume grasses but are highly versatile in consumption of forbs and shrubs when grasses are not available (Kufeld 1973, pp. 106-107; Vallentine 1990, p. 235). In the winter, heavy snow forces elk to lower-elevation sagebrush areas where they forage heavily on sagebrush (Wambolt and Sherwood 1999, p. 225). Mule deer utilize forbs, shrubs, and grasses throughout the year dependent upon availability and preference (Kufeld *et al.* 1973 as cited in Wallmo and Regelin 1981, pp. 389-396). Pronghorn antelope, most commonly associated with grasslands and sagebrush, consume a wide variety of available shrubs and forbs and consume new spring grass growth (Allen *et al.* 1984, p. 1; Vallentine 1990, p. 236).

We are unaware of studies evaluating the effects of native ungulate herbivory on sage-grouse and sage-grouse habitat. However, concentrated native ungulate herbivory may impact vegetation in sage-grouse habitat on a localized scale. Native ungulate winter browsing can have substantial, localized impacts on sagebrush vigor, resulting in decreased shrub cover or sagebrush mortality (Wambolt 1996, p. 502; Wambolt and Hoffman 2004, p. 195). Additionally, despite decreased habitat availability, elk and mule deer populations are currently higher than pre-European estimates (Wasley 2004, p. 3; Young and Sparks 1985, pp. 67-68). As a result, some States started small-scale supplemental feeding programs for deer and elk. In those localized areas, vegetation is heavily utilized from the concentration of animals (Doman and Rasmussen 1944, p. 319; Smith 2001, pp. 179-181). Unlike domestic ungulates, wild ungulates are not confined to the same area, at the same time each year. Therefore, the impacts from wild ungulates are spread more diffusely across the landscape, resulting in minimal long-term impacts to the vegetation community.

Summary: Grazing

Livestock management and domestic grazing can seriously degrade sage-grouse habitat. Grazing can adversely impact nesting and brood-rearing habitat by decreasing vegetation concealment from predators. Grazing also has been shown to compact soils, decrease herbaceous abundance, increase erosion, and increase the probability of invasion of exotic plant species. Once plant communities have an invasive annual grass understory dominance, successful restoration or rehabilitation techniques are largely unproven and experimental (Pyke, in press, p. 25). Massive systems of fencing constructed to manage domestic livestock cause direct mortality to sage-grouse in addition to degrading and fragmenting habitats. Livestock management also can involve water developments that can degrade important brood-rearing habitat and or facilitate the spread of WNv. Additionally, some research suggests there may be direct competition between sage-grouse and livestock for plant resources. However, although there are obvious negative impacts, some research suggests that under very specific conditions grazing can benefit sage-grouse.

Similar to domestic grazing, wild horses and burros have the potential to negatively affect sage-grouse habitats in areas where they occur by decreasing grass cover, fragmenting shrub canopies, altering soil characteristics, decreasing plant diversity, and increasing the abundance of invasive *Bromus tectorum*.

Native ungulates have coexisted with sage-grouse in sagebrush ecosystems. Elk and mule deer browse sagebrush during the winter and can cause mortality to small patches of sagebrush from heavy winter use. Pronghorn antelope, largely overlapping with sage-grouse habitat year around, consume grasses and forbs during the summer and browse on sagebrush in the winter. We are not aware of research analyzing impacts from these native ungulates on sage-grouse or sage-grouse habitat.

Currently there is little direct evidence linking grazing practices to population levels of greater sage-grouse. However, testing for impacts of grazing at landscape scales important to sage-grouse is confounded by the fact that almost all sage-grouse habitat has at one time been grazed and thus no non-grazed, baseline areas currently exist with which to compare (Knick *et al.* in press, p. 43). Although we cannot examine grazing at large spatial scales, we do know that grazing can have negative impacts to sagebrush and consequently to sage-grouse at local scales. However, how these impacts operate at large spatial scales and thus on population levels is currently unknown. Given the widespread nature of grazing, the potential for population-level impacts cannot be ignored.

Energy Development

Greater sage-grouse populations are negatively affected by energy development activities (primarily oil, gas, and coal-bed methane), especially those that degrade important sagebrush habitat, even when mitigative measures are implemented (Braun 1998, p. 144; Lyon 2000, pp. 25-28; Holloran 2005, pp. 56-57; Naugle *et al.* 2006, pp. 8-9; Walker *et al.* 2007a, p. 2651; Doherty *et al.* 2008, p. 192; Harju *et al.* in press, p. 22). Impacts can result from direct habitat loss, fragmentation of important habitats by roads, pipelines, and powerlines (Kaiser 2006, p. 3; Holloran *et al.* 2007, p. 16), noise (Holloran 2005, p. 56), and direct human disturbance (Lyon and Anderson 2003, p. 489). The negative effects of energy development often add to the impacts from other human development and activities and result in sage-grouse population declines (Harju *et al.* in press, p. 22; Naugle *et al.*, in press, p. 1). For example, 12 years of coal-bed methane gas development in the Powder River Basin of Wyoming has coincided with 79 percent decline in the sage-grouse population (Emmerich 2009, pers. comm.). Population declines associated with energy development result from the abandonment of leks (Braun *et al.* 2002, p. 5; Walker *et al.* 2007a, p. 2649; Clark *et al.* 2008, pp. 14, 16), decreased attendance at the leks that persist (Holloran 2005, pp. 38-39, 50; Kaiser 2006, p. 23; Walker *et al.* 2007a, p. 2648; Harju *et al.* in press, p. 22), lower nest initiation (Lyon 2000, p. 109; Lyon and Anderson 2003, p. 5), poor nest success and chick survival (Aldridge and Boyce 2007, p. 517), decreased yearling survival (Holloran *et al.*, in press, p. 6), and avoidance of energy infrastructure in important wintering habitat (Doherty *et al.* 2008, pp. 192-193).

Nonrenewable Energy Sources

Nonrenewable fossil fuel energy development (e.g., petroleum products, coal) has been occurring in sage-grouse habitats since the late 1800s (Connelly *et al.* 2004, p. 7-28). Interest in developing oil and gas resources in North America has been cyclic based on demand and market conditions (Braun *et al.* 2002, p. 2). Between 2004 and 2008, the exploration and development of fossil fuels in sagebrush habitats increased rapidly as prices and demand were spurred by geopolitical uncertainties and legislative mandates (National Petroleum Council 2007, pp. 5-7). Legislative mandates that were used to effect an increase in energy development include those of the Energy Policy and Conservation Act (EPCA) of 1975 (42 United States Code (U.S.C.) 6201 *et seq.*) to secure energy supplies and increase the availability of fossil fuels. Reauthorization and amendments to the EPCA have occurred through subsequent legislation including the Energy Policy Act of 2000 (Public Law (P.L.) 106-469) that mandates the inventory of Federal nonrenewable resources (42 U.S.C. 6217). The 2005 Energy Policy Act requires identification and resolution of impediments to timely granting of Federal leases and post-leasing development (42 U.S.C. 15851). In addition, the 2005 Energy Policy Act mandated the designation of corridors on Federal lands for energy transport (42 U.S.C. 15926), ordered the identification of renewable energy sources (e.g., wind, geothermal), and provided incentives for development of renewable energy sources (42 U.S.C. 15851).

Global recession starting in 2008 resulted in decreased energy demand and subsequently slowed rate of energy development (Energy Information Administration (EIA) 2009b, p. 2). However, the production of fossil fuels is predicted to regain and surpass the early 2008 levels starting in 2010 (EIA 2009b, p. 109). Forecasts to the year 2030 predict fossil fuels to continue to provide for the United States' energy needs while not necessarily in conventional forms or from present extraction techniques (EIA 2009b, pp. 2-4, 109). Recent concerns about curbing greenhouse gas emissions associated with fossil fuel use are being addressed through government policy, legislation, and advanced technologies and are likely to effect a transition in fuel form (EIA 2009b, pp. 2-3, 78).

The decline in use of conventional fossil fuels for power generation in the future is expected to be supplemented with biomass, unconventional oil and gas, and renewable sources—all of which are existing or potentially available in current sage-grouse habitats (U.S. Department of Energy (DOE) 2006, p. 3; National Petroleum Council 2007, p. 6; BLM 2005a, p. 2-4; National Renewable Energy Laboratory (NREL) 2008a, entire; Idaho National Engineering and Environmental Laboratory 2003, entire; EIA 2009b, pp. 2-4). For example, oil shale and tar sands are unconventional fossil fuel liquids predicted for increased development in the sage-grouse range. Shale sources providing 2 million barrels per day in 2007 are expected to contribute 5.6–6.1 million barrels by 2030 (EIA 2009b, p. 30). Extraction of this resource involves removal of habitat and disturbance similar to oil and gas development (see discussion below). National reserves of oil shale lie primarily in the Uinta–Piceance area of Colorado and Utah (MZs II, III, and VII), and the Green River and Washakie areas of southwestern Wyoming (MZ II). These 1.4 million ha (3.5 million ac) of Federal lands contain an estimated 1.23 trillion barrels of oil—more than 50 times the United States' proven conventional oil reserves (BLM 2008a, p. 2).

Available EPCA inventories detail energy resources in 11 geological basins (DOI *et al.* 2008, entire) in the greater sage-grouse conservation assessment area identified in the 2006 Conservation Strategy (Stiver *et al.* 2006, p. 1-11). Extensive oil and gas reserves are identified in the Williston Basin of western North Dakota, northwestern South Dakota, and eastern Montana; Montana Thrust Belt in west-central Montana; Powder River Basin of northeastern Wyoming and southeastern Montana; Wyoming Thrust Belt of extreme southwestern Wyoming, northern Utah, and southeastern Idaho; Southwest Wyoming Basin including portions of southwestern and central Wyoming, northeastern Utah, and northwestern Colorado; Uinta–Piceance Basin of west-central Colorado and east-central Utah; Eastern Great Basin in eastern Nevada, western Utah, and southern Idaho; and Paradox Basin in south-central and southeastern Utah. Although all these geological basins have some component of sage habitats, the Southwestern Wyoming Basin as defined by EPCA (DOI *et al.* 2008, p. 3-11) is highest in sagebrush-dominated landscapes (Knick *et al.* 2003, pp. 613, 615) and is located in MZ II as described in Stiver *et al.* 2006 (pp. 1-11).

Oil and gas dèvelopment has occurred in the past, with historical well locations concentrated in MZs I, II, III, and VII of Wyoming, eastern Montana, western Colorado, and eastern Utah (IHS Incorporated 2006). Currently, oil, conventional gas, or coal-bed methane development occur across the eastern component of the SGCA. Four geological basins are most affected by a concentration of development—Powder River (MZ I), Williston (MZ I), Southwestern Wyoming (MZ II), and the Uinta–Piceance (MZs II, III, VII) coinciding with the highest proportion of high-density areas of sage-grouse, the greatest number of leks, and the highest male sage-grouse attendance at leks compared with any other area in the eastern part of the range (Doherty *et al.* in press, p. 11). The Powder River Basin in northeastern Wyoming and southeastern Montana is home to an important regional population of the larger Wyoming Basin populations, which represents 25 percent of the sage-grouse in the species' range (Connelly *et al.* 2004, p. A4-37). The Powder River Basin serves as a link to peripheral populations in eastern Wyoming and western South Dakota and between the Wyoming Basin and central Montana. The Pinedale Anticline Project is in the Greater Green River area of the Southwest Wyoming Basin where the subpopulation in southwestern Wyoming and northwestern Colorado has been a stronghold for sage-grouse with some of the highest estimated densities of males per square kilometer anywhere in the remaining range of the species (Connelly *et al.* 2004, pp. 6-62, A5-23). The southwestern Wyoming-northwestern Colorado subpopulation has historically supported more than 800 leks (Connelly *et al.* 2004, p. 6-62). The preservation of large contiguous blocks or interconnected patches of habitats that exist in southwestern Wyoming is considered a conservation priority for sage-grouse (Knick and Hanser in press, p. 31).

Extensive development and operations are occurring in sage-grouse habitats where the number of producing wells has tripled in the past 30 years (Naugle *et al.*, in press, p. 17). More than 8 percent of the distribution of sagebrush habitats is directly or indirectly affected by oil and gas development and associated pipelines (Knick *et al.* in press, p. 48). Forty-four percent of the 16-million-ha (39-million-ac) Federal mineral estate in MZs I and II is leased and authorized for exploration and development (Naugle *et* *al.* in press, pp. 17-18). Wyoming contains the highest percentage of the Federal mineral estate with 10.6 million ha (26.2 million ac); 52 percent of it is authorized for development (Naugle *et al.*, in press, pp. 17-18). Other Federal mineral estates in the eastern portion of the sage-grouse conservation assessment area that are authorized for development include at least 27 percent of Montana's 3.7 million ha (9.1 million ac), 50 percent of 915,000 ha (2.3 million ac) in Colorado, 25 percent of 405,000 ha (1.0 million ac) in Utah, and 14 percent of North and South Dakota's combined 365,000 ha (902,000 ac) (Naugle *et al.* in press, p. 38).

The Great Plains MZ (MZ I) contains all or portions of the 20.9-million-ha (51.7-million-ac) Powder River and Williston geological basins identified as significant oil and gas resources. The resource areas include 7.2 million ha (18.2 million ac) of sagebrush habitats. Oil and gas infrastructure and planned development occupies less than 1 percent of the land area in MZ I; however, the ecological effect is greater than 20 percent of the sagebrush habitat, based on applying a buffer zone to estimate the potential the distance of sage-grouse response to infrastructure (Lyon and Anderson 2003, p. 489; Knick *et al.*, in press, p. 133). Energy development is concentrated in the Powder River geologic basin in northeastern Wyoming and southeastern Montana. Coal-bed natural gas extraction is the most recent development in the Powder River Basin, which also is the largest actively producing coal basin in the United States (Wyoming Mining Association 2008, p. 2).

In 2002, the BLM in Wyoming proposed development of 39,367 coal-bed methane wells and 3,200 conventional oil or gas wells in the Powder River Basin in addition to an existing 12,024 coal-bed methane wells drilled or permitted (BLM 2002, pp. 2-3). Wells would be developed over a 10-year period with production lasting until 2019 (BLM 2002, p. 3). The BLM estimated 82,073 ha (202,808 ac) of surface disturbance from all activities such as well pads, pipelines, roads, compressor stations, and water handling facilities over a 3.2-million-ha (8-million-ac) project area (BLM 2002, p. 2). Roads and water handling facilities were expected to be long-term disturbances encompassing approximately 38,501 ha (95,140 ac) (BLM 2002, p. 3). Reclamation of well sites was expected to be complete by 2022 (BLM 2002, p. 3). It is not clear if this 2022 date takes into consideration the length of time necessary to achieve suitable habitat conditions for sage-grouse or if restoration of sage-grouse habitat is possible.

Between 1997 and 2007, approximately 35,000 producing wells were in place on Federal, State, and private holdings in the Powder River Basin area (Naugle *et al.*, in press, p. 7). In 2008, the BLM in Montana completed a supplement to the 2003 Environmental Impact Statement (EIS) and Record of Decision (ROD) to allow for 5,800–16,500 new coal bed methane wells in the Montana portion of the Powder River Basin over the pursuant 20 years (BLM 2008b, pp. 4.2, 4.4-4.5). The BLM estimated a direct impact of 0.8–1.3 ha (2–3.4 ac) per well site (BLM 2008b, p. 4.11). In addition to the well footprint, each additional group of 2–10 wells has been shown to increase the number of new roads, power lines, and other infrastructure (Naugle *et al.* in press, p. 7). Ranching, tillage agriculture, and energy development are the primary land uses in the Powder River Basin. The presence of human features and road densities are high in areas where all three activities coincide to the level that every 0.8 ha (0.5 mi) could be bounded by a road and bisected by a power line (Naugle *et al.* in press, p. 9).

The Powder River Basin serves as a link to peripheral sage-grouse populations in eastern Wyoming and western South Dakota and between the Wyoming basin and central Montana. This connectivity is expected to be lost in the near future because of the intensity of development in the region. Sage-grouse populations have declined in the Powder River Basin by 79 percent since the development of coal-bed methane resources (Emmerich 2009, pers. comm.). In the Powder River Basin between 2001 and 2005, sage-grouse lek-count indices declined by 82 percent inside gas fields compared to 12 percent outside development (Walker *et al.* 2007a, p. 2648). By 2004–2005, fewer leks remained active (38 percent) inside gas fields compared to leks outside fields (84 percent) (Walker *et al.* 2007a, p. 2648). Sage-grouse are less likely to use suitable wintering habitat with abundant sagebrush when coal-bed methane development is present (Doherty *et al.* 2008, p. 192). At current maximum permitted well density (12 wells per 359 ha (888 ac)), planned full-field development will impact the remaining wintering habitat in the basin (Doherty *et al.* 2008, pp. 192, 194) and lead to extirpation.

Energy development in the Powder River Basin is predicted to continue to actively reduce sage-grouse populations and sagebrush habitats over the next 20 years based on the length of development and production projects described in existing project and management plans. The BLM concluded that sage-grouse habitats would not be restored to pre-disturbance conditions for an extended time (BLM 2003, p. 4-268). Sagebrush restoration after development is difficult to achieve, and successful restoration is not assured as described above (Habitat Description and Characteristics).

The 9.6-million-ha (23.9-million-ac) Williston Basin underlies the northeastern corner of the current sage-grouse range in Montana, North and South Dakota. It is another energy resource area experiencing concentrated oil and gas development in MZ I. Oil production has occurred in the Williston Basin for at least 80 years with oil production peaking in the 1980s (Advanced Resources International 2006, p. 3-3). Advances in technology including directional drilling and coal-bed methane technology have boosted development of oil and gas in the basin (Advanced Resources International 2006, p. 3.2; Zander 2008, p. 1). Large, developed fields are concentrated in the Bowdoin Dome area of north-central Montana and the 193-km (120-mi) long Cedar Creek Anticline area of southeastern Montana, southwestern North Dakota, and northwestern South Dakota. Extensive energy development in the Cedar Creek Anticline area could be isolating the very small North Dakota population from sage-grouse populations in central Montana and the northern Powder River Basin.

One hundred and thirty-six wells were put into production in 2008–2009 in major oil and gas fields of the Williston Basin north of the Missouri River in the range of the Northern Montana sage-grouse population (Montana Department of Natural Resources 2009, entire) including the Bowdoin Dome area. The Bowdoin Dome area is populated by more than 1,500 gas wells with associated infrastructure, and an additional 1,200 new or replacement wells were approved in the remaining occupied active sage-grouse habitat (BLM 2008c, pp. 1, 3-127 to 3-129). Active drilling operations are expected to occur over 10–15 years, and gas production is expected to extend the project life 30–50 additional years (BLM 2008c, p. 1). The BLM's project description does not take into consideration the time period necessary to restore native sagebrush communities to suitability for sage-grouse. Energy extraction, ranching, and tillage agriculture coincide in this area of the State described by Leu and Hanser (in press, p. 44) as experiencing high-intensity human activity that is consistent with lek loss and population decline (Wisdom *et al.*, in press, p. 23). Energy development in Montana has contributed to post-settlement sage-grouse range contraction and possibly the geographic separation of the existing subpopulations in northern Montana and Canada. Foreseeable development is expected to further reduce the remaining sage-grouse habitat within developed oil and gas fields, and contribute to future range and population reductions (Copeland *et al.* 2009, p. 5).

Southwestern and central Wyoming and northwestern Colorado in MZ II has been considered a stronghold for sage-grouse with some of the highest estimated densities of males anywhere in the remaining range of the species (Connelly *et al.* 2004, pp. 6-62, A5-23). Wisdom *et al.* (in press, p. 23) identified this high-density sagebrush area as one of the highest priorities for conservation consideration as it comprises one of two remaining areas of contiguous range essential for the long-term persistence of the species. The Southwestern Wyoming geological basin also is experiencing significant growth in energy development which, based on the conclusions of recent investigations on the effects of oil and gas development, is expected over time to reduce sage-grouse habitat, increase fragmentation, and decrease and isolate sage-grouse populations leading to extirpations.

Oil, gas, and coal-bed methane development is occurring across MZ II, and development is concentrated in some areas. Intensive development and production is occurring in the Greater Green River area in southwestern Wyoming and northern Colorado and northeastern Utah. The BLM published a ROD in 2000 for the Pinedale Anticline Project Area in southwestern Wyoming (BLM 2000, entire). The project description included up to 900 drill pads, including dry holes, over a 10- to 15–year development period (BLM 2008d, p. 4-4). By the end of 2005, approximately 457 wells on 322 well pads were under production (BLM 2008d, p. 6). In 2008, the BLM amended the project to accommodate an accelerated rate of development exceeding that in the 2002 project description (BLM 2008d, p. 4). Approximately 250 new well pads are proposed in addition to pipelines and other facilities (BLM 2008d, p. 36). Total initial direct disturbance acres for the entire Pinedale project are approximately 10,400 ha (25,800 ac) with more than 7,200 ha (18,000 ac) in sagebrush land cover type (BLM 2008d, p. 4-52).

The Jonah Gas Infill Project also is underway in the Pinedale Anticline area of the Southwest Wyoming Basin that expands on the Jonah Project started in 2000. In 2006, the BLM issued a ROD and EIS to extend the existing project to an additional 3,100 wells and up to 6,556 ha (16,200 ac) of new surface disturbance (BLM 2006, p. 2-4). In addition, at least 64 well pads would be situated per 259 ha (640 ac), and up to 761 km (473 mi) of pipeline and roads, 56 ha (140 ac) of additional disturbance for ancillary facilities (p. 2-5) also would occur. The project life of 76 years includes 13 years of development and 63 years of production (BLM 2006, p. 2-15). The project description requires reclamation of disturbed sites and establishment of stabilizing vegetation by 1 year post-reclamation (BLM 2006, p. 2-24) and standard lease stipulations to protect sage-grouse. This project is located in high-density sage-grouse habitat, but it is not clear from the project description if suitable sage-grouse habitat is the reclamation goal. Therefore, sagebrush habitats, and the associated sage-grouse are likely to be lost.

Knick *et al.* (in press, pp. 49, 128) reviewed BLM documents for the Greater Green River Basin area, which includes the Pinedale and Jonah projects, and reported that 6,185 wells have been drilled, and there are agency plans for more than 9,300 wells and associated infrastructure. Existing and planned energy development influences over 20 percent of the sagebrush area in the Wyoming Basin (MZ II) (Knick *et al.*, in press, p. 133). Drilling, gas production, and traffic on main haul roads have all been shown to affect lek attendance and lek persistence when it coincides with breeding habitat within 3.2 km (2 mi) (Holloran 2005, p. 40; Walker *et al.* 2007a, p. 2651). Using 2006 well point data and, therefore, a conservative estimate as oil exploration and development experienced significant growth between 2006 and 2008, we calculated that 21 to 35 percent of active breeding habitat for subpopulations in the Southwest Wyoming geological basin may be negatively impacted by the proximity of energy development (Service 2008b).

In the Greater Green River Basin area, yearling male sage-grouse reared near gas field infrastructure had lower survival rates and were less likely to establish breeding territories than males with less exposure to energy development; yearling female sage-grouse avoided nesting within 950 m (0.6 mi) of natural gas infrastructure (Holloran *et al.*, in press, p. 6). The fidelity of sage-grouse to natal sites may result in birds staying in areas with development but they do not breed (Lyon and Anderson 2003, p. 49; Walker *et al.* 2007a, p. 2651; Holloran *et al.*, in press, p. 6). The effect of energy development on sage-grouse population numbers may then take 4 to 5 years to appear (Walker *et al.* 2007a, p. 2651). Copeland *et al.* (2009, p. 5) depicted an extensive development scenario for southwest Wyoming, northern Colorado, and northeastern Utah based on known reserves and existing project plans that indicates an intersection between future oil and gas development and high-density sage-grouse core areas that could result in 6.3 to 24.1 percent decrease in sage-grouse numbers over the next 20 years in MZ II (Copeland 2010, pers. comm.).

The Greater Green River area of southwest Wyoming and the Uintah–Piceance basin (discussed below) also are, in addition to oil and gas, important reserves of oil shale and tar sands that are expected to supply more of the nation's resource needs in the future (EIA 2009b, p. 30). The Uintah–Piceance geologic basin includes the Colorado Plateau (MZ VII) and overlaps into the southern edge of the Wyoming Basin (MZ II). Sage-grouse in this part of the range are reduced to four small, isolated populations, a likely consequence of urban and agricultural development (Knick *et al.*, in press, pp. 106-107; Leu and Hanser, in press, p. 15). All four populations are threatened by environmental, demographic, and genetic stochasticity due to their small population sizes as well as housing and energy development, predation, disease, and conifer invasion (Garton *et al.*, in press, p. 7; Petch 2009, pers. comm.; Maxfield 2009, pers. comm.) although population data are limited for most of this area (Garton *et al.*, in press, p. 63).

Based on applying a 3 km (1.9 mi) buffer to construction areas, Knick *et al.* (in press, p. 133) estimate existing energy development affects over 30 percent of sagebrush habitats in this area. In the past 4 years, the number of oil and gas wells increased in sage-grouse habitats of northwestern Colorado and northeastern Utah by 325 and 870 wells, respectively (Service 2008c). More than 1,370 wells were completed in Uintah (location of the two Utah populations) and Duchesne Counties of northeast Utah between July 2008 and August 2009 (Utah Oil and Gas Program 2009, entire), and approximately 7,700 wells are active in the counties (Utah DNRC 2009, entire). We expect that the development of energy resources will continue based on available reserves and recent development history (Copeland *et al.* 2009, p. 5), and development will further stress the persistence of these small populations at the southern edge of the sage-grouse range.

Using GIS analysis, we calculated that 70 percent of the sage-grouse breeding habitat is potentially impacted by oil and gas development in the Powder River Basin (Service 2008b). The 70 percent figure was derived from well point data supplied by the BLM, buffered by 3.2 km (2 mi), and intersecting these areas with known lek locations buffered to 6.4 km (4 mi). The 70 percent figure is conservative because the most comprehensive well point data set available was 2 years old and did not reflect the rapid development that occurred in 2008. Breeding habitat is defined as a 6.4-km (4-mi) radius around known lek points and includes the range of the average distances between nests and nearest lek (Autenrieth 1981, p. 18; Wakkinen *et al.* 1992, p. 2).

The effects of oil and gas development, as described in detail later in this section, are likely to continue for decades even with the current protective or mitigative measures in place. Based on a review of project EISs, Connelly *et al.* (2004, p. 7-41) concluded that the economic life of a coal-bed methane well averages 12–18 years and 20–100 years for deep oil and gas wells. A recent review of energy projects in development, primarily gas and coal-bed methane, supports these timeframes (BLM 2008b, p. 4-2; 2008c, p. 2; 2009b, p. 2). In addition, many energy projects are tiered to the 20–year land use plans developed by individual BLM field offices or districts to guide development and other activities.

The BLM is the primary Federal agency managing the United States' energy resources and has the legal authority to regulate and condition oil and gas leases and permits. Although the restrictive stipulations that BLM applies to permits and leases are variable, a 0.4-km (0.25-mi) radius around sage-grouse leks is generally restricted to no surface occupancy (NSO) during the breeding season, and noise and development activities are often limited during the breeding season within a 0.8- to 3.2-km (0.5 to 2-mi) radius of sage-grouse leks. As stated above, the BLM's NSO buffer stipulation is ineffective in protecting sage-grouse (Walker *et al.* 2007a, p. 2651), and it is not applied or applicable to all development sites (see discussion under Factor D). We estimated the sage-grouse breeding habitat impacted within 0.4 km (0.25 mi) of a producing well or drilling site with an approved BLM permit using 2006 well-site locations (the most comprehensive data available to us). Figures derived from the 2006 data are conservative because the rapid pace of development in 2007 and 2008 is not reflected. Within 16.2 million ha (38 million ac) of sage-grouse breeding habitat in MZs I and II (where 65 percent of all sage-grouse reside), approximately 1.7 million ha (4.2 million ac) or 10 percent are within 0.4 km (0.25 mi) of a producing well, drilling operation or site (Service 2008d). Walker *et al.* (2007a, p. 2651) reported negative impacts on lek attendance of coal-bed methane development within 0.8 km (0.5 mi) and 3.2 km (2 mi) of a lek, and Holloran (2005, pp. 57-60) observed that the influence of producing well sites and mail haul roads on lek attendance extended to at least 3 km (2 mi). Expanding our analysis area from 0.4 km (0.25 mi) to include breeding habitat within 3 km (2 mi) of producing well or drilling sites with an approved BLM permit, we determined that 40 percent of the sage-grouse breeding habitat in MZs I and II is potentially affected by oil or gas development (Service 2008b).

In some cases, localized areas are experiencing higher levels of effects. Seventy percent of the sage-grouse breeding habitat is within 3 km (2 mi) of development in the Powder River Basin of northeastern Wyoming and southeastern Montana (Service 2008b), where Walker *et al.* (2007, p. 2651) concluded that full-field development would reduce the probability of lek persistence from 87 to 5 percent. Our analyses show that subpopulations of sage-grouse in MZ II have up to 35 percent of breeding habitat within 3.2 km (2 mi) of development, and where data are available for populations in the Uintah–Piceance Basin of Colorado and Utah, 100 percent of the breeding habitat is affected by oil and gas development (Service 2008b). Additionally these calculations do not take into account the added effects of loss of habitat or habitat effectiveness resulting from the increasing level of renewable energy development or other anthropogenic factors occurring in concert with oil and gas development, such as agricultural tillage, urban expansion, or predation, fire, and invasives (see discussions under those headings).

Energy development impacts sage-grouse and sagebrush habitats through direct habitat loss from well pad, access construction, seismic surveys, roads, powerlines, and pipeline corridors; indirectly from noise, gaseous emissions, changes in water availability and quality, and human presence; and the interaction and intensity of effects could cumulatively or individually lead to fragmentation (Suter 1978, pp. 6-13; Aldridge 1998, p. 12; Braun 1998, pp. 144-148; Aldridge and Brigham 2003, p. 31; Knick *et al.* 2003, pp. 612, 619; Lyon and Anderson 2003, pp. 489-490; Connelly *et al.* 2004, pp. 7-40 to 7-41; Holloran 2005, pp. 56-57; Holloran 2007, pp. 18-19; Aldridge and Boyce 2007, pp. 521-522; Walker *et al.* 2007a, pp. 2652-2653; Zou *et al.* 2006, pp. 1039-1040; Doherty *et al.* 2008, p. 193; Leu and Hanser, in press, p. 28).

The development of oil and gas resources requires surveys for economically recoverable reserves, construction of well pads and access roads, subsequent drilling and extraction, and transport of oil and gas, typically through pipelines. Ancillary facilities can include compressor stations, pumping stations, electrical generators, and powerlines (Connelly *et al.* 2004, p. 7-39; BLM 2007c, p. 2-110). Surveys for recoverable resources occur primarily through seismic activities, using vibroesis buggies (thumpers) or shothole explosives. Well pads vary in size from 0.10 ha (0.25 ac) for coal-bed natural gas wells in areas of level topography to greater than 7 ha (17.3 ac) for deep gas wells and multiwell pads (Connelly *et al.* 2004, p. 7-39; BLM 2007c, p. 2-123). Pads for compressor stations require 5–7 ha (12.4–17.3 ac) (Connelly *et al.* 2004, p. 7-39).

Well densities and spacing are typically designed to maximize recovery of the resource and are administered by State oil and gas agencies and the BLM, the Federal agency charged with administering the nation's Federal mineral estate (Connelly *et al.* 2004 pp. 7-39 to 7-40). Well density on BLM-administered lands is incorporated in land use plans and often based on the spacing decision of individual State oil and gas boards. Each geologic basin has a standard spacing, but exemptions are granted. Density of wells for current major developments in the sage-grouse range vary from 1 well per 2 ha (5ac) to 1 well per 64 ha (158 ac) (Knick *et al.*, in press, pp. 128). Greater sage-grouse respond to the density and distribution of infrastructure on the landscape. Holloran (2005, pp. 38-39, 50) reported that male sage-grouse attendance at leks decreased over 23 percent in gas fields where well density was 5 or more within 3 km (1.9 mi). Sage-grouse are less likely to occupy areas with wells at a 32 ha (80 ac) spacing than a 400 ha (988 ac) spacing (Doherty *et al.* 2008, p. 193).

Direct habitat loss from the human footprint contributes to decreased population numbers and distribution of the greater sage-grouse (Knick *et al.* 2003, p. 1; Connelly *et al.* 2004, p. 7-40; Aldridge *et al.* 2008, p. 983; Copeland *et al.* 2009, p. 6; Knick *et al.*, in press, p. 60; Leu and Hanser, in press, p. 5). The footprint of energy development contributes to direct habitat loss from construction of well pads, roads, pipelines, powerlines, and through the crushing of vegetation during seismic surveys. The amount of direct habitat loss within an area is ultimately determined by well densities and the associated loss from ancillary facilities.

The ecological footprint is the extended effect of the infrastructure or activity beyond its physical footprint and determined by a physical or behavioral response of the sage-grouse. The physical footprint of oil and gas infrastructure including pipelines is estimated to be 5 million ha (1.2 million ac) and less than 1 percent of the SGCA (Knick *et al.*, in press, p. 133). However, the estimated ecological footprint is more than 13.8 million ha (34.2 million ac) or 6.7 percent of the SGCA (Knick *et al.*, in press, p. 133) based on applying a buffer zone to estimate potential avoidance, increased mortality risk, and lowered fecundity in the vicinity of development (Lyon and Anderson 2003, p. 459; Walker *et al.* 2007a, p. 2651; Holloran *et al.* in press, p. 6). Based on their method, Knick *et al.* (in press, p. 133) estimated more than 8 percent of sagebrush habitats within the SGCA are affected by energy development. The MZs with concentrations of oil and gas development have a higher estimated percentage of sagebrush habitats affected: 20 percent of the Great Plains (MZ I), 20 percent of the Wyoming Basin (MZ II), and 29 percent of the Colorado Plateau (MZ VII) (Knick *et al*, in press, p. 133). Copeland *et al.* (2009, p. 6) predict a scenario with a minimum of 2.3 million additional ha (5.7 million ac) directly impacted by oil and gas development by the year 2030. The corresponding ecological footprint is likely much larger. The projected increase in oil and gas energy development within the sage-grouse range could reduce the population by 7 to 19 percent from today's numbers (Copeland *et al.* 2009, p. 6). This projection does not reflect the effects of the increased development of renewable energy sources.

Roads associated with oil and gas development were suggested to be the primary impact to greater sage-grouse due to their persistence and continued use even after drilling and production ceased (Lyon and Anderson 2003, p. 489). Declines in male lek attendance were reported within 3 km (1.9 mi) of a well or haul road with a traffic volume exceeding one vehicle per day (Holloran 2005, p. 40; Walker *et al.* 2008a, p. 2651). Sage-grouse also may be at increased risk for collision with vehicles simply due to the increased traffic associated with oil and gas activities (Aldridge 1998, p. 14; BLM 2003, p. 4-222).

Habitat fragmentation resulting from oil and gas development infrastructure, including access roads, may have effects on sage-grouse greater than the associated direct habitat losses. The Powder River Basin infrastructure footprint is relatively small (typically 6-8 ha per 2.6 km^2 (15-20 ac per section)). Considering the mostly contiguous nature of the project area, the density of facilities could affect sage-grouse habitats on over 2.4 million ha (5.9 million ac). Energy development and associated infrastructure works cumulatively with other human activity or development to decrease available habitat and increase fragmentation. Walker *et al.* (2007, p. 2652) determined that leks had the lowest probability of persisting (40–50 percent) in a landscape with less than 30 percent sagebrush within 6.4 km (4 mi) of the lek. These probabilities were even less in landscapes where energy development also was a factor.

Noise can drive away wildlife, cause physiological stress, and interfere with auditory cues and intraspecific communication. Aldridge and Brigham (2003, p. 32) reported that, in the absence of stipulations to minimize the effects of noise, mechanical activities at well sites may disrupt sage-grouse breeding and nesting activities. Hens bred on leks within 3 km (1.9 mi) of oil and gas development in the upper Green River Basin of Wyoming selected nest sites with higher total shrub canopy cover and average live sagebrush height than hens nesting away from disturbance (Lyon 2000, p. 109). The author hypothesized that exposure to road noise associated with oil and gas drilling may have been one cause for the difference in habitat selection. However, noise could not be separated from the potential effects of increased predation resulting from the presence of a new road. In the Pinedale Anticline area of southwest Wyoming, lek attendance declined most noticeably downwind from a drilling rig indicating that noise likely affected male presence (Holloran 2005, p. 49).

Above-ground noise is typically not regulated to mitigate effects to sage-grouse or other wildlife (Connelly *et al.* 2004, p. 7-40). Ground shock from seismic activities may affect sage-grouse if it occurs during the lekking or nesting seasons (Moore and Mills 1977, p. 137). We are unaware of any research on the impact of ground shock to sage-grouse.

Water quality and quantity may be affected by oil and gas development. In many large field developments, the contamination threat is minimized by storing water produced by the gas dehydration process in tanks. Water also may be depleted from natural sources for drilling or dust suppression purposes. Concentrating wildlife and domestic livestock may increase habitat degradation at remaining water sources. Negative effects of changes in water quality, availability, and distribution are a reduction in habitat quality (e.g., trampling of vegetation, changes in water filtration rates), and habitat degradation (e.g., poor vegetation growth), which could result in brood habitat loss. However, we have no data to suggest that this, by itself, is a limiting factor to sage-grouse.

Water produced by coal-bed methane drilling may benefit sage-grouse through expansion of existing riparian areas and creation of new areas (BLM 2003, p. 4-223). These habitats could provide additional brood rearing and summering habitats for sage-grouse. However, the increased surface-water on the landscape may negatively impact sage-grouse populations by providing an environment for disease vectors (Walker and Naugle in press, p. 13). Based on the 2002 discovery of WNv in the Powder River Basin, and the resulting mortalities of sage-grouse (Naugle *et al.* 2004, p. 705), there is concern that produced water could have a negative impact if it creates suitable breeding reservoirs for the mosquito vector of this disease (see also discussion in Factor C, Disease and Predation). Produced water also could result in direct habitat loss through prolonged flooding of sagebrush areas, or if the discharged water is of poor quality because of high salt or other mineral content, either of which could result in the loss of sagebrush or grasses and forbs necessary for foraging broods (BLM 2003, p. 4-223).

Air quality could be affected where combustion engine emissions, fugitive dust from road use and wind erosion, natural gas-flaring, fugitive emissions from production site equipment, and other activities (BLM 2008d, p. 4-74) occur in sage-grouse habitats. Presumably, as with surface mining, these emissions are quickly dispersed in the windy, open conditions of sagebrush habitats (Moore and Mills 1977, p. 109), minimizing the potential effects on sage-grouse. However, high-density development could produce airborne pollutants that reach or exceed quality standards in localized areas for short periods of time (BLM 2008d, pp. 4-82 to 4-88). Walker (2008, entire) characterized emissions from well flaring in the Pinedale Anticline area of Sublette County, Wyoming. The investigator suggested a comprehensive study be conducted by regulatory agencies of the potential health effects of alkali elements in combusted well-plume material (Walker 2008, entire). No information is available regarding the effects to sage-grouse of gaseous emissions produced by oil and gas development.

Increased human presence resulting from oil and gas development can impact sage-grouse either through avoidance of suitable habitat, disruption of breeding activities, or increased hunting and poaching pressure (Braun *et al.* 2002, pp. 4-5; Aldridge and Brigham 2003, pp. 30-31; Aldridge and Boyce 2007, p. 518; Doherty *et al.* 2008, p. 194). Sage-grouse also may be at increased risk for collision with vehicles simply due to the increased traffic associated with oil and gas activities (BLM 2003, p. 4-216).

Negative effects of direct habitat disturbance can be offset by successful reclamation. Reclamation of areas disturbed by oil and gas development can be concurrent with field development or conducted after the shut-in or abandonment of the well or field. Sage-grouse may repopulate the area as disturbed areas are reclaimed. However, there is no evidence that populations will attain their previous size, and reestablishment may take 20 to 30 years (Braun 1998, p. 144). For most developments, return to pre-disturbance population levels is not expected due to a net loss and fragmentation of habitat (Braun *et al.* 2002, p. 150). After 20 years, sage-grouse have not recovered to pre-development numbers in Alberta, even though well pads in these areas have been reclaimed (Braun *et al.* 2002, pp. 4-5). In some reclaimed areas, sage-grouse have not returned (Aldridge and Brigham 2003, p. 31).

Mining

Mining began in the range of the sage-grouse before 1900 (State of Wyoming, 1898; U.S. Census 1913, p. 187) and continues today. Currently, surface and subsurface mining activities for numerous resources are conducted in all 11 States across the sage-grouse range. We do not have comprehensive information on the number or surface extent of mines across the range, but the development of mineral resources is occurring in sage-grouse habitats and is important to the economies of a few of the States. Nevada (MZs III, IV, and V) is ranked second in the United States in terms of value of overall nonfuel mineral production in 2006 (USGS 2006, p. 10). Wyoming (MZs I and II) is the largest coal producer in the United States, and the top ten producing mines in the country are located in Wyoming's Powder River Basin (MZ I) (Wyoming Mining Association 2008, p. 2). A preliminary estimate of at least 9.9 km² (3.8 mi²) of occupied sage-grouse habitat will be directly impacted by new or expanded mining operations, currently in the planning phase, for coal in Montana (MZ I) and Utah (MZ III), for phosphate in Idaho (MZ IV), and uranium in Nevada (MZ IV) and Wyoming (MZs I and II) (Service 2008b).

Uranium mining and milling has occurred in Wyoming, Utah, and Colorado, and Nevada within the greater sage-grouse conservation area; however, recent production has been very limited with only one operation in production in Wyoming (EIA 2009c, entire). Tax credits indicated in the 2005 Energy Policy Act and concerns for green-house gas emissions associated with fossil-fuel electricity generation are expected to increase nuclear power generation (EIA 2009b, p. 73) and stimulate the demand for uranium. Electricity supplied by nuclear plants is expected to increase 2–55 percent by 2030; the increase is dependent on variables such as construction costs and regulatory mandates (EIA 2009b, p. 52), which are difficult to predict. In 2009, industry announced the intent to pursue development (Peninsula Minerals 2009, entire), and the Nuclear Regulatory Commission announced the review of numerous new uranium facilities in Wyoming (74 FR 41174, Uaugust 14, 2009; 74 FR 45656, September 3, 2009). Areas in central Wyoming and Wyoming's Powder River Basin are considered major reserves of uranium coinciding with areas of high sage-grouse population densities (Finch 1996, pp. 19-20; Wyoming State Governor's Sage-grouse Implementation Team 2008, entire).

Bentonite mining has been conducted on over 85 km² (33 mi²) in the Bighorn Basin of north-central Wyoming (EDAW, Inc. and BLM 2008, p. 1). Bentonite is a primary component of oil and gas drilling muds. The loss of sagebrush associated with bentonite mining has been intensive on a localized level and has contributed to altering 12 percent of the sagebrush habitats in the 2,173 km² (839 mi²) Bighorn Basin (EDAW Inc., and BLM 2008, p. 2). Restoration efforts at mine sites have been mostly unsuccessful (EDAW, Inc. and BLM 2008, p. 1). The BLM foresees up to 89 additional km² (34 mi²) to be disturbed by bentonite mining in the area through 2024, in addition to possible oil and gas and energy transmission disturbances (EDAW, Inc. and BLM 2008, p. 2; BLM 2009c, p. 5).

Between 2006 and 2007, surface coal production decreased 9 percent in Colorado while increasing by 1.6 and 4.4 percent in Wyoming (MZ I) and Montana (MZ I), respectively (EIA 2008a, entire). The number of Wyoming coal mines increased from 19 in 2005 to 23 in 2008 (Wyoming Mining Association 2005, p. 5). All of Wyoming's 23 coal mines are in sagebrush and in the SGCA. Sixteen of these mines are located in the Powder River Basin (MZ I) where oil and gas development is extensive (Wyoming Mining Association 2008, p. 2).

Coal mining in Montana is focused in the Powder River Basin just north of the Wyoming border, in sagebrush habitat. In Wyoming and Montana, an estimated 558 km² (215 mi²) of sagebrush habitats have been disturbed by coal mines and associated facilities; disturbance increased approximately 170 km² (66 mi²) between 2005 and 2007 (Service 2005, p. 75; Service 2008c; Wyoming Mining Association 2008, p. 7). Wyoming estimates that 275 km² ha (106 mi²) of mine-disturbed land has been reclaimed (Wyoming Mining Association 2008, p. 7), but we have no knowledge of the effectiveness of these reclamation projects in providing functional sage-grouse habitat.

While western coal production has grown steadily since 1970, growth is predicted to increase through 2030, but at a much slower rate than in the past (EIA 2009b, p. 83). Coal production is projected to increase with the development of technology to reduce sulfur emissions and most of the future output of coal is expected from low-sulfur coal mines in Wyoming, Montana, and North Dakota (EIA 2009b, p. 83). We do not have information to quantify the footprint of future coal production; however, additional losses and deterioration of sage-grouse habitats are expected where mining activity occurs (described later in this section). The use of coal may be reduced if limitations on green-house gas emissions are enacted in the future. A transition would require development of lower emission sources, such as wind, solar, or nuclear, that may have their own impacts on sage-grouse environments.

Surface and subsurface mining for mineral resources (coal, uranium, copper, phosphate, aggregate, and others) results in direct loss of habitat if occurring in sagebrush habitats. The direct impact from surface mining is usually greater than it is from subsurface activity. Habitat loss from both types of mining can be exacerbated by the storage of overburden (soil removed to reach subsurface resource) in otherwise undisturbed habitat. If the construction of mining infrastructure is necessary, additional direct loss of habitat could result from structures, staging areas, roads, railroad tracks, and powerlines. Sage-grouse and nests could be directly affected by trampling or vehicle collision. Sage-grouse also will likely be impacted indirectly from an increase in human presence, land use practices, ground shock, noise, dust, reduced air quality, degradation of water quality and quantity, and changes in vegetation and topography (Moore and Mills 1977, entire; Brown and Clayton 2004, p. 2).

An increase in human presence increases collision risk with vehicles and potentially exposes sage-grouse and other wildlife to pathogens introduced from septic systems and waste disposal (Moore and Mills 1977, pp. 114-116, 135). Water contamination also could occur from leaching of waste rock and overburden and nutrients from blasting chemicals and fertilizer (Moore and Mills 1977, pp. 115, 133). Altering of water regimes could lead to decreased surface water and eventual habitat degradation from wildlife or livestock concentrating at remaining sources. Sage-grouse do not require water other than what they obtain from plant resources (Schroeder *et al.* 1999, p. 6); therefore, local water quality deterioration or dewatering is not expected to have population-level impacts. Degradation of riparian areas could result in a loss of brood habitat.

Mining and associated activities creates an opportunity for invasion of exotic and noxious weed species that alter suitability for sage-grouse (Moore and Mills 1977, pp. 125, 129). Reclamation is required by State and Federal laws, but laws generally allow for a change in post-mining land use. Restoration of sagebrush is difficult to achieve and disturbed sites may never return to suitability for sage-grouse (refer to Habitat Description and Characteristics section).

Heavy equipment operations and use of unpaved roads produces dust that can interfere with plant photosynthesis and insect populations. Most large surface mines are required to control dust. Gaseous emissions generated from heavy equipment operation are quickly dispersed in open, windy areas typical of sagebrush (Moore and Mills 1977, p.109). Blasting, to remove overburden or the target mineral, produces noise and ground shock. The full effect of ground shock on wildlife is unknown. Repeated use of explosives during lekking activity could potentially result in lek or nest abandonment (Moore and Mills 1977, p. 137). Noise from mining activity could mask vocalizations resulting in reduced female attendance and yearling recruitment as seen in sharp-tailed grouse (*Pedioecetes phasianellus*) (Amstrup and Phillips 1977, pp. 23, 25-27). In this study, the authors found that the mining noise in the study area was continuous across days and seasons and did not diminish as it traveled from its source. The mechanism of how noise affects sage-grouse is not known, but it is known that sage-grouse depend on acoustical signals to attract females to leks (Gibson and Bradbury 1985, pp. 81-82; Gratson 1993, pp. 693-694). Noise associated with oil and gas development may have played a factor in habitat selection and a decrease in lek attendance by sage-grouse (Holloran 2005, pp. 49, 56).

A few scientific studies specifically examine the effects of coal mining on greater sage-grouse. In a study in North Park, Colorado, overall sage-grouse population numbers were not reduced, but there was a reduction in the number of males attending leks within 2 km (0.8 mi) of three coal mines, and existing leks failed to recruit yearling males (Braun 1986, pp. 229-230; Remington and Braun 1991, pp. 131-132). New leks formed farther from mining disturbance (Remington and Braun 1991, p. 131). Additionally, some leks that were abandoned adjacent to mine areas were reestablished when mining activities ceased, suggesting disturbance rather than habitat loss was the limiting factor (Remington and Braun 1991, p.132). Hen survival did not decline in a population of sage-grouse near large surface coal mines in northeast Wyoming, and nest success appeared not to be affected by adjacent mining activity (Brown and Clayton 2004, p. 1). However, the authors concluded that continued mining would result in fragmentation and eventually impact sage-grouse persistence if adequate reclamation was not employed (Brown and Clayton 2004, p.16).

Surface coal mining and associated activities have negative short-term impacts on sage-grouse numbers and habitats near mines (Braun 1998, p. 143). Sage-grouse will reestablish on mined areas once mining has ceased, but there is no evidence that population levels will reach their previous size, and any population reestablishment could take 20 to 30 years based on observations of disturbance in oil and gas fields (Braun 1998, p. 144). Local sage-grouse populations could decline if several leks are affected by coal mining, but the loss of one or two leks in a regional area was likely not limiting to local populations in the Caballo Rojo Mine in northeastern Wyoming based on the presence of viable habitat elsewhere in the region (Hayden-Wing Associates 1983, p. 81).

As described above, mining directly removes habitat, may interfere with auditory clues important to mate selection, and results in a decrease of males and inhibits yearling recruitment at leks in proximity to mining activity. Sage-grouse habitat reestablishment and recovery of population numbers in an area post-disturbance is uncertain. Similar avoidance of disturbance has been noted in recent investigations of oil and gas development in Wyoming and discussed in detail in the Nonrenewable Energy section. The studies recounted here were conducted on a local scale that provides limited insight into impacts at a larger landscape perspective. In Wyoming specifically, the cumulative impacts of surface coal mine disturbance, concurrent increases in oil and gas development, increased development of renewable energy resources (discussed in the following section), and transmission infrastructure development could have significant impacts on sage-grouse in the Powder River Basin. The Powder River Basin is home to an important regional population of the larger Wyoming Basin populations covering most of Wyoming, northwestern Colorado, and northeastern Utah (Connelly *et al.* 2004, pp. 6-62 to 6-63).

Renewable Energy Sources

The demand for electricity from renewable energy sources is increasing. Electricity production from renewable sources increased from 6.4 quadrillion British thermal units (Btu) in 2005 to 6.9 quadrillion Btu in 2006. Production was down slightly in 2007, but energy production by renewables reached 7.3 quadrillion Btu by the end of 2008 (EIA 2009d, entire). Wind, geothermal, solar and biomass are renewable energy sources developable in sage-grouse habitats. Large-scale hydropower generation occurs in the sage-grouse range in parts of Washington State. Conventional hydropower electrical generation has actually decreased over the past 10 years (EIA 2009d, entire). In general, growth of the renewable energy industry is predictable based on legislated mandates to achieve target levels of renewable-produced electricity in many States within the sage-grouse range.

Wind

Areas of commercially viable wind generation have been identified by the NREL (2008b, entire) and BLM (2005, p. 2.4) in all 11 States in the greater sage-grouse range.

MZs III through VII each have approximately 1 to 14 percent of sagebrush habitats that are commercially developable for wind energy (Service 2008e, entire). Wind harvesting potentials are more concentrated and geographically extensive in sage-grouse MZs I and II that include parts of Montana, Wyoming, North Dakota, and South Dakota; areas of highest commercial potential include 59 percent of the available sagebrush habitats in these four States. Over 30 percent of the sagebrush lands in the sage-grouse range have high potential for wind power (Table 8).

TABLE 8—AREA OF SAGEBRUSH HABITAT WITH WIND ENERGY DEVELOPMENT POTENTIAL, BY MANAGEMENT ZONE. (DATA FROM SERVICE 2008E)

SAGE-GROUSE MZ	Area of Sagebrush with Developable Wind Potential		
	km²	mi²	Percent of MZ
I	137,733	53,179	76.02
II	46,835	18,083	42.16
III	3,028	1,169	3.23
IV	12,952	5,001	9.05
V	5,532	2,136	8.27
VI	2,660	1,027	14.44
VII	199	77	1.10
TOTAL	208,939	80,672	33.02

Commercial viability is based on wind intensity and consistency, available markets and access to transmission facilities. Consequently, current development is focused in areas with existing power transmission infrastructure associated with urban development, preexisting conventional energy resource development (e.g., coal and natural gas) and power generation. Growth of wind power development is expected to continue even in the current economic climate (EIA 2009b, p. 3), spurred by statutory mandates or financial incentives to use renewable energy sources in all 11 States in the range (Association of Fish and Wildlife Agencies (AFWA) and Service 2007, pp. 7, 8, 14, 28, 30, 36, 39, 43, 46, 49, 52; State of Oregon 2008, entire).

Wind generating facilities have increased in size and number, outpacing development of other renewable sources in the sage-grouse range. The BLM, the major land manager in the sage-grouse range, developed programmatic guidance to facilitate the use of BLM land for wind development (BLM 2005a, entire). The BLM wind policy permits granting private right-of-ways and leasing of public land for 3–year monitoring and testing facilities and long-term (30 to 35 years) commercial generating facilities (American Wind Energy Association (AWEA) 2008, p. 4-24). Active leases for wind energy development on BLM lands increased from 9.7 km² (3.7 mi²) in 2002 to 5,113 km² (1,973 mi²) in 2008, and an additional 5,381 km² (2,077 mi²) of lease requests were pending approval in the sage-grouse range (Knick *et al.*, in press, p. 136).

A recent increase in wind energy development is most notable within the range of the south-central Wyoming subpopulation of greater sage-grouse in MZ II where 1,387 km² (535 mi²) have active wind leases and an additional 2,828 km² (1,092 mi²) are pending (Knick *et al.*, in press, p. 136). The south-central Wyoming subpopulation has a loose association with adjacent populations where there is accelerated oil, gas, and coal development in the State – the Powder River Basin (MZ I) to the northeast and Pinedale-Jonah Gas Fields in the southwest Wyoming Basin (MZ II) (Connelly *et al.* 2004, p. 6-62). As stated previously, the Powder River Basin is home to an important regional population of the larger Wyoming Basin populations (Connelly *et al.* 2004, p. 6-62). The subpopulation in southwest Wyoming and northwest Colorado is a stronghold for sage-grouse with some of the highest estimated densities of males anywhere in the remaining range of the species (Connelly *et al.* 2004, pp. 6-62, A5-23). The south-central Wyoming wind potential corridor is not only a geographical bridge between two important population areas but is home to a large population of sage-grouse (Connelly *et al.* 2004, p. A5-22) and core areas identified preliminarily as high density breeding areas for sage-grouse by the Wyoming State Governor's Executive Order (State of Wyoming 2008, entire). Although regulatory mechanisms are being developed for Wyoming's core areas (see regulatory mechanisms section below), they are still largely subject to the impacts of both conventional and renewable energy development. Twenty-one percent of Wyoming core areas have high wind development potential, and 51 percent are subject to either wind or authorized development of oil and gas leases (Doherty *et al.*, in press, p. 31).

In addition to Wyoming, southeastern Oregon is a focus area for potential commercial-scale wind development. Currently, south-central and southeastern Oregon have large areas of relatively unfragmented sage-dominated landscapes which are important for maintaining long-term connectivity between the sage-grouse populations (Knick and Hanser, in press, pp. 1-2.). Historically, central Oregon's population provided connectivity with the Columbia Basin area through narrow habitat corridors (Connelly *et al.* 2004, p. 6-13). These connections have now been lost, resulting in the isolation of the northern extant population in Washington. The Northern Great Basin ranks lowest of the MZs in the intensity of the human footprint and consequent effects (Leu and Hanser, in press, p. 25; Wisdom *et al.*, in press, p. 16), and this could be contributing to the substantial connectivity that still exists between the Northern Great Basin, Snake River Plain, and the Southern Great Basin Region populations (Knick and Hanser, in press, p. 1). The BLM is the major land manager in this part of the southeastern Oregon, with jurisdiction over 49,000 km^2 (18,900 mi^2) (BLM 2009d, entire) that include much of the scantily vegetated ridge tops prone to high and sustained wind. At this time, most of the development activity is in the initial phase of meteorological site investigation and involves little infrastructure (AWEA 2009, entire; BLM 2009e). Many of these monitoring sites could be developed, considering the projected demand for renewable energy, contributing to fragmentation of this relatively intact sagebrush landscape.

Most published reports of the effects of wind development on birds focus on the risks of collision with towers or turbine blades. No published research is specific to the effects of wind farms on the greater sage-grouse. However, the avoidance of human-made structures such as powerlines and roads by sage-grouse and other prairie grouse is documented (Holloran 2005, p. 1; Pruett *et al*, in press, p. 6). Renewable energy facilities, including wind power, typically require many of the same features for construction and operation as do nonrenewable energy resources. Therefore, we anticipate that potential impacts from direct habitat losses, habitat fragmentation through roads and powerlines, noise, and increased human presence (Connelly *et al.* 2004, pp. 7-40 to 7-41) will generally be similar to those already discussed for nonrenewable energy development.

Wind farm development begins with site monitoring and collection of meteorological data to accurately characterize the wind regime. Turbines are installed after the meteorological data indicate the appropriate siting and spacing. Roads are necessary to access the turbine sites for installation and maintenance. Each turbine unit has an estimated footprint of 0.4 to 1.2 ha (1 to 3 ac) (BLM 2005a, pp. 3.1-3.4). One or more substations may be constructed depending on the size of the farm. Substation footprints are 2 ha (5 ac) or less in size (BLM 2005a, p. 3.7).

The average footprint of a turbine unit is relatively small from a landscape perspective. Turbines require careful placement within a field to avoid loss of output from interference with neighboring turbines. Spacing improves efficiency but expands the overall footprint of the field. Sage-grouse populations are impacted by the direct loss of habitat, primarily from construction of access roads as well as indirect loss of habitat due to avoidance. Sage-grouse could be killed by flying into turbine rotors or towers (Erickson *et al.* 2001, entire) although reported collision mortalities have been few. One sage-grouse was found dead within 45 m (148 ft) of a turbine on the Foote Creek Rim wind facility in south-central Wyoming, presumably from flying into a turbine (Young *et al.* 2003, Appendix C, p. 61). This is the only known sage-grouse mortality at this facility during three years of monitoring. Sage-grouse hens with broods have been observed under turbines at Foote Creek Rim (Young 2004, pers. comm.). We have no recent reports of sage-grouse mortality due to collision with a wind turbine; however, many facilities may not be monitored. No deaths of gallinaceous birds were reported in a comprehensive review of avian collisions and wind farms in the United States; the authors hypothesized that the average tower height and flight height of grouse, and diurnal migration habitats of some birds minimized the risk of collision (Johnson *et al.* 2000, pp. ii-iii; Erickson *et al.* 2001, pp. 8, 11, 14, 15).

Noise is produced by wind turbine mechanical operation (gear boxes, cooling fans) and airfoil interaction with the atmosphere. No published studies have focused specifically on the effects of wind power noise and greater sage-grouse. In studies conducted in oil and gas fields, noise may have played a factor in habitat selection and decrease in lek attendance (Holloran 2005, pp. 49, 56). However, comparison between wind turbine and oil and gas operations is difficult based on the character of sound. Adjusting for manufacturer type and atmospheric conditions, the audible operating sound of a single wind turbine has been calculated as the same level as conversational speech at 1 m (3 ft) at a distance of 600 m (2,000 ft) from the turbine. This level is typical of background levels of a rural environment (BLM 2005a, p. 5-24). However, commercial wind farms do not have a single turbine, and multiple turbines over a large area would likely have a much larger noise print. Low-frequency vibrations created by rotating blades produce annoyance responses in humans (van den Berg 2003, p. 1), but the specific effect on birds is not documented.

Moving blades of turbines cast moving shadows that cause a flickering effect producing a phenomenon called "shadow flicker" (AWEA 2008, p. 5-33). Hypothetically, shadow flicker could mimic predator shadows and elicit an avoidance response in birds during daylight hours, but this potential effect has not been investigated.

Since 2005, states have required an increasing amount of energy to come from renewable sources. For example, Colorado law requires incremental increases of renewable generation from 3 percent in 2007 to 20 percent by 2020 (AFWA and Service 2007, p. 8). Financial incentives, including grants and tax breaks, encourage private development of renewable sources. Although development of renewables is encouraged at a State level, siting authority for wind varies from State to State (AFWA and Service 2007, pp. 7, 8, 14, 28, 30, 36, 39, 43, 46, 49, 52; State of Oregon 2008, entire). For example, the State of Idaho provides tax incentives and loan programs for renewable energy development, but wind power is currently unregulated at any level of government (AFWA and Service 2007, p. 14). The North Dakota Public Service Commission regulates siting of wind power facilities over 100 megawatts using the Service's interim voluntary guidelines (Service 2003, entire).

Wyoming does not have a requirement for increased reliance on renewable energy sources and no specific wind siting authority. However, large construction projects in the State are subject to approval by an Industrial Siting Council (ISC) of the State Department of Environmental Quality, with the WGFD providing recommendations for mitigating impacts to wildlife associated with development considered by the ISC. The ISC's review and approval of projects is subject to the Wyoming Governor's executive order (State of Wyoming 2008, entire) that is intended to prevent harmful effects to sage-grouse from development or new land uses in designated core areas. Wind developers in Wyoming understand that most proposed wind developments regardless of locale must be approved by the ISC and that development proposed in core areas is unlikely to be permitted by the ISC due to the Governor's Executive Order (see discussion in Factor D below).

The BLM manages more land areas of high wind resource potential than any other land management agency. In 2005, the BLM completed the Wind Energy Final Programmatic EIS that provides an overarching guidance for wind project development on BLM-administered lands (BLM 2005a, entire). Best management practices (BMPs) are prescribed to minimize impacts of all phases of construction and operation of a wind production facility. The BMPs guide future project planning and do not guarantee protections specific to sage-grouse. We do not have information on how or where the EIS guidance has been applied since 2005 and cannot evaluate its effectiveness. The footprint of wind energy developments is reported to be small (BLM 2005a, p. 5-2). The BLM indicates that approximately 600 km² (232 mi²) of BLM-administered lands are likely to be developed in nine States within the sage-grouse's range before 2025 (BLM 2005a, pp. ES-8, 5-2). It is estimated that only 5 to 10 percent of a development will have a long-term disturbance that remains on the landscape for at least as long as the generating facility is viable (i.e., roads, foundations, substation, fencing) (BLM 2005a, p. 5-2). However, this estimate does not account for sage-grouse avoidance of developed areas and could be an underestimation of indirect effects. Based on what we know of oil and gas development (previously described), the impact of structures, noise and human activity can reach far beyond the point of origin and contribute cumulatively to other human-made and natural disturbances that fragment and decrease the quality of sage-grouse habitats. The BLM's determination of the quantity of lands potentially impacted by wind energy development could be extremely conservative considering the interest in reducing green-house emissions and the institution of State renewable energy mandates and incentives that have occurred since 2005.

Wind development is guided by policy at BLM national and State levels that generally offers only guidance to avoid impacts to sage-grouse and habitats. A 2008 BLM Instruction Memo IM 2009-43 (BLM 2008e, p. 2) emphasizes the use of the Service's 2003 interim guidelines as voluntary and to be used only on a general basis in siting, design, and monitoring decisions. The BLM's Oregon State Office Instruction Memorandum OR-2008-014 (BLM 2007d, entire) is explicit in the placement of meteorological test towers to avoid active leks, seasonal concentrations, and collision; IM OR-2009-038 (BLM 2009f, entire) reduces the ODFW's recommended buffer distance for wind farms and applies only guidelines for avoidance of sage-grouse leks and seasonal habitats.

Wind energy resources are found throughout the range of the greater sage-grouse, and growth of wind power development is expected to continue. The DOE predicts that wind may provide a significant portion of the nation's energy needs by the year 2030, and substantial growth of wind developments will be required (DOE 2008, p. 1). In mid-2009, wind energy production facilities in the sage-grouse range in operation or under construction had a capacity of 11.93 gigawatts (AWEA 2009, entire) (Table 9). To achieve predicted levels of 49 to greater than 90 gigawatts capacity (DOE 2008, p. 10), the generation capacity will need to increase by 400 to 800 percent by 2030. Existing commercial wind turbines range from 1-2 megawatt generating capacity (AWEA 2009, entire). The forecasted increase in production would require approximately 37,000 to 78,000 or more turbines based on the existing technology and equipment in use. Assuming a generation capacity of 5 megawatts per km² (0.4 mi²) density, Copeland *et al.* (2009, p. 1) estimated an additional 50,000 km² (19,305 mi²) of land in the sage-grouse range would be required to meet the predicted level of wind-generated electricity by 2030.

TABLE 9— WIND ENERGY DEVELOPMENT IN THE GREATER SAGE-GROUSE RANGE, 2009–2030.

STATE	MZ	Existing Capacity 2009* (gigawatts)	Forecasted Capacity in 2030 (gigawatts)**
North Dakota	I	1.2	1 to 5
South Dakota	I	0.31	5 to 10
Montana	I	0.17	5 to 10
Wyoming	I, II	1.3	10 plus
Utah	II, III, IV, VII	0.4	1 to 5
Idaho	IV	0.15	1 to 5
Nevada	III, IV, V	0	5 to 10
California	III, V	2.8	10 plus
Oregon	IV, V	2.2	5 to 10
Washington	VI	2.2	5 to 10
Colorado	II, VII	1.2	1 to 5
Total		11.93	49 to 90 plus

*Includes completed and under construction, Source: American Wind Energy Assn. (2009, entire).
** Source: DOE (2008, p. 10).
(1000 megawatt = 1 gigawatt)

States such as Nevada and Montana that have not been tapped for extensive wind power development are likely to experience significant new energy development within the next 20 years (Table 9). In Wyoming, where wind development is advancing and predicted to increase by 10 fold or more (Table 9), the effects of both conventional and nonconventional renewable sources may claim a substantial toll on sage-grouse habitats and geographic areas that were in the past considered refugia for the species. As with oil and gas development, the average footprint of a turbine unit is relatively small from a landscape perspective, but the effects of large-scale developments have the potential to reduce the size of sagebrush habitats directly, degrade habitats with invasive species, provide pathways for synanthropic predators (i.e., predators that live near and benefit from an association with humans), and cumulatively contribute to habitat fragmentation.

Other Renewable Energy Sources

Hydropower development can cause direct habitat losses and possibly an increase in human recreational activity. Reservoirs created concurrently with power generation structures inundated large areas of riparian habitats used by sage-grouse broods (Braun 1998, p. 144). Reservoirs and the availability of irrigation water precipitated conversion of large expanses of upland shrub-steppe habitat in the Columbia Basin adjacent to the rivers (65 FR 51578, August 24, 2000). We were unable to find any information regarding the amount of sage-grouse habitat affected by hydropower projects in other areas of the species' range beyond the Columbia Basin. No new large-scale facilities have been constructed and hydropower electricity generation has decreased steadily over the past 10 years (EIA 2009d, entire). We do not anticipate that future dam construction will result in large losses of sagebrush habitats.

Solar-powered electricity generation is increasing. Between 2005 and the end of 2008, solar electricity generation increased from the equivalent of 66 trillion Btu to 83 trillion Btu (EIA 2009d, entire). Solar-generating systems have been used on a small scale to power individual buildings, small complexes, remote facilities, and signs. Solar energy infrastructure is often ancillary to other development, and large-scale solar-generating systems have not contributed to any calculable direct habitat loss for sage-grouse, but this may change as more systems come on line for commercial electricity generation. Solar energy systems require, depending on local conditions, 1.6 ha (4 ac) to produce 1 megawatt of electricity. For example, the 162-ha (400-ac) Nevada Solar One, the third largest solar electricity producer in the world, has a maximum potential of 75 megawatts from a 121-ha (300-ac) solar field (nevadasolarone.com 2008, entire).

No commercial solar plants are operating in sage-grouse habitats at this time. Southern and eastern Nevada, the Pinedale area of Wyoming, and east-central Utah are the areas of the sage-grouse range with good potential for commercial solar development (EIA 2009e, entire). There are a total of 196 ha (484 ac) of active solar leases on BLM property in northern California (MZ IV) and central Wyoming (MZ II) (BLM 2009g, map) in sagebrush habitats within the current sage-grouse range and these leases will likely be developed. The BLM is developing a programmatic EIS for leasing and development of solar energy on BLM lands. The EIS planning period has been extended to analyze the effects of concentrating large-scale development in selected geographic areas including sage-grouse habitats in east-central Nevada and southern Utah (BLM 2009h, entire) because of the considerable administrative and public interest in developing public lands for solar-generated electricity (BLM 2009i, entire). At this time, we do not have enough information available to evaluate the scale of future impacts of solar power generation in sage-grouse habitats. We will continue to evaluate and monitor the impacts of solar power development in sage-grouse habitats as more information becomes available. We are not aware of any investigations reporting the impacts of solar generating facilities on sage-grouse or other gallinaceous birds. Commercial solar generation could produce direct habitat loss (i.e., solar fields completely eliminate habitat), fragmentation, roads, powerlines, increased human presence, and disturbance during facility construction with similar effects to sage-grouse as reported with oil and gas development.

Geothermal energy production has remained steady since 2005 (EIA 2009d, entire). Geothermal facilities are within the sage-grouse range in California (3 plants, MZ III), Nevada (5 plants, MZs III and V), Utah (2 plants, MZ III), and Idaho (1 plant, MZ IV). Since 2005, two additional plants were constructed is in current sage-grouse range – one in Idaho and one in Utah (Geothermal Energy Association 2008, pp. 2-7). One existing geothermal plant in southern Utah is in the vicinity of sage-grouse habitat in an area where wind power is being considered for development (First Wind-Milford 2009, entire), which will result in cumulative impacts. Geothermal potential occurs across the sage-grouse range in States with existing development and southeast Oregon, west-central Wyoming, and north-central Colorado (EIA 2009e, entire).

Geothermal energy production is similar to oil and gas development such that it requires surface exploration, exploratory drilling, field development, and plant construction and operation. Wells are drilled to access the thermal source and could take from 3 weeks to 2 months of continuous drilling (Suter 1978, p. 3), which may cause disturbance to sage-grouse. The ultimate number of wells, and therefore potential loss of habitat, depends on the thermal output of the well and expected production of the plant (Suter 1978, p. 3). Pipelines are needed to carry steam or superheated liquids to the generating plant which is similar in size to a coal- or gas-fired plant, resulting in further habitat and indirect disturbance. Direct habitat loss occurs from well pads, structures, roads, pipelines and transmission lines, and impacts would be similar to those described previously for oil and gas development.

The development of geothermal energy requires intensive human activity during field development and operation. Geothermal plants could be in remote areas necessitating housing construction, transportation, and utility infrastructure for employees and their families (Suter 1978, p. 12). Geothermal development could cause toxic gas release; the type and effect of these gases depends on the geological formation in which drilling occurs (Suter 1978, pp. 7-9). The amount of water necessary for drilling and condenser cooling may be high. Local water depletions may be a concern if such depletions result in the loss of brood-rearing habitat.

The BLM has the authority to lease geothermal resources in 11 western States. A programmatic EIS for geothermal leasing and operations was completed in 2008 (BLM and USFS 2008a, entire). Best management practices for minimizing the effects of geothermal development and operations on sage-grouse are guidance only and are general in nature (BLM and USFS 2008a, pp. 4.82-4.83). The EIS' reasonably foreseeable development scenario predicts that Nevada will experience the greatest increase in geothermal growth–doubling the production of electricity from geothermal sources by 2025 (BLM and USFS 2008, p. 2-35). Currently, approximately 1,800 km^2 (694 mi^2) of active geothermal leases exist on public lands primarily in the Southern (MZ IV) and Northern Great Basin (MZ III) and 1,138 km^2 (439 mi^2) of leases are pending (Knick *et al.*, in press, p. 138).

Energy production from biomass sources has increased every year since 2005 (EIA 2009d, entire). Wood has been a primary biomass source, but corn ethanol and biofuels produced from cultivated crops are on the increase (EIA 2008b, entire). Currently, wood products and corn production do not occur in the range of the sage-grouse in significant quantities (Curtis 2008, p. 7). The National Renewable Energy Laboratory cites potentials for agricultural biomass resources in northern Montana (MZ I), southern Idaho (MZ IV), eastern Washington (MZ

VI), eastern Oregon MZ IV), northwest Nevada (MZ V), and southeast Wyoming (MZ II) (NREL 2005, entire). Conversion from native sod to agriculture for the purpose of biomass production could result in a loss of sage-grouse habitat on private lands. The 2007 Energy Independence and Security Act mandated incremental production and use through the year 2022 of advanced biofuel, cellulosic biofuel, and biomass-based diesel (P.L. 110-140, section 203) and could provide an incentive to convert native sod or expired CRP lands to biomass crops. The effects on sage-grouse will depend on amount and location of sagebrush habitats developed. The effects of agriculture are discussed in habitat conversion section above.

Transmission Corridors

Section 368(a) of the Energy Policy Act of 2005 (42 U.S.C. 15926) directs Federal land management agencies to designate corridors on Federal land in 11 western States for oil, gas and hydrogen pipelines and electricity transmission and distribution facilities (energy transport corridors). The agencies completed a programmatic EIS (DOE *et al.* 2008, entire) to address the environmental impacts of corridors on Federal lands. The proposed action calls for designating more than 9,600 km (6,000 mi) with an average width of 1 km (0.6 mi) of energy corridors across the western United States (DOE *et al.* 2008, p. S-17). The designated corridors on Federal lands will tie in to corridors on private lands and lands in other governmental jurisdictions. Some of the areas proposed for designation are currently used for transmission. Federal lands newly incorporated into transportation or utility rights-of-way are mostly BLM lands in California (185 km, 115 mi), Colorado (97 km, 60 mi), Idaho (303 km, 188 mi), Montana (254 km, 158 mi), Nevada (810 km, 503 mi), Oregon (418 km, 260 mi), Washington (no additional land), Utah (356 km, 221 mi), and Wyoming (198 km, 123 mi) (DOE *et al.* 2008, p. S-18).

It is uncertain how much of the proposed corridors are in sagebrush habitat within the distribution area of sage-grouse, but based on the proposed location, habitat in Wyoming (MZ II), Idaho (MZ IV), Utah (MZ III), Nevada (MZ III) and Oregon (MZs III and IV) would be most affected. The purpose of the corridor designation is to serve a role in expediting applications to construct or modify oil, gas, and hydrogen pipelines and electricity transmission and distribution. These designated areas will likely facilitate the development of novel renewable and nonrenewable electricity generating facilities on public and private lands. Sage-grouse could be impacted through a direct loss of habitat, human activity (especially during construction periods), increased predation, habitat deterioration through the introduction of nonnative plant species, and additional fragmentation of habitat.

Summary: Energy Development

Energy development is a significant risk to the greater sage-grouse in the eastern portion of its range (Montana, Wyoming, Colorado, and northeastern Utah – MZs I, II, VII and the northeastern part of MZ III), with the primary concern being the direct effects of energy development on the long-term viability of greater sage-grouse by eliminating habitat, leks, and whole populations and fragmenting some of the last remaining large expanses of habitat necessary for the species' persistence. The intensity of energy development is cyclic and based on many factors including energy demand, market prices, and geopolitical uncertainties. However, continued exploration and development of traditional and nonconventional fossil fuel sources in the eastern portion of the greater sage-grouse range is predicted to continue to increase over the next 20 years (EIA 2009b, p. 109). Greater sage-grouse populations are predicted to decline 7 to 19 percent over the next 20 years due to the effects of oil and gas development in the eastern part of the range (Copeland *et al.* 2009, p. 4); this decline is in addition to the 45 to 80 percent decline that is estimated to have already occurred range wide (Copeland *et al.* 2009, p. 4).

Development of commercially viable renewable energy—wind, solar, geothermal, biomass—is increasing across the range with focus in some areas already experiencing traditional energy development (EIA 2009b, pp. 3-4; AWEA 2009a, entire). In Wyoming, where wind development is advancing and predicted to increase by 10-fold (DOE 2008, p. 10), the effects of both conventional and nonconventional and renewable sources may claim a substantial toll on sage-grouse habitats and geographic areas that were in the past considered refugia for the species. Renewable energy resources are likely to be developed in areas previously untouched by traditional energy development. Wind energy resources are being investigated in south-central and southeastern Oregon where large areas of relatively unfragmented sage-dominated landscapes are important for maintaining long-term connectivity within the sage-grouse populations (Knick and Hanser in press, pp. 1-2.).

Greater sage-grouse populations are negatively affected by energy development activities, even when mitigative measures are implemented (Holloran 2005, pp. 57-60; Walker *et al.* 2007a, p. 2651). Energy development, particularly high density development, will continue to threaten sage-grouse populations, specifically in the MZs I and II, which contain the greatest numbers of birds throughout their range.

Development of commercially viable renewable energy–wind, solar, geothermal, biomass–is rapidly increasing rangewide with a focus in some areas already experiencing significant traditional energy development (e.g., MZs I and II). The effects of renewable energy development are likely similar to those of nonrenewable energy as similar types of infrastructure are required. Based on our review of the literature, we anticipate the impacts of these developments will negatively affect the ability of greater sage-grouse to persist in those areas in the foreseeable future.

Climate Change

The Intergovernmental Panel on Climate Change (IPCC) has concluded that warming of the climate is unequivocal, and that continued greenhouse gas emissions at or above current rates will cause further warming (IPCC 2007, p. 30). Eleven of the 12 years from 1995 through 2006 rank among the 12 warmest years in the instrumental record of global surface temperature since 1850 (ISAB 2007). Climate-change scenarios estimate that the mean air temperature could increase by over 3°C (5.4°F) by 2100 (IPCC 2007, p. 46). The IPCC also projects that there will very likely be regional increases in the frequency of hot extremes, heat waves, and heavy precipitation (IPCC 2007, p. 46), as well as increases in atmospheric carbon dioxide (IPCC 2007, p. 36).

We recognize that there are scientific differences of opinion on many aspects of climate change, including the role of natural variability in climate. In our analysis, we rely primarily on synthesis documents (e.g., IPCC 2007; Global Climate Change Impacts in the United States 2009) that present the consensus view of a very large number of experts on climate change from around the world. We have found that these synthesis reports, as well as the scientific papers used in those reports or resulting from those reports, represent the best available scientific information we can use to inform our decision and have relied upon them and provided citation within our analysis. In addition, where possible we have used projections specific to the region of interest, the western United States and southern Canada, which includes the range of the greater sage-grouse. We also use projections of the effects of climate change to sagebrush where appropriate, while acknowledging that the uncertainty of climate change effects increases as one applies those potential effects to a habitat variable like sagebrush, and then increases again when the impacts to the habitat variable are applied to the species.

Projected climate change and its associated consequences have the potential to affect greater sage-grouse and may increase its risk of extinction, as the impacts of climate change interact with other stressors such as disease, and habitat degradation and loss that are already affecting the species (Walker and Naugle, in press, entire; Global Climate Change Impacts in the United States 2009, p. 81; Miller *et al.* in press, pp. 46-50). In the Pacific Northwest, regionally averaged temperatures have risen 0.8 degrees Celsius (1.5 degrees Fahrenheit) over the last century (as much as 2 degrees Celsius (4 degrees Fahrenheit) in some areas), and are projected to increase by another 1.5 to 5.5 degrees Celsius (3 to 10 degrees Fahrenheit) over the next 100 years (Mote *et al.* 2003, p. 54; Global Climate Change Impacts in the United States 2009, p. 135). Arid regions such as the Great Basin where greater sage-grouse occurs are likely to become hotter and drier; fire frequency is expected to accelerate, and fires may become larger and more severe (Brown *et al.* 2004, pp. 382-383; Neilson *et al.* 2005, p. 150; Chambers and Pellant 2008, p. 31; Global Climate Change Impacts in the United States 2009, p. 83).

Climate changes such as shifts in timing and amount of precipitation, and changes in seasonal high and low temperatures, as well as average temperatures, may alter distributions of individual species and ecosystems significantly (Bachelet *et al.* 2001, p174). Under projected future temperature conditions, the cover of sagebrush within the distribution of sage-grouse is anticipated to be reduced (Neilson *et al.* 2005, p. 154; Miller *et al.* in press, p. 45). Warmer temperatures and greater concentrations of atmospheric carbon dioxide create conditions favorable to *Bromus tectorum*, as described above, thus continuing the positive feedback cycle between the invasive annual grass and fire frequency that poses a significant threat to greater sage-grouse (Chambers and Pellant 2008, p. 32; Global Climate Change Impacts in the United States 2009, p. 83). Fewer frost-free days also may favor frost-sensitive woodland vegetation of Sonoran and Chihuahuan deserts, which may expand, potentially encroaching on the sagebrush biome in the southern Great Basin where sage-grouse populations currently exist (Miller *et al.* in press, p. 44). Such encroachment of woody vegetation degrades sage-grouse habitat (see Factor A, Invasive plants).

Temperature and precipitation both directly influence potential for West Nile virus (WNv) transmission (Walker and Naugle in press, p. 12). In sage-grouse, WNv outbreaks appear to be most severe in years with higher summer temperatures (Walker and Naugle in press, p. 13) and under drought conditions (Epstein and Defilippo, p. 105). This relationship is due to the breeding cycle of the WNv vector, *Culex tarsalis* being highly dependent on warm water temperature for mosquito activity and virus amplification (Walker and Naugle in press, p. 12; see discussion under Disease and Predation below). Therefore, the higher summer temperatures and more frequent or severe drought or both, that are likely under current climate change projections, make more severe WNv outbreaks likely in low-elevation sage-grouse habitats where WNv is already endemic, and also make WNv outbreaks possible in higher elevation sage-grouse habitats that to date have been WNv-free due to relatively cold conditions.

Emissions of carbon dioxide, considered to be the most important anthropogenic greenhouse gas, increased by approximately 80 percent between 1970 and 2004 due to human activities (IPCC 2007, p. 36). Future carbon dioxide emissions from energy use are projected to increase by 40 to 110 percent over the next few decades, between 2000 and 2030 (IPCC 2007, p. 44). An increase in the atmospheric concentration of carbon dioxide has important implications for greater sage-grouse, beyond those associated with warming temperatures, because higher concentrations of carbon dioxide are favorable for the growth and productivity of *Bromus tectorum* (Smith *et al.* 1987, p. 142; Smith *et al.* 2000, p. 81). Although most plants respond positively to increased carbon dioxide levels, many invasive nonnative plants respond with greater growth rates than native plants, including *B. tectorum* (Smith *et al.* 1987, p. 142; Smith *et al.* 2000, p. 81; Global Climate Change Impacts in the United States 2009, p. 83). Laboratory research results illustrated that *B. tectorum* grown at carbon dioxide levels representative of current climatic conditions matured more quickly, produced more seed and greater biomass, and produced significantly more heat per unit biomass when burned than *B. tectorum* grown at "pre-industrial" carbon dioxide levels (Blank *et al.* 2006, pp. 231, 234). These responses to increasing carbon dioxide may have increased the flammability in *B. tectorum* communities during the past century (Ziska *et al.* 2005, as cited in Zouhar *et al.* 2008, p. 30; Blank *et al.* 2006, p. 234).

Field studies likewise demonstrate that *Bromus* species demonstrate significantly higher plant density, biomass, and seed rain (dispersed seeds) at elevated carbon dioxide levels relative to native annuals (Smith *et al.* 2000, pp. 79-81). The researchers conclude that "the results from this study confirm experimentally in an intact ecosystem that elevated carbon dioxide may enhance the invasive success of *Bromus* spp. in arid ecosystems," and suggest that this enhanced success will then expose these areas to accelerated fire cycles (Smith *et al.* 2000, p. 81). Chambers and Pellant (2008, p. 32) also suggest that higher carbon dioxide levels are likely increasing *B. tectorum* fuel loads due to increased productivity, with a resulting increase in fire frequency and extent. Based on the best available information, we expect the current and predicted atmospheric carbon dioxide levels to increase the threat posed to greater sage-grouse by *B. tectorum* and from more frequent, expansive, both in sage-grouse habitat degradation (functional fragmentation) and severe wildfires (Smith *et al.* 1987, p. 143; Smith *et al.* 2000, p. 81; Brown *et al.* 2004, p. 384; Neilson *et al.* 2005, pp. 150, 156; Chambers and Pellant 2008, pp. 31-32). Therefore, beyond the potential changes associated with temperature and precipitation, increases in carbon dioxide concentrations represent a threat to the sagebrush biome and an indirect threat to sage-grouse through habitat degradation and loss (Miller *et al.* in press, p. 45), with the combined effects of higher temperatures and carbon dioxide concentrations leading to a loss of 12 percent of the current area of sagebrush per degree Celsius of temperature increase, or from 34 to 80 percent of sagebrush distribution depending on the emissions scenario used (Nielson *et al.* 2005, p. 6, 10; Miller *et al.* in press, p. 45).

Bradley (2009, pp. 196-208) and Bradley *et al.* (2009, pp. 1-11) predict that nonnative invasive species in the sagebrush-steppe ecosystem may either expand or contract under climate change, depending on the current and projected future range of a particular invasive plant species. They developed a bioclimatic model for *B. tectorum* based on maps of invaded range derived from remote sensing. The best predictors of *B. tectorum* occurrence were summer, annual, and spring precipitation, followed by winter temperature (Bradley *et al.*, 2009, p. 5). Depending primarily on future precipitation conditions, the model predicts *B. tectorum* is likely to shift northwards, leading to expanded risk of *B. tectorum* invasion in Idaho, Montana, and Wyoming, but reduced risk of invasion in southern Nevada and Utah, which currently have large areas dominated by this nonnative grass (Bradley *et al.*, 2009, p. 5). Therefore, the threat posed to greater sage-grouse by the greater frequency and geographic extent of wildfires and other associated negative impacts from the presence of *B. tectorum* is expected to continue into the foreseeable future. Bradley (2009, pp. 205) stated that the bioclimatic model she used is an initial step in assessing the potential geographic extent of *B. tectorum*, because climate conditions only affect invasion on the broadest regional scale. Other factors relating to land use, soils, competition, or topography may affect suitability of a given location. Bradley (2009, entire) concludes that the potential for climate to shift away from suitability for *B. tectorum* in the future may offer an opportunity for restoration of the sagebrush biome in this area. We anticipate that areas that become unsuitable for *B. tectorum*, may transition to other vegetation over time. However, it is not known if transition back to sagebrush as a dominant landcover or to other native or nonnative vegetation is more likely.

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

Shafer *et al.* (2001, pp. 213) explicitly state that their approach should not be used to predict the future range of a species, and that the underlying assumptions of the models they used are "unsatisfying" because they presume a direct causal relationship between the distribution of a species and particular environmental variables. Shafer *et al.* (2001, pp. 207, 213) identify cautions similar to Bradley *et al.* (in press, pp. 205) regarding their models. A variety of factors are not included in climate space models, including: the effect of elevated CO2 on the species' water-use efficiency, what really is the physiological effect of exceeding the assumed (modeled) bioclimatic limit on the species, the life stage at which the limit affects the species (seedling versus adult), the life span of the species, and the movement of other organisms into the species range (Shafer *et al.*, 2001, pp. 207). These variables would likely help determine how climate change would affect species distributions. Shafer *et al.* (2001, pp. 213) concludes that while more empirical studies are needed on what determines a species and multi-species distributions, those data are often lacking; in their absence climatic space models can play an important role in characterizing the types of changes that may occur so that the potential impacts on natural systems can be assessed.

Schrag *et al.* (submitted MS, 2009, pp. 1-42) developed a bioclimatic envelope model for big sagebrush and silver sagebrush in the States of Montana, Wyoming, and North and South Dakotas. This analysis suggests that large displacement and reduction of sagebrush habitats will occur under climate change as early as 2030 for both species of sagebrush examined. At the time of this finding, the Schrag *et al.* analysis has not been peer reviewed, and we have significant reservations about using analyses of this level of complexity in making management decisions, without it having gone through a review process where experts in the fields of climate change, bioclimatic modeling, and sagebrush ecology can all assess the validity of the reported results. Other models projecting the affect of climate change on sagebrush habitat discussed more below, identify uncertainty associated with projecting climatic habitat conditions into the future given the unknown influence of other factors that such models do not incorporate (e.g., local physiographic conditions, life stage of the plant, generation time of the plant and its reaction to changing CO2 levels).

In some cases, effects of climate change can be demonstrated (e.g., McLaughlin *et al.* 2002) and where it can be, we rely on that empirical evidence, such as increased stream temperatures (see Rio Grande cutthroat trout, 73 FR 27900), or loss of sea ice (see polar bear, 73 FR 28212), and treat it as a threat that can be analyzed. However, we have no such data relating to greater sage-grouse. Application of continental scale climate change models to regional landscapes, and even more local or "step-down" models projecting habitat potential based on climatic factors, while informative, contain a high level of uncertainty due to a variety of factors including: regional weather patterns, local physiographic conditions, life stages of individual species, generation time of species, and species reactions to changing CO2 levels. The models summarized above are limited by these types of factors; therefore, their usefulness in assessing the threat of climate change on greater sage-grouse also is limited.

Summary: Climate Change

The direct, long-term impact from climate change to greater sage-grouse is yet to be determined. However, as described above, the invasion of *Bromus tectorum* and the associated changes in fire regime currently pose one of the significant threats to greater sage-grouse and the sagebrush-steppe ecosystem. Under current climate-change projections, we anticipate that future climatic conditions will favor further invasion by *B. tectorum*, as well as woody invasive species that affect habitat suitability, and that fire frequency will continue to increase, and the extent and severity of fires may increase as well. Climate warming is also likely to increase the severity of WNv outbreaks and to expand the area susceptible to outbreaks into areas that are now too cold for the WNv vector. Therefore, the consequences of climate change, if current projections are realized, are likely to exacerbate the existing primary threats to greater sage-grouse of frequent wildfire and invasive nonnative plants, particularly *B. tectorum* as well as the threat posed by disease. As the IPCC projects that the changes to the global climate system in the 21st century will likely be greater than those observed in the 20th century (IPCC 2007, p. 45), we anticipate that these effects will continue and likely increase into the foreseeable future. As there is some degree of uncertainty regarding the potential effects of climate change on greater sage-grouse specifically, climate change in and of itself was not considered a significant factor in our determination whether greater sage-grouse is warranted for listing. However, we expect the severity and scope of two of the significant threats to greater sage-grouse, frequent wildfire and *B. tectorum* colonization and establishment; as well as epidemic WNv, to magnify within the foreseeable future due the effects of climate change already underway (i.e., increased temperature and carbon dioxide). Thus, currently we consider climate change as playing a potentially important indirect role in intensifying some of the current significant threats to the species.

Analysis of Habitat Fragmentation in the Context of Factor A

Greater sage-grouse are a landscape-scale species requiring large, contiguous areas of sagebrush for long-term persistence. Large-scale characteristics within surrounding landscapes influence habitat selection, and adult sage-grouse exhibit a high fidelity to all seasonal habitats, resulting in little adaptability to changes. Fragmentation of sagebrush habitats has been cited as a primary cause of the decline of sage-grouse populations (Patterson 1952, pp. 192-193; Connelly and Braun 1997, p. 4; Braun 1998, p. 140; Johnson and Braun 1999, p. 78; Connelly *et al.* 2000a, p. 975; Miller and Eddleman 2000, p. 1; Schroeder and Baydack 2001, p. 29; Johnsgard 2002, p. 108; Aldridge and Brigham 2003, p. 25; Beck *et al.* 2003, p. 203; Pedersen *et al.* 2003, pp. 23-24; Connelly *et al.* 2004, p. 4-15; Schroeder *et al.* 2004, p. 368; Leu *et al.* in press, p. 19). Documented negative effects of fragmentation include reduced lek persistence, lek attendance, population recruitment, yearling and adult annual survival, female nest site selection, nest initiation, and loss of leks and winter habitat (Holloran 2005, p. 49; Aldridge and Boyce 2007, pp. 517-523; Walker *et al.* 2007a, pp. 2651-2652; Doherty *et al.* 2008, p. 194). Functional habitat loss also contributes to habitat fragmentation as greater sage-grouse avoid areas due to human activities, including noise, even though sagebrush remains intact. In an analysis of population connectivity, Knick and Hanser (in press, p. 31) demonstrated that in some areas of the sage-grouse range, populations are already isolated and at risk for extirpation due to genetic, demographic, and environmental stochasticity. Habitat loss and fragmentation contribute to this population isolation and increased risk of extirpation.

We examined several factors that result in habitat loss and fragmentation. Historically, large losses of sagebrush habitats occurred due to conversion for agricultural croplands. This conversion is continuing today, and may increase due to the promotion of biofuel production and new technologies to provide irrigation to arid lands. Indirect effects of agricultural activities, such as linear corridors created by irrigation ditches, also contribute to habitat fragmentation by allowing the incursion of nonnative plants. Direct habitat loss and fragmentation also has occurred as the result of expanding human populations in the western United States, and the resulting urban development in sagebrush habitats.

Fire is one of the primary factors linked to population declines of greater sage-grouse because of long-term loss of sagebrush and conversion to nonnative grasses. Loss of sagebrush habitat to wildfire has been increasing in the western portion of the greater sage-grouse range due to an increase in fire frequency and size. This change is the result of incursion of nonnative annual grasses, primarily *Bromus tectorum*, into sagebrush ecosystems. The positive feedback loop between *B. tectorum* and fires facilitates future fires and precludes the opportunity for sagebrush, which is killed by fire, to become re-established. *B. tectorum* and other invasive plants also alter habitat suitability for sage-grouse by reducing or eliminating native forbs and grasses essential for food and cover. Annual grasses and noxious perennials continue to expand their range, facilitated by ground disturbances, including wildfire, grazing, agriculture, and infrastructure associated with energy development and urbanization. Concern with habitat loss and fragmentation due to fire and invasive plants has mostly been focused in the western portion of the species' range. However, climate change may alter the range of invasive plants, potentially expanding this threat into other areas of the species' range. The establishment of these plants will then contribute to increased fire frequency in those areas, further compounding habitat loss and fragmentation. Functional habitat loss is occurring from the expansion of native conifers, mainly due to decreased fire return intervals, livestock grazing, increases in global carbon dioxide concentrations, and climate change.

Sage-grouse populations are significantly reduced, including local extirpation, by nonrenewable energy development activities, even when mitigative measures are implemented (Walker *et al.* 2007a, p. 2651). The persistent and increasing demand for energy resources is resulting in their continued development within sage-grouse range, and will only act to increase habitat fragmentation. Habitat fragmentation due to energy development results not only from the actual footprint of energy development and its appurtenant facilities (e.g., powerlines, roads), but also from functional habitat loss (e.g., noise, presence of overhead structures).

Livestock management and domestic livestock and wild horse grazing have the potential to seriously degrade sage-grouse habitat at local scales through loss of nesting cover, decreasing native vegetation, and successional stage and, therefore, vegetative resiliency, and increasing the probability of incursion of invasive plants. Fencing constructed to manage domestic livestock causes direct mortality, degradation, and fragmentation of habitats, and increased predator populations. There is little direct evidence linking grazing practices to population levels of greater sage-grouse. However, testing for impacts of grazing at landscape scales important to sage-grouse is confounded by the fact that almost all sage-grouse habitat has at one time been grazed, and thus no non-grazed areas currently exist with which to compare. While some rangeland treatments to remove sagebrush for livestock forage production can temporarily increase sage-grouse foraging areas, the predominant effect is habitat loss and fragmentation, although those losses cannot be quantified or spatially analyzed due to lack of data collection.

Restoration of sagebrush habitat is challenging, and restoring habitat function may not be possible because alteration of vegetation, nutrient cycles, topsoil, and cryptobiotic crusts have exceeded recovery thresholds. Even if possible, restoration will require decades and will be cost-prohibitive. To provide habitat for sage-grouse, restoration must include all seasonal habitats and occur on a large scale (4,047 ha (10,000 ac) or more) to provide all necessary habitat components. Restoration may never be achieved in the presence of invasive grass species.

The WAFWA identified a goal of "no net loss" of birds and habitat in their Greater Sage-grouse Comprehensive Conservation Strategy (Stiver *et al.* 2006, p. 1-7). Knick and Hanser (in press, p. 32) have concluded that this strategy may no longer be possible due to natural and anthropogenic threats that are degrading the remaining sagebrush habitats. They recommend focusing conservation on areas critical to range-wide persistence of this species (Knick and Hanser in press, p. 31). Wisdom *et al.* (in press, pp. 24-25) and Knick and Hanser (in press, p. 17) identified two strongholds of contiguous sagebrush habitat essential for the long-term persistence of greater sage-grouse (the southwest Wyoming Basin and the Great Basin area straddling the States of Oregon, Nevada, and Idaho). Other areas within the greater sage-grouse range had a high uncertainty for continued population persistence (Wisdom *et al.*, in press, p. 25) due to fragmentation from anthropogenic impacts. However, our analyses of fragmentation in the two stronghold areas showed that habitats in these areas are becoming fragmented due to wildfire, invasive species, and energy development. Therefore, we are concerned that the level of fragmentation in these areas may already be limiting sage-grouse populations and further reducing connectivity between populations. These threats have intensified over the last two decades, and we anticipate that they will continue to accelerate due to the positive feedback loop between fire and invasives and the persistent and increasing demand for energy resources.

Population Trends in Relation to Habitat Loss and Fragmentation

In order to assess the effects of habitat loss and fragmentation on greater sage-grouse populations and persistence, we examined a variety of data to understand how population trends reflected the changing habitat condition. Patterns of sage-grouse extirpation were identified by Aldridge *et al.* 2008 (entire) Johnson *et al.* (in press, entire), Wisdom *et al.* (in press, entire), Knick and Hanser (in press, entire), and others, and discussed in detail above. Examples include fragmentation of populations and their isolation as a result of habitat loss from fire (Knick and Hanser in press, p. 20; Wisdom *et al.* in press, p. 22), an increase in the probability of extirpation as a result of fire (Knick and Hanser in press, p. 31) and agricultural activities and human densities (Aldridge *et al.* 2008, p. 990; Wisdom *et al.* in press, p. 4), and sage-grouse population declines as a result of energy development (Doherty *et al.* 2008, p. 193; Johnson *et al.* in press, p. 13; Leu and Hanser, in press, p. 28). Therefore, where these habitat factors, and others identified above, are occurring, we anticipate that sage-grouse population trends will continue to decline.

Lek count data are the only data available to estimate sage-grouse population trends, and are the data WAFWA collects (WAFWA 2008, p. 3). The use of lek count data as an index of trends involves various types of uncertainty (such as measurement error, count methods, statistical and other types of assumptions; e.g. see Connelly *et al.*, 2004, pp. 6-18 to 6-20; and WAFWA 2008, pp. 7-8). Nevertheless, these data have been collected for 50 years in most locations and therefore do have utility in examining long-term trends (Gerrodette 1987, p. 1370; Connelly *et al.* 2004, p. A3-3; Stiver *et al.* 2009, p. 3-5; WAFWA 2008, p. 3), and in evaluating differences in trends across the species' range. Therefore, we are considering the results of researchers whose work relies on lek data (e.g., Garton *et al.* (in press), Wisdom *et al.* (in press), Connelly *et al.* (2004, p. 6-18 to 6-59; WAFWA 2008, entire) to help inform our overall analyses.

Population trends (average number of males per lek) in MZs I and II, the areas with the highest concentration of nonrenewable energy development, decreased by 17 and 30 percent from 1965 to 2007, respectively (Garton *et al.* in press, pp. 28, 35). Individual population trends within each MZ varied. However, in areas of intensive energy development, trends were negative as habitat continued to be fragmented. For example, in the Powder River Basin of Wyoming, sage-grouse populations have declined by 79 percent in the 12 years since coal-bed methane development was initiated there (Emmerich 2009, pers. comm.). In MZs affected by *Bromus tectorum* and fire, (primarily MZs IV (Snake River Plain) and V (Northern Great Basin)), population trends from 1995 to 2007 also were negative (Table 6). These results are consistent with the analyses conducted by Wisdom *et al.* (in press, p. 24) that demonstrate that fragmentation as a result of disturbance results in reduced population numbers and population isolation.

In some populations within the species' range, population trends (number of males counted on leks) since the early 1990s appear to be stable, and in some cases increasing (Garton *et al.* in press, Figs.2-8, pp.188-219). However, simply looking at total number of males counted does not accurately reflect habitat conditions, as leks, and by inference the associated breeding habitats, could have been lost. Additionally, as discussed above, sage-grouse will continue to attend leks even after habitat suitability is diminished simply due to site fidelity (Walker *et al.* 2007a, p. 2651). Therefore, the counts of males on these leks may artificially minimize the declines seen in trend analyses, as little productivity results from them. Because the analyses were truncated in 2007 to be comparable to other analyses of population trends (i.e. Connelly *et al.* 2004 and WAFWA 2008, see discussion under population size above), delays in population response to habitat loss and fragmentation events within the past 2 to 3 years may not have been captured. Also, some significant events that have resulted in habitat loss occurred after the 2007 lekking season. For example, the Murphy complex fire in Idaho and Nevada burned 264,260 ha (653,000 ac), resulting in the loss of 75 of 102 leks, and the associated nesting habitats in the area. Population-level effects of this fire would not be reflected by any of the three population trend analyses (Connelly *et al.*, 2004; WAFWA 2008; Garton *et al.* in press) simply because it occurred after the time period analyzed.

Projections of Future Populations

As described above, our analysis of habitat trends, and those provided in the published literature show that population extirpation and declines have, and are likely to continue to track habitat loss or environmental changes (e.g., Walker *et al.*, 2005, Aldridge *et al.* 2008; Knick and Hanser in press; Wisdom *et al.* in press). Estimation of how these trends may affect future population numbers and habitat carrying capacity was conducted by Garton *et al.* (in press, entire). We realize population viability analyses are based on assumptions that may or may not be realistic given the species analyzed. Additionally, lek counts are not the best data for use in these kinds of analyses as variability in lek attendance, observer bias, and the unknown relationship between males counted to actual population sizes limit unbiased estimation of future population numbers (see also discussion under population sizes above, and in Garton *et al.*, in press, pp. 8, 66). At the request of the Colorado Division of Wildlife, three individuals (Conroy 2009, entire; Noon 2009, entire; Runge 2009, entire) reviewed Garton *et al.* outside the established peer review process and noted similar limitations of these data. We received these reviews and have reviewed them in the context of all other data we received in preparation of this finding. Their primary concern was about the applicability of analyzing and presenting future population projections in the manner done by Garton *et al.* in press, based on the limitations of the data, the assumptions required, and uncertainty in the estimates of the model parameters (see also discussion above).

Garton *et al.*, (in press, pp. 6-8, 64-67) acknowledged these concerns, as several of the reviewers pointed out, and their analyses underwent peer review via the normal scientific process prior to acceptance for publication. Population viability analyses can provide useful information in examining the potential future status of a species as long as the assumptions of the model, and violations thereof, are clearly identified and considered in the interpretation of the results. Therefore, we present the analyses conducted by Garton *et al.* (in press, entire) here in relation to our conclusion of how existing and continued habitat fragmentation may impact the greater sage-grouse within the foreseeable future. The projections reported by Garton *et al.* (in press, entire; see discussion below) are generally consistent with what we expect given the causes of sage-grouse declines and extirpation documented in the literature (see above) and where those threats occur in the species range, despite the concerns of the authors and others about the limitations of lek data and prospective analysis. We are unaware of any other prospective rangewide population viability analyses for this species.

Garton *et al.* (in press, entire) projected population and habitat carrying capacity trends (the modeled estimate where population growth rate is 0) at 30 (2037) and 100 (2107) years into the future. Growth rates were analogous to rates from 1987 to 2007, and quasi-extinction thresholds (artificial thresholds below which the long-term persistence and viability of a species is questionable due to stochastic variables, such as small populations or genetic inbreeding) corresponded to minimum counts of 20 and 200 males at leks (Garton *et al.* in press, p. 19). The thresholds were established to correspond to populations of 50 and 500 breeding birds, numbers generally accepted for adequate effective population sizes to avoid negative genetic effects from inbreeding (Garton *et al.* in press, p. 19). Therefore, population projections that fell below 50 breeding adults (males and females) were identified as being at short-term risk of extinction, and those that fell below 500 breeding adults (males and females) were identified as being at long-term risk for extinction. However, recent work by Bush (2009, p. 106) suggests that a higher proportion of male sage-grouse are breeding than previously identified. Therefore, Garton *et al.* (in press, p. 20) state that their resulting projections are likely underestimates of actual impacts as more birds are necessary than they assumed for population productivity. Additionally, Traill *et al.* (2010, p. 32) argue that a minimum effective population size must be 5,000 individuals to maintain evolutionary minimal viable populations of wildlife (retention of sufficient genetic material to avoid effect of inbreeding depression or deleterious mutations). We examined the projected population trends for 30 years to minimize the risk of error associated with the 100 year projections simply due to using lek data.

One assumption made by Garton *et al.* (in press, p. 19) is that future population growth would be analogous to what occurred from 1987 to 2007. We anticipate adverse habitat impacts (see discussion of foreseeable future below) and synergism between these impacts (e.g. fire and invasive species expansion) to increase habitat loss; therefore, Garton *et al.*'s (in press) likely over-estimate the resulting future habitat carrying capacity and population numbers.

In all MZs, the analyses by Garton *et al.* (in press) predict that populations will continue to decline. In MZ I, Garton *et al.* (in press, p. 29) project a population decline of 59 percent between 2007 and 2037 if current population and habitat trends continue (Table 10). In the Powder River Basin area, where significant gas development is occurring, population trends were projected an almost 90 percent decline by 2037 (Garton *et al.* in press, p. 26). This projection is consistent with Walker *et al.* (2007, p. 2651) estimate that lek persistence would decline to 5 percent in the Powder River Basin with full field development over a similar time frame. Also, Johnson (in press, p. 13) found that lek counts were reduced from 1997 to 2007 in areas of oil and gas development, and our GIS analyses found that a minimum of 70 percent of breeding habitats is affected by energy development activities in this area (Service 2008b; see discussion under Energy Development). Declines in the Powder River Basin within the past 12 years of development have reached 79 percent (Emmerich 2009, pers. comm.). Populations in MZ I that do not experience the same levels of energy development are not projected to decline as significantly, with the exception of the Yellowstone watershed population (Table 10). This population is projected to be extirpated within 30 years (Garton *et al.* in press, p. 46). This area is highly fragmented by agricultural and energy development, factors identified by Aldridge *et al.* (2008, p. 991) and Wisdom *et al.* (in press, p. 23) with sage-grouse extirpation. Wisdom *et al.* (in *press*, p. 23) also predicted extirpation in this area due to the continuing loss of sagebrush. Loss of the Yellowstone watershed population will result in a gap in the species' range, isolating sage-grouse north of the Missouri River from the rest of the species.

TABLE 10—PROJECTED CHANGES IN CARRYING CAPACITIES OF MANAGEMENT ZONES AND POPULATIONS FROM 2007 TO 2037. CARRYING CAPACITIES ARE REFLECTED AS THE AVERAGE NUMBER OF MALES PER LEK, AND WERE CALCULATED BY DIVIDING POPULATION PROJECTIONS FOR 2037 BY THE POPULATION ESTIMATE IN 2007. DATA FROM GARTON *et al.* (IN PRESS, PP. 22-63, 95-97).

Management Zone	Population	Change in Carrying Capacity from 2007 to 2037 (%)
I (Great Plains)		-59
	Yellowstone watershed	-100
	Powder River	-90
	Northern Montana	-11
	Dakotas	-62

TABLE 10—PROJECTED CHANGES IN CARRYING CAPACITIES OF MANAGEMENT ZONES AND POPULATIONS FROM 2007 TO 2037. CARRYING CAPACITIES ARE REFLECTED AS THE AVERAGE NUMBER OF MALES PER LEK, AND WERE CALCULATED BY DIVIDING POPULATION PROJECTIONS FOR 2037 BY THE POPULATION ESTIMATE IN 2007. DATA FROM GARTON *et al.* (IN PRESS, PP. 22-63, 95-97).—Continued

Management Zone	Population	Change in Carrying Capacity from 2007 to 2037 (%)
II (Wyoming Basin)		-66
	Eagle – S. Routt	extirpated
	Jackson Hole	—
	Middle Park	—
	Wyoming Basin	-64
III (Southern Great Basin)		-55
	Bi-State NV/CA	-7
	S. Mono Lake	—
	NE Interior UT	+211
	San Pete County UT	—
	S. central UT	-36
	Summit-Morgan UT	-14
	Toole-Juab UT	-27
	Southern Great Basin	-61
IV (Snake River Plain)		-55
	Baker, OR	No change
	Bannack, MT	-9
	Red Rocks, MT	-18
	Wisdom, MT	—
	E. central ID	—
	Snake, Salmon, Beaverhead, ID	-18
	Northern Great Basin	-73
V (Northern Great Basin)		-74
	Central OR	-67
	Klamath, OR	—
	NW Interior NV	—
	Western Great Basin	-59
VI (Columbia Basin)		-46
	Moses Coulee	-74
	Yakima	—

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TABLE 10—PROJECTED CHANGES IN CARRYING CAPACITIES OF MANAGEMENT ZONES AND POPULATIONS FROM 2007 TO 2037. CARRYING CAPACITIES ARE REFLECTED AS THE AVERAGE NUMBER OF MALES PER LEK, AND WERE CALCULATED BY DIVIDING POPULATION PROJECTIONS FOR 2037 BY THE POPULATION ESTIMATE IN 2007. DATA FROM GARTON *et al.* (IN PRESS, PP. 22-63, 95-97).—Continued

Management Zone	Population	Change in Carrying Capacity from 2007 to 2037 (%)
VII (Colorado Plateau)*		—

— Data insufficient to model
* Although the model projects population increases, habitat is limited in the area, likely limiting actual population growth.

Garton *et al.* (in press, p. 36) projected populations will decline in MZ II by 66 percent between 2007 and 2037 if current population trends and habitat activities continue (Table 10). The Wyoming Basin area, where significant oil, gas and renewable energy development is occurring, is projected to decline by 64 percent (Garton *et al.* in press, p. 34). Population persistence for the Eagle–South Routt population, an area also experiencing significant energy development activities, could not be estimated due to data sampling concerns. However, the population is unlikely to persist for 20 years (Braun, as cited in Garton *et al.* in press, p 30), where 100 percent of the breeding habitat is affected by energy development (Service 2008b). Johnson (in press, p. 13) found that declines in lek attendance was strongly, negatively associated with the presence of wells in these areas once the total number of wells in this MZ exceeded 250. Wells in both of these populations currently exceed that threshold. Therefore, the results of Garton *et al.*'s (in press) analyses are not unexpected.

Garton *et al.* (in press, p. 46) projected populations in MZ III will decline by 53 percent between 2007 and 2037 if current population trends and habitat activities continue (Table 10). Most populations in this area are already isolated by topographic features and experience high native conifer incursions. *Bromus tectorum* also is of significant concern in the Southern Great Basin population. Large losses of sagebrush in this MZ have resulted from *B. tectorum* incursion and the resulting altered fire cycle (Johnson in press, p. 23). Fire within 54 km (33.5 mi) of a lek was identified by Knick and Hanser (in press, p. 29) as one of the most important factors negatively affecting sage-grouse persistence on the landscape. Assuming the current rate of habitat loss continues in this MZ, carrying capacity is projected to decline by 45 percent by 2037 (Garton *et al.* in press, p. 46).

In MZ IV, Garton *et al.* (in press, p. 53) populations are projected to decline by 55 percent between 2007 and 2037 if current population trends and habitat activities continue (Table 10). The Northern Great Basin population is projected to have the greatest drop in carrying capacity, and is the area currently most affected by reduced fire cycles as a result of *Bromus tectorum* incursions. As discussed above, fire within 54 km (33.5 mi) of a lek was identified by as one of the most important factors negatively affecting sage-grouse persistence on the landscape (Knick and Hanser in press, p. 29). The associated incursion of *B. tectorum* has resulted in large losses of habitat in this MZ (Johnson in press, p. 23). Carrying capacities in other populations in this MZ are not projected to decline as much, but these populations do not have significant fire and *B. tectorum* incursions.

In MZ V, Garton *et al.* (in press, p. 58) projected populations will decline by 74 percent between 2007 and 2037 if current population trends and habitat activities continue (Table 10). Nearly all populations within this MZ are affected by reduced fire frequencies and *Bromus tectorum* incursions (see discussion above). In MZ VI, Garton *et al.* (in press, p. 62) projected populations will decline by 46 percent between 2007 and 2037 if current population trends and habitat activities continue (Table 10). The two populations in this MZ are already isolated from the rest of the range, and actively managed by the State of Washington to maintain birds (e.g., translocations, active habitat enhancement). In addition to impacts from agricultural activities and human development (Johnson in press, p. 27), these populations are affected by the loss of CRP lands and military activities, neither of which were quantified by Garton *et al.* (in press, entire). Therefore, the projections provided in the population viability analysis are likely underestimated.

Carrying capacity projections could not be estimated for MZ VII due to insufficient data. Energy development activities occur within most populations in this area, and Johnson (in press, p. 13) reported that lek attendance was lower around producing wells in this MZ. We believe that based on habitat impacts, if birds are retained in this area, the populations will be reduced in size and further isolated.

The projections from Garton *et al.* (in press, entire), which are consistent with results reported by Wisdom *et al.* (in press, entire), our own analyses, and others examining the effects of habitat loss and degradation on population trends, reflect that by 2037 sage-grouse populations and connectivity between them will be further reduced across the species range. This is consistent with other literature that has documented patterns of decline and extirpation as a result of the ongoing habitat losses and fragmentation (for example, see Johnson in press, Knick *et al.* in press and Wisdom *et al.* in press). We are cautious in using a single projection for determining future population status based on the limitation of lek data and the lack of any other comparable rangewide population viability analyses. However, Garton *et al.*'s (in press, entire) results are consistent with the habitat loss and fragmentation analyses conducted by the Service and many other authors, as noted in the individual MZ discussions above.

The population and carrying capacity projections by Garton *et al.* (in press, pp. 22-64) are generally consistent with what we would expect given the causes of sage-grouse declines and extirpation documented in the literature (see above) and where those threats occur in the species range. Therefore, despite the concerns of the authors and other about the limitations of lek data and prospective analysis, the results presented by Garton *et al.* (in press, entire) are consistent with our analyses of habitat impacts based on the review of the best available scientific information.

Foreseeable Future of Habitat Threats

We examined the persistence of each of these habitat threats on the landscape to help inform a determination of foreseeable future. Habitat conversion and fragmentation resulting from agricultural activities and urbanization will continue indefinitely. Human populations are increasing in the western United States and we have no data indicating this trend will be reversed. Increased fire frequency as facilitated by the expanding distribution of invasive plant species will continue indefinitely unless an effective means for controlling the invasives is found. In the last approximately 100 years, no broad scale *Bromus tectorum* eradication method has been developed. Therefore, given the history of invasive plants on the landscape, our continued inability to control such species, and the expansive infestation of invasive plants across the species' range currently, we anticipate they and associated fires will be on the landscape for the next 100 years or longer.

Continued exploration and development of traditional and nonconventional fossil fuel sources in the eastern portion of the greater sage-grouse range will continue to increase over the next 20 years (EIA 2009b, p. 109). Based on existing National Environmental Policy Act (NEPA) documents for major oil and gas developments, production within existing developments will continue for a minimum of 20 years, with subsequent restoration (if possible) requiring from 30 to 50 additional years. Renewable energy development is estimated to reach maximum development by 2030. However, since most renewable energy facilities are permanent landscape features, unlike oil, gas and coal, direct and functional habitat loss from the development footprint will be permanent. Based on this information, we estimate the foreseeable future of energy development at a minimum of 50 years, and perhaps much longer for nonrenewable sources.

Grazing (both domestic and wild horse and burro) is unlikely to be removed from sagebrush ecosystems. Therefore, it is difficult to estimate a foreseeable future for livestock grazing. However, as of 2007, there were 7,118,989 permitted AUMs in sage-grouse habitat. Although there have been recent reductions in the number of AUMs (3.4 percent since 2005), we have no information suggesting that livestock grazing will be significantly reduced, or removed, from sage-grouse habitats. Therefore, while we cannot provide an exact estimate of the foreseeable future for grazing, we expect it to be a persistent use of the sage-grouse landscape for several decades.

Summary of Factor A

As identified above in our Factor A analysis, habitat conversion for agriculture, urbanization, infrastructure (e.g., roads, powerlines, fences); fire, invasive plants, pinyon-juniper woodland encroachment, grazing, energy development, and climate change are all contributing, individually and collectively, to the present and threatened destruction, modification, and curtailment of the habitat and range of the greater sage-grouse. The impacts are compounded by the fragmented nature of this habitat loss, as fragmentation results in functional loss of habitat for greater sage-grouse even when otherwise suitable habitat is still present.

Fragmentation of sagebrush habitats is a key cause, if not the primary cause, of the decline of sage-grouse populations. Fragmentation can make otherwise suitable habitat either too small or isolated to be of use to greater sage-grouse (i.e., functional habitat destruction), or the abundance of sage-grouse that can be supported in an area is diminished. Fire, invasive plants, energy development, various types of infrastructure, and agricultural conversion have resulted in habitat fragmentation and additional fragmentation is expected to continue for the foreseeable future in some areas.

In our evaluation of Factor A, we found that although many of the habitat impacts we analyzed (e.g, fire, urbanization, invasive species) are present throughout the range, they are not at a level that is causing a threat to greater sage-grouse everywhere within its range. Some threats are of high intensity in some areas but are low or nonexistent in other areas. Fire and invasive plants, and the interaction between them, is more pervasive in the western part of the range than in the eastern. Oil and gas development is having a high impact on habitat in many areas in the eastern part of the range, but a low impact further to the west. The impact of pinyon-juniper encroachment generally is greater in western areas of the range, but is of less concern in more eastern areas such as Wyoming and Montana. Agricultural development is high in the Columbia Basin, Snake River Plain, and eastern Montana, but low elsewhere. Infrastructure of various types is present throughout the most of range of the greater sage-grouse, as is livestock grazing, but the degree of impact varies depending on grazing management practices and local ecological conditions. The degree of urbanization and exurban development varies across the range, with some areas having relatively low impact to habitat.

While sage-grouse habitat has been lost or altered in many portions of the species' range, habitat still remains to support the species in many areas of its range (Connelly *et al.* in press c, p. 23), such as higher elevation sagebrush, and areas with a low human footprint (activities sustaining human development) such as the Northern and Southern Great Basin (Leu and Hanser in press, p. 14), indicating that the threat of destruction, modification or curtailment of the greater sage-grouse is moderate in these areas. In addition, two strongholds of contiguous sagebrush habitat (the southwest Wyoming Basin and the Great Basin area straddling the States of Oregon, Nevada, and Idaho) contain the highest densities of males in the range of the species (Wisdom *et al.* in press, pp. 24-25; Knick and Hanser in press, p. 17). We believe that the ability of these strongholds to maintain high densities to date in the presence of several threats indicates that there are sufficient habitats currently to support the greater sage-grouse in these areas, but not throughout its entire range unless these threats are ameliorated.

As stated above, the impacts to habitat are not uniform across the range; some areas have experienced less habitat loss than others, and some areas are at relatively lower risk than others for future habitat destruction or modification. Nevertheless, the impacts are substantial in many areas and will continue or even increase in the future across much of the range of the species. With continued habitat destruction and modification, resulting in fragmentation and diminished connectivity, greater sage-grouse populations will likely decline in size and become more isolated, making them more vulnerable to further reduction over time and increasing the risk of extinction.

We have evaluated the best scientific and commercial information available regarding the present or threatened destruction, modification, or curtailment of the greater sage-grouse's habitat or range. Based on the current and ongoing habitat issues identified here, their synergistic effects, and their likely continuation in the future, we conclude that this threat is significant such that it provides a basis for determining that the species warrants listing under the Act as a threatened or endangered species.

Factor B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes.

Commercial Hunting

The greater sage-grouse was heavily exploited by commercial hunting in the late 1800s and early 1900s (Patterson 1952, pp. 30-32; Autenrieth 1981, pp. 3-11). Hornaday (1916, pp. 179-221) and others alerted the public to the risk of extinction of the species as a result of this overharvest. The impacts of hunting on greater sage-grouse during those historical decades may have been exacerbated by impacts from human expansion into sagebrush-steppe habitats (Girard 1937, p. 1). In response, many States closed sage-grouse hunting seasons by the 1930s (Patterson 1952, pp.30-33; Autenrieth 1981, p. 10). Sage-grouse have not been commercially harvested for many decades; therefore, commercial hunting does not affect the greater sage-grouse.

Recreational Hunting

With the increase of sage-grouse populations by the 1950s, limited recreational hunting seasons were allowed in most of the species' range (Patterson 1952, p. 242; Autenrieth 1981, p.11). Currently, greater sage-grouse are legally sport-hunted in 10 of 11 States where they occur (Connelly *et al.* 2004, p. 6-3). The hunting season for sage-grouse in Washington was closed in 1988, and the species was added to the State's list of threatened species in 1998 (Stinson *et al.* 2004, p. 1). In Canada, sage-grouse are designated as an endangered species, and hunting is not permitted (Connelly *et al.* 2004, p. 6-3).

[INSERT FIGURE 3 GRAPH HERE]

Harvest levels have varied considerably since the 1950s, and in recent years have been much lower than in past decades (Figure 3) (Service 2009, unpublished data). From 1960 to 1980, the majority of sage-grouse hunting mortality occurred in Wyoming, Idaho, and Montana, accounting for at least 75 to 85 percent of the annual harvest (Service 2009, unpublished data). In the 1960s harvest exceeded 120,000 individuals annually for 7 out of 10 years. Harvest levels reached a maximum in the 1970s, being above 200,000 individuals in 9 of 10 years with the total estimate at 2,322,581 birds harvested for the decade. During the 1980s, harvest exceeded 130,000 individuals in 9 of 10 years (Service 2009, unpublished data). The harvest was above 100,000 annually during the early 1990s but in 1994 dropped below 100,000 for the first time in decades. From 2000 to 2007, annual harvest has averaged approximately 31,000 birds (Service 2009, unpublished data).

Sustainable harvest is determined based on the concept of compensatory and additive mortality (Connelly 2005, p. 7). The compensatory mortality hypothesis asserts that if sage-grouse produce more offspring than can survive to sexual maturity, individuals lost to hunting represent losses that would have occurred otherwise from some other source (e.g., starvation, predation, disease). Hunting mortality is termed additive if it exceeds natural mortality and ultimately results in a decline of the breeding population. The validity of compensatory mortality in upland gamebirds has not been rigorously tested, and as we stated above, annual sage-grouse productivity is relatively low compared to other grouse species. Autenrieth (1981, p. 77) suggested sage-grouse could sustain harvest rates of up to 30 percent annually. Braun (1987, p. 139) suggested a rate of 20 to 25 percent was sustainable. State wildlife agencies currently attempt to keep harvest levels below 5 to 10 percent of the population, based on a recommendation taken from Connelly *et al.* (2000a, p. 976). However, it is unclear from Connelly *et al.* (2000a) what this recommendation is based on, and similar to previous suggested harvest rates, it has not been experimentally tested with regard to its impacts on sage-grouse populations.

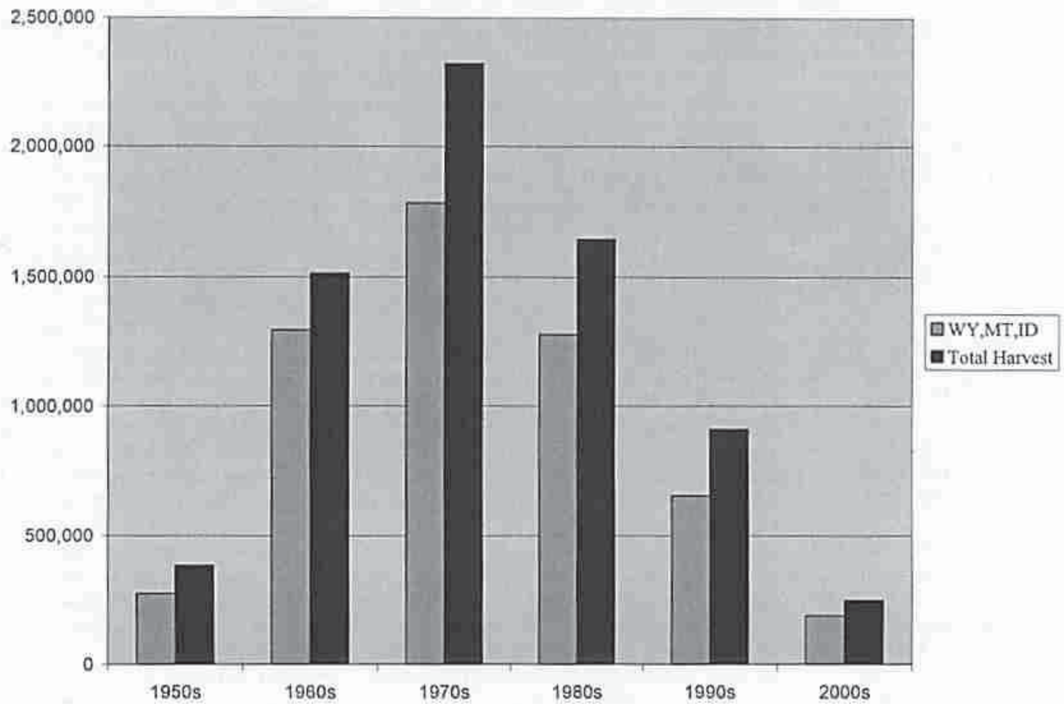
The validity of the idea that hunting is a form of compensatory mortality for upland game birds has been questioned in recent years (Reese and Connelly, in press, p. 6). Connelly *et al.* 2005 (pp. 660, 663) cite many studies suggesting that hunting of upland game, including the greater sage-grouse, is often not compensatory. Other studies have sought to determine whether hunting mortality in sage-grouse is compensatory or additive (Crawford 1982; Crawford and Lutz 1985; Braun 1987; Zunino 1987; Johnson and Braun 1999; Connelly *et al.* 2003; Sedinger *et al.* in press; Sedinger *et al.* unpublished data). Results of those studies have been contradictory. For example, Braun (1987, p. 139) found that harvest levels of 7 to 11 percent had no effect on subsequent spring breeding populations based on lek counts in North Park, Colorado. Johnson and Braun (1999, p. 83) determined that overwinter mortality correlated with harvest intensity in North Park, Colorado, and hypothesized that hunting mortalities may be additive.

Numerous contradictions are likely due to differing methods, lack of experimental data, and differing effects of harvest due to a relationship between harvest and habitat quality. For example, Connelly *et al.* (2003, pp. 256-257) evaluated data for monitored lek routes in areas experiencing different levels of harvest (no harvest, 1-bird season, 2-bird season) in Idaho and found that populations with no hunting season had faster rates of population increase than populations with a light to modest harvest. The effect was particularly pronounced in xeric habitats near human populations, which suggests that the impact of hunting on sage-grouse to some extent depends on habitat quality. Gibson (1998, p. 15) found that hunting mortality had negative impacts on the population dynamics of an isolated population of sage-grouse in Long Valley, California, but appeared to have no effect on sage-grouse in Bodie Hills, California, a nearby population that is contiguous with adjacent occupied areas of Nevada. Data indicated that hunting suppressed the population size of the isolated Long Valley population well below the apparent carrying capacity (Gibson 1998, p. 15; Gardner 2008, pers. comm.).

Sage-grouse hunting is regulated by State wildlife agencies. Hunting seasons are reviewed annually, and States change harvest management based on estimates for spring production and population size (e.g., Bohne 2003, pp.1-10). However, harvest affects fall populations of sage-grouse, and currently there is no reliable method for obtaining estimates of fall population size (Connelly *et al.* 2004, p. 9-6). Instead, lek counts conducted in the spring are used as a surrogate for fall population size. However, fall populations are already reduced from spring estimates as some natural mortality inevitably has occurred in the interim (Kokko 2001, p. 164). The discrepancy between spring and fall population size estimates plays a role in determining whether harvest will be within the recommended level of less than 5-10 percent of the fall population. For example, hen mortality in Montana increased from the typical level of 1 to 5 percent to 16 percent during July/August in a year (2003) with WNv mortality (Moynahan 2006, p.1535). During the summer of 2006 and 2007 in South Dakota, mortality from WNv was estimated to be between 21 and 63 percent of the population (Kaczor 2008, p.72). Despite the increased mortalities due to WNv, hunting regulations in both States remained similar to previous years.

Female survivorship is a key element of population productivity. Harvest might affect female and male grouse differently. Connelly *et al.* (2000b, p.228-229) found that in Idaho 42

Figure 3—Total greater sage-grouse harvest by decade for available State-wide harvest estimates. For illustrative purposes, harvest estimates are shown as totals and as a combination for WY, MT, and ID, the States with the greatest individual harvest levels. (Values are underestimates as no data were available for CA, CO, MT, and NV in the 1950s, and total harvest values for WY were not reported prior to 1957; no data were available in the 1960s for CA, ND, or SD, and data for NV and CO were only partially reported; and no data were available for CA and ND in the 1970s).



percent of all documented female mortality was attributable to hunting while for males the number was 15 percent. Patterson (1952, p. 245) found females accounted for 60 percent (1950) and 63 percent (1951) of total hunting mortalities. Because sage-grouse are relatively long-lived, have moderate reproductive rates, and are polygynous, their populations are likely to be especially sensitive to adult female survival (Schroeder 1999, p.2, 13; Saether and Bakke 2000, p. 652; Connelly 2005, p.9). Yearling sage-grouse hens have less reproductive potential than adults (Dalke *et al.* 1963, p. 839; Moynahan 2006, p. 1537). Adult females have higher nest initiation rates, higher nest success, and higher chick survival rates than yearling females (Connelly *et al.*, in press a, pp. 15, 20, 48). High adult female mortality has the potential to result in negative lag effects as future populations become overrepresented by yearling females (Moynahan 2006, p. 1537).

All States with hunting seasons have changed limits and season dates to more evenly distribute hunting mortality across the entire population structure of greater sage-grouse, harvesting birds after females have left their broods (Bohne 2003, p. 5). Females and broods congregate in mesic areas late in the summer potentially making them more vulnerable to hunting (Connelly *et al.* 2000b, p. 230). However, despite increasingly later hunting seasons, hens in Wyoming continue to comprise the majority of the harvest in all years (WGFD 2004a, p. 4; 2006, p. 7). From 1996 to 2008, on average 63 percent of adult hunting mortalities in Nevada were females (range 58 percent to 73 percent) (NDOW, 2009, unpublished data). In 2008 in Oregon, adult females accounted for 70 percent of the adults harvested (ODFW 2009). These results could indicate that females are more susceptible to hunting mortality, or it could be a reflection of a female skewed sex ratio in adult birds. Male sage-grouse typically have lower survival rates than females, and the varying degrees of female skewed sex ratios recorded for sage-grouse are thought to be as a result of this differential survival (Swenson 1986, p. 16; CO Conservation Plan, p. 54). The potential for negative effects on populations by harvesting reproductive females has long been recognized by upland game managers (e.g., hunting of female ring-necked pheasants, (*Phasianus colchicus)*, is prohibited in most States).

Harvest management levels that are based on the concept of compensatory mortality assume that overwinter mortality is high, which is not true for sage-grouse (winter mortality rates approximately 2 percent, Connelly *et al.* 2000b, p. 229). Additionally, due to WNv, sage-grouse population dynamics may be increasingly affected by mortality that is density independent (i.e., mortality that is independent of population size). Further, there is growing concern regarding wide-spread habitat degradation and fragmentation from various sources, such as development, fire, and the spread of noxious weeds, resulting in density independent mortality which increases the probability that harvest mortality will be additive.

State management agencies have become increasingly responsive to these concerns. All of the States where hunting greater sage-grouse is legal, except Montana, now manage harvests on a regional scale rather than applying State-wide limits. Bag limits and season lengths are relatively conservative compared to prior decades (Connelly 2005, p. 9; Gardner 2008, pers. comm.). Emergency closures have been used for some declining populations. For example, North Dakota closed the 2008 and 2009 hunting seasons following record low lek attendance likely due to WNv (Robinson 2009, pers. comm.). Hunting on the Duck Valley Indian Reservation (Idaho/Nevada) has been closed since 2006 due to WNv (Dick 2009, pers. comm.; Gossett 2008, pers. comm.). Hunting in Owyhee County, Idaho was closed in 2006 and again in 2008 and 2009 as a result of WNv (Dick 2008, pers. comm.; IDFG 2009).

All ten States that allow bow and gun hunting of sage-grouse also allow falconers to hunt sage-grouse. Falconry seasons are typically longer (60 to 214 days), and in some cases have larger bag limits than bow/gun seasons. However, due to the low numbers of falconers and their dispersed activities, the resulting harvest is thought to be negligible (Apa 2008, pers. comm.; Northrup 2008, pers. comm.; Hemker 2008, pers. comm.; Olsen 2008, pers. comm.; Kanta 2008, pers. comm.). Wyoming is one of the few States that collects falconry harvest data and reported a take of 180 sage-grouse by falconers in the 2006-2007 season (WGFD 2007, unpublished data). In Oregon, the take is probably less than five birds per year (Budeau 2008, pers. comm.). In Idaho the 2005 estimated Statewide falconry harvest was 77 birds, and that number has likely remained relatively constant (Hemker 2008, pers. comm.). We are not aware of any studies that have examined falconry take of greater sage-grouse in relation to population trends, but the amount of greater sage-grouse mortality associated with falcon sport hunting appears to be negligible.

We surveyed the State fish and wildlife agencies within the range of greater sage-grouse to determine what information they had on illegal harvest (poaching) of the species. Nevada and Utah indicated they were aware of citations being issued for sage-grouse poaching, but that it was rare (Espinosa 2008, pers. comm.; Olsen 2008, pers. comm.). Sage-grouse wings are infrequently discovered in wing-barrel collection sites during forest grouse hunts in Washington, but such take is considered a result of hunter misidentification rather than deliberate poaching (Schroeder 2008, pers. comm.). None of the remaining States had any quantitative data on the level of poaching. Based on these results, illegal harvest of greater sage-grouse poaching appears to occur at low levels. We are not aware of any studies or other data that demonstrate that poaching has contributed to sage-grouse population declines.

Recreational Use

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

To reduce any potential impact of lek viewing on sage-grouse, several States have implemented measures to protect most leks while allowing recreational viewing to continue. The Wyoming Game and Fish Department (WGFD) provides the public with directions to 16 leks and guidelines to minimize viewing disturbance. Leks included in the brochure are close to roads and already subject to some level of disturbance (Christiansen 2008, pers. comm.); presumably, focusing attention on these areas reduces pressure on relatively undisturbed leks. Colorado and Montana have some sites with viewing trailers for the public for the same reasons (Apa 2008, pers. comm.; Northrup 2008, pers. comm.). We were not able to locate any studies documenting how lek viewing, or other forms of non-consumptive recreational uses, of sage-grouse are related to sage-grouse population trends. Given the relatively small number of leks visited, we have no reason to believe that this type of recreational activity is having a negative impact on local populations or contributing to declining population trends.

Religious Use

Some Native American tribes harvest greater sage-grouse as part of their religious or ceremonial practices as well as for subsistence. Native American hunting occurs on the Wind River Indian Reservation (Wyoming), with about 20 males per year taken off of leks in the spring plus an average fall harvest of approximately 40 birds (Hnilicka 2008, pers. comm.). The Shoshone-Bannock Tribe (Idaho) occasionally takes small numbers of birds in the spring, but no harvest figures have been reported for 2007 and 2008 (Christopherson 2008, pers. comm.). The Shoshone-Paiute Tribe of the Duck Valley Indian Reservation (Idaho and Nevada) suspended hunting in 2006 to 2009 due to significant population declines resulting from a WNv outbreak in the area (Dick 2009, pers. comm.; Gossett 2008, pers. comm.). Prior to 2006, the sage-grouse hunting season on the Duck Valley Indian Reservation ran from July 1 to November 30 with no bag or possession limits. Preliminary estimates indicate that the harvest may have been as high as 25 percent of the population (Gossett 2008, pers. comm.). Despite the hunting ban, populations have not recovered on the reservation (Dick 2009, pers. comm.; Gossett 2008, pers. comm.). No harvest by Native Americans for subsistence or religious and ceremonial purposes occurs in South Dakota, North Dakota, Colorado, Washington, or Oregon (Apa 2008, pers. comm.; Hagen 2008, pers. comm.; Kanta 2008, pers. comm.; Robinson 2008, pers. comm.; Schroeder 2008, pers. comm.).

Scientific and Educational Use

Greater sage-grouse are the subject of many scientific research studies. We are aware of some 51 studies ongoing or completed during 2005 and 2008. Of the 11 western States where sage-grouse currently occur, all reported some type of field studies that included the capture, handling, and subsequent banding, or banding and radio-tagging of sage-grouse. In 2005, the overall mortality rate due to the capture, handling, and/or radio-tagging process was calculated at approximately 2.7 percent of the birds captured (68 mortalities of 2,491 captured). A survey of State agencies, BLM, consulting companies, and graduate students involved in sage-grouse research indicates that there has been little change in direct handling mortality since then. We are not aware of any studies that document that this level of taking has affected any sage-grouse population trends.

Greater sage-grouse have been translocated in several States and the Province of British Columbia (Reese and Connelly 1997, p. 235). Reese and Connelly (1997, pp. 235-238) documented the translocation of over 7,200 birds between 1933 and 1990. Only 5 percent of the translocation efforts documented by Reese and Connelly (1997, p. 240) were considered to be successful in producing sustained, resident populations at the translocation sites. From 2003 to 2005, 137 adult female sage-grouse were translocated to Strawberry Valley, Utah and had a 60 percent annual survival rate (Baxter *et al.* 2006, p. 182). Since 2004, Oregon and Nevada have supplied the State of Washington with close to 100 greater sage-grouse to increase the genetic diversity of the geographically isolated Columbia Basin populations and to reestablish a historical population. One bird has died during transit and as expected natural mortality for translocated birds has been higher than resident populations (Schroeder 2008, pers. comm.). Given the low numbers of birds that have been used for translocation spread over many decades, it is unlikely that the removals from source populations have contributed to greater sage-grouse declines, while the limited success of translocations also has likely had nominal impact on rangewide population trends. We did not find any information regarding the direct use of greater sage-grouse for educational purposes.

Summary of Factor B

Greater sage-grouse are not used for any commercial purpose. In Canada, hunting of sage-grouse is prohibited in Alberta and Saskatchewan. In the United States, sage-grouse hunting is regulated by State wildlife agencies and hunting regulations are reevaluated yearly. We have no information that suggests any change will occur in the current situation, in which hunting greater sage-grouse is prohibited in Washington and allowed elsewhere in the range of the species in the U.S. under State regulations, which provide a basis for adjustments in annual harvest and emergency closures of hunting seasons. We have no evidence suggesting that gun and bow sport hunting has been a primary cause of range-wide declines of the greater sage-grouse in the past, or that it currently is at level that poses a significant threat to the species. However, although harvest as a singular factor does not appear to threaten the species throughout its range, negative impacts on local populations have been demonstrated and there remains a large amount of uncertainty regarding harvest impacts because of a lack of experimental evidence and conflicting studies. Significant habitat loss and fragmentation have occurred during the past several decades, and there is evidence that the sustainability of harvest levels depends to a large extent upon the quality of habitat and the health of the population. However, recognition that habitat loss is a limiting factor is not conclusive evidence that hunting has played no role in population declines or that reducing or eliminating harvest will not have an effect on population stability or recovery.

Take from poaching (illegal hunting) appears to occur at low levels in localized areas, and there is no evidence that it contributes to population declines. The information on non-consumptive recreational activities is limited to lek viewing, the extent of such activity is small, and there is no indication that it has a negative impact that contributes to population declines. Harvest by Native American tribes, and mortality that results from handling greater sage-grouse for scientific purposes appears to occur at low levels in localized areas and thus we do not consider these to be a significant threat at either the rangewide or local population levels. We know of no utilization for educational purposes. We have no reason to believe any of the above activities will increase in the future.

We do not believe data support overuse of sage-grouse as a singular factor in rangewide population declines. We note, however, that in light of present and threatened habitat loss (Factor A) and other considerations (e.g. West Nile virus outbreaks in local populations), continued close attention will be needed by States and tribes to carefully manage hunting mortality, including adjusting seasons and allowable harvest levels, and imposing emergency closures if needed.

In sum, we find that this threat is not significant to the species such that it causes the species to warrant listing under the Act.

Factor C: Disease and Predation.

Disease

Greater sage-grouse are hosts for a variety parasites and diseases, including macroparasitic arthropods, helminths and microparasites (protozoa, bacteria, viruses and fungi) (Thorne *et al.* 1982, p. 338; Connelly *et al.* 2004, pp. 10-4 to 10-7; Christiansen and Tate, in press, p. 2). However, there have been few systematic surveys for parasites or infectious diseases of greater sage-grouse; therefore, whether they have a role in population declines is unknown (Connelly *et al.* 2004, p. 10-3; Christiansen and Tate, in press, p. 3). Early studies have suggested that sage-grouse populations are adversely affected by parasitic infections (Batterson and Morse 1948, p. 22). Parasites also have been implicated in sage-grouse mate selection, with potentially subsequent effects on the genetic diversity of this species (Boyce 1990, p. 263; Deibert 1995, p. 38). However, Connelly *et al.* (2004, p. 10-6) note that, while these relationships may be important to the long-term ecology of greater sage-grouse, they have not been shown to be significant to the immediate population status. Connelly *et al.* (2004, p. 10-3) have suggested that diseases and parasites may limit isolated sage-grouse populations, but that the effects of emerging diseases require additional study (see also Christiansen and Tate, in press, pp. 22-23).

Internal parasites which have been documented in the greater sage-grouse include the protozoans *Sarcosystis* spp. and *Tritrichomonas simoni*, blood parasites (including avian malaria (*Plasmodium* spp.), *Leucocytozoon* spp., *Haemoproteus* spp., and *Trypanosoma avium*, tapeworms (*Raillietina centrocerci* and *R. cesticillus*), gizzard worms (*Habronema* spp. and *Acuaria* spp.), cecal worms (*Heterakis gallinarum*), and filarid nematodes (*Ornithofilaria tuvensis*) (Honess 1955, pp.1-2; Hepworth 1962, p. 6: Thorne *et al.* 1982, p. 338; Connelly *et al.* 2004, pp. 10-4 to 10-6; Petersen 2004, p. 50; Christiansen and Tate, in press, pp. 9-13). None of these parasites have been known to cause mortality in the greater sage-grouse (Christiansen and Tate, in press, p. 8-13). Sub-lethal effects of these parasitic infections on sage-grouse have never been studied.

Greater sage-grouse host many external parasites, including lice, ticks, and dipterans (midges, flies, mosquitoes, and keds) (Connelly *et al.* 2004, pp. 10-6 to 10-7). Most ectoparasites do not produce disease, but can serve as disease vectors or cause mechanical injury and irritation (Thorne *et al.* 1982, p. 231). Ectoparasites can be detrimental to their hosts, particularly when the bird is stressed by inadequate habitat or nutritional conditions (Petersen 2004, p. 39). Some studies have suggested that lice infestations can affect sage-grouse mate selection (Boyce 1990, p. 266; Spurrier *et al.* 1991, p. 12; Deibert 1995, p. 37), but population impacts are not known (Connelly *et al.* 2004, p. 10-6).

Only a few parasitic infections in greater sage-grouse have been documented to result in fatalities, including the protozoan, *Eimeria* spp. (coccidiosis) (Connelly *et al.* 2004, p. 10-4), and possibly ixodid ticks (*Haemaphysalis cordeilishas*). Mortality is not 100 percent with coccidiosis, and young birds that survive an initial infection typically do not succumb to subsequent infections (Thorne *et al.* 1982, p. 112). Infections also tend to be localized to specific geographic areas. Most cases of coccidiosis in greater sage-grouse have been found where large numbers of birds congregated, resulting in soil and water contamination by fecal material (Scott 1940, p. 45; Honess and Post 1968, p. 20; Connelly *et al.* 2004, p. 10-4; Christiansen and Tate, in press, p. 3). While the role of this parasite in population regulation is unknown, Petersen (2004, p. 47) hypothesized that coccidiosis could be limiting for local populations, as this parasite causes decreased growth and resulted in significant mortality in young birds, thereby potentially limiting recruitment. However, no cases of sage-grouse mortality resulting from coccidiosis have been documented since the early 1960s (Connelly *et al.* 2004, p. 10-4), with the exception of two yearlings being held in captivity (Cornish 2009a, pers. comm.). One hypothesis for the apparent decline in occurrences of coccidiosis is the reduced density of sage-grouse, limiting the spread of the disease (Christiansen and Tate, in press, p. 14).

The only mortalities associated with ixodid ticks were found in association with a tularemia (*Francisella tularenis*) outbreak in Montana (Parker *et al.* 1932, p. 480; Christiansen and Tate, in press, p. 7). The sage-grouse mortality was likely from the pathological effects of the abnormally high number of feeding ticks found on the birds, as well as tularemia infection itself (Christiansen and Tate, in press, p.15). No other reports of tularemia have been recorded in greater sage-grouse (Christiansen and Tate, in press, p. 15).

Greater sage-grouse also are subject to a variety of bacterial, fungal, and viral pathogens. The bacteria *Salmonella* spp. has caused mortality in the greater sage-grouse and was apparently contracted through of exposure to contaminated water supplies around livestock stock tanks (Connelly *et al.* 2004, p. 10-7). However, it is unlikely that diseases associated with *Salmonella* spp. pose a significant risk to sage-grouse unless environmental conditions concentrate birds, resulting in contamination of limited water supplies by accumulated fecal material (Christiansen and Tate, in press, p. 15). A tentative documentation of *Mycoplasma* spp. in sage-grouse is known from Colorado (Hausleitner 2003, p. 147), but we found no other information to suggest this bacterium is either fatal or widespread. Other bacteria found in sage-grouse include avian tuberculosis (*Mycobacterium avium*), and avian cholera (*Pasteurella multocida*). These bacteria have never been identified as a cause of mortality in greater sage-grouse and the risk of exposure and hence, population effects, is low (Connelly *et al.* 2004, p. 10-7 to 10-8).

Sage-grouse afflicted with coccidiosis in Wyoming also were positive for *Escherichia coli* (Honess and Post 1968, p. 17). This bacterium is not believed to be a threat to wild populations of greater sage-grouse (Christiansen and Tate, in press, p. 15), as it has only been shown to cause acute mortality in captive birds kept in unsanitary conditions (Friend 1999, p. 125). One death from *Clostridium perfringens* has been recorded in a free-ranging adult male sage-grouse in Oregon (Hagen and Bildfell 2007, p. 545). Friend (1999, p. 123) mentions that outbreaks of *Clostridum* have been reported in greater sage-grouse, but the only information we located were two deaths reported from northeastern Wyoming (Cornish 2009a, pers. comm.). Christiansen and Tate (in press, p. 14) caution that given the persistence of this bacterium's spores in the soil, the resulting necrotic enteritis, especially when coupled with coccidiosis, may be a concern in small isolated populations.

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

Viruses could cause serious diseases in grouse species and potentially influence population dynamics (Petersen 2004, p. 46). However, prior to 2002, only avian infectious bronchitis (caused by a coronavirus) had been identified in the greater sage-grouse during necropsy. No clinical signs of the disease were observed.

West Nile virus was introduced into the northeastern United States in 1999 and has subsequently spread across North America (Marra *et al.* 2004, p.394). This virus is thought to have caused millions of wild bird deaths since its introduction (Walker and Naugle in press, p. 4), but most WNv mortality goes unnoticed or unreported (Ward *et al.* 2006, p. 101). The virus persists largely within a mosquito-bird-mosquito infection cycle (McLean 2006, p. 45). However, direct bird-to-bird transmission of the virus has been documented in several species (McLean 2006, pp. 54, 59) including the greater sage-grouse (Walker and Naugle in press, p. 13; Cornish 2009b, pers. comm.). The frequency of direct transmission has not been determined (McLean 2006, p. 54).

Impacts of WNv on the bird host varies by species with some species being relatively unaffected (e.g., common grackles (*Quiscalus quiscula*)) and others experiencing mortality rates of up to 68 percent (e.g., American crow (*Corvus brachyrhynchos*)) (Walker and Naugle in press, p. 4, and references therein). Greater sage-grouse are considered to have a high susceptibility to WNv, with resultant high levels of mortality (Clark *et al.* 2006, p. 19; McLean 2006, p. 54).

In sagebrush habitats, WNv transmission is primarily regulated by environmental factors, including temperature, precipitation, and anthropogenic water sources, such as stock ponds and coal-bed methane ponds, that support the mosquito vectors (Reisen *et al.* 2006, p. 309; Walker and Naugle in press, pp. 10-12). Cold ambient temperatures preclude mosquito activity and virus amplification, so transmission to and in sage-grouse is limited to the summer (mid-May to mid-September) (Naugle *et al.* 2005, p. 620; Zou *et al.* 2007, p. 4), with a peak in July and August (Walker and Naugle in press, p. 10). Reduced and delayed WNv transmission in sage-grouse has occurred in years with lower summer temperatures (Naugle *et al.* 2005, p. 621; Walker *et al.* 2007b, p. 694). In non-sagebrush ecosystems, high temperatures associated with drought conditions increase WNv transmission by allowing for more rapid larval mosquito development and shorter virus incubation periods (Shaman *et al.* 2005, p.134; Walker and Naugle in press, p. 11). Greater sage-grouse congregate in mesic habitats in the mid-late summer (Connelly *et al.* 2000, p. 971) thereby increasing the risk of exposure to mosquitoes. If WNv outbreaks coincide with drought conditions that aggregate birds in habitat near water sources, the risk of exposure to WNv will be elevated (Walker and Naugle in press, p. 11).

Greater sage-grouse inhabiting higher elevation sites in summer are likely less vulnerable to contracting WNv than birds at lower elevation as ambient temperatures are typically cooler (Walker and Naugle in press, p. 11). Greater sage-grouse populations in northwestern Colorado and western Wyoming are examples of high elevation populations with lower risk for impacts from WNv (Walker and Naugle in press, p. 26). Also, due to summer temperatures generally being lower in more northerly areas, sage-grouse populations that are in geographically more northern populations my be less susceptible than those at similar elevations farther south (Naugle *et al.* 2005, cited in Walker and Naugle in press, p. 11). Climate change could result in increased temperatures and thus potentially exacerbate the prevalence of WNv, and thereby impacts on greater sage-grouse, but this risk also depends on complex interactions with other environmental factors including precipitation and distribution of suitable water (Walker and Naugle in press, p. 12)

The primary vector of WNv in sagebrush ecosystems is *Culex tarsalis* (Naugle *et al.* 2004, p. 711; Naugle *et al.* 2005, p. 617; Walker and Naugle in press, p. 6). Individual mosquitoes may disperse as much as 18 km (11.2 mi) (Miller 2009, pers. comm.; Walker and Naugle in press, p. 7). This mosquito species is capable of overwinter survival and, therefore, can emerge as infected adults the following spring (Walker and Naugle in press, p. 8 and references therein), thereby decreasing the time for disease cycling (Miller 2009, pers. comm.). This ability may increase the occurrence of this virus at higher elevation populations or where ambient temperatures would otherwise be insufficient to sustain the entire mosquito-virus cycle.

In greater sage-grouse, mortality from WNv occurs at a time of year when survival is otherwise typically high for adult females (Schroeder *et al.* 1999, p.14; Aldridge and Brigham 2003, p. 30), thus potentially making these deaths additive and reducing average annual survival (Naugle *et al.* 2005, p. 621). WNv has been identified as a source of additive mortality in American white pelicans (*Pelecanus erythrorhynchos*) in the northern plains breeding colonies (Montana, North Dakota and South Dakota), and its continued impact has the potential to severely impact the entire pelican population (Sovada *et al.* 2008, p. 1030).

WNv was first detected in 2002 as a cause of greater sage-grouse mortalities in Wyoming (Walker and Naugle in press, p. 15). Data from four studies in the eastern half of the sage-grouse range (Alberta, Montana, and Wyoming; MZ I) showed survival in these populations declined 25 percent in July and August of 2003 as a result of the WNv infection (Naugle *et al.* 2004, p. 711). Populations of sage-grouse that were not affected by WNv showed no similar decline. Additionally, individual sage-grouse in exposed populations were 3.4 times more likely to die during July and August, the peak of WNv occurrence, than birds in non-exposed populations (Connelly *et al.* 2004, p. 10-9; Naugle *et al.* 2004, p. 711). Subsequent declines in both male and female lek attendance in infected areas in 2004 compared with years before WNv suggest outbreaks could contribute to local population extirpation (Walker *et al.* 2004, p. 4). One outbreak near Spotted Horse, Wyoming in 2003 was associated with the subsequent extirpation of the local breeding population, with five leks affected by the disease becoming inactive within 2 years (Walker and Naugle in press, p. 16). Lek surveys in northeastern Wyoming in 2004 indicated that regional sage-grouse populations did not decline, suggesting that the initial effects of WNv were localized (WGFD, unpublished data, 2004b).

Eight sage-grouse deaths resulting from WNv were identified in 2004: four from the Powder River Basin area of northeastern Wyoming and southeastern Montana, one from the northwestern Colorado, near the town of Yampa, and three in California (Naugle *et al.* 2005, p. 618). Fewer other susceptible hosts succumbed to the disease in 2004, suggesting that below average precipitation and summer temperatures may have limited mosquito production and disease transmission rates (Walker and Naugle in press, pp. 16-17). However, survival rates in greater sage-grouse in July and September of that year were consistently lower in areas with confirmed WNv mortalities than those without (avg. 0.86 and 0.96, respectively; Walker and Naugle in press, p. 17). There were no comprehensive efforts to track sage-grouse mortalities outside of these areas, so the actual distribution and extent of

WNv in sage-grouse in 2004 is unknown (70 FR 2270).

Mortality rates from WNv in northeastern Wyoming and southeastern Montana (MZ I) were between 2.4 (estimated minimum) and 28.9 percent (estimated maximum) in 2005 (Walker *et al.* 2007b, p. 693). Sage-grouse mortalities also were reported in California, Nevada, Utah, and Alberta, but no mortality rates were calculated (Walker and Naugle in press, p. 17). Mortality rates in 2006 in northeastern Wyoming ranged from 5 to15 percent of radio-marked females (Walker and Naugle in press, p. 17). Mortality rates in South Dakota among radio-marked juvenile sage-grouse ranged between 6.5 and 71 percent in the same year (Kaczor 2008, p. 63). Large sage-grouse mortality events, likely the result of WNv, were reported in the Jordan Valley and near Burns, Oregon (over 60 birds), and in several areas of Idaho and along the Idaho-Nevada border (over 55 birds) (Walker and Naugle in press, p. 18). While most of the carcasses had decomposed and, therefore, were not testable, results for the few that were tested showed that they died from WNv. Mortality rates in these areas were not calculated. However, the hunting season in Owyhee County, Idaho, was closed that year due to the large number of birds that succumbed to the disease (USGS 2006, p. 1; Walker and Naugle in press, p. 18).

In 2007, a WNv outbreak in South Dakota contributed to a 44-percent mortality rate among 80 marked females (Walker and Naugle in press, p. 18). Juvenile mortality rates in 2007 in the same area ranged from 20.8 to 62.5 percent (Kaczor 2008, p. 63), reducing recruitment the subsequent spring by 2 to 4 percent (Kaczor 2008, p. 65). Twenty-six percent of radio-marked females in northeastern Montana died during a 2–week period immediately following the first detection of WNv in mosquito pools. Two of those females were confirmed dead from WNv (Walker and Naugle in press, p. 18). In the Powder River Basin, WNv-related mortality among 85 marked females was between 8 and 21 percent (Walker and Naugle in press, p. 18). A 52-percent decline in the number of males attending leks in North Dakota between 2007 and 2008 also were associated with WNv mortality in 2007 that prompted the State wildlife agency to close the hunting season in 2008 (North Dakota Game and Fish 2008, entire) and 2009 (Robinson 2009, pers. comm.). The Duck Valley Indian Reservation along the border of Nevada and Idaho closed their hunting season in 2006 due to population declines resulting from WNv (Gossett 2008, pers. comm.). WNv is still present in that area, with continued population declines (50.3 percent of average males per lek from 2005 to 2008) (Dick 2008, p. 2), and the hunting season remains closed. The hunting season was closed in most of the adjacent Owyhee County, Idaho for the same reason in both 2008 and 2009 (Dick 2008, pers. comm.; IDFG 2009).

Only Wyoming reported WNv mortalities in sage-grouse in 2008 (Cornish 2009c, pers. comm.). However, with the exceptions of Colorado, California, and Idaho, research on sage-grouse in other States is limited, minimizing the ability to identify mortalities from the disease, or recover infected birds before tissue deterioration precludes testing. Three sage-grouse deaths were confirmed in 2009 in Wyoming (Cornish 2009c, pers. comm.), two in Idaho (Moser 2009, pers. comm.) and one other is suspected in Utah (Olsen 2009, pers. comm.).

Greater sage-grouse deaths resulting from WNv have been detected in 10 States and 1 Canadian province. To date, no sage-grouse mortality from WNv has been identified in either Washington State or Saskatchewan. However, it is likely that sage-grouse have been infected in Saskatchewan based on known patterns of sage-grouse in infected areas of Montana (Walker and Naugle in press, p. 15). Also, WNv has been detected in other species within the range of greater sage-grouse in Washington (USGS 2009).

In 2005, we reported that there was little evidence that greater sage-grouse can survive a WNv infection (70 FR 2270). This conclusion was based on the lack of sage-grouse found to have antibodies to the virus and from laboratory studies in which all sage-grouse exposed to the virus, at varying doses, died within 8 days or less (70 FR 2270; Clark *et al.* 2006, p. 17). These data suggested that sage-grouse do not develop a resistance to the disease, and death is certain once an individual is exposed (Clark *et al.* 2006, p. 18). However, 6 of 58 females (10.3 percent) birds captured in the spring of 2005 in northeastern Wyoming and southeastern Montana were seropositive for neutralizing antibodies, which suggests they were exposed to the virus the previous fall and survived an infection. Additional, but significantly fewer (2 of 109, or 1.8 percent) seropositive females were found in the spring of 2006 (Walker *et al.* 2007b, p. 693). Of approximately 1,400 serum tests on sage-grouse from South Dakota, Montana, Wyoming and Alberta, only 8 tested positive for exposure to WNv (Cornish 2009dpers. comm.), suggesting that survival is extremely low. Seropositive birds have not been reported from other parts of the species' range (Walker and Naugle in press, p. 20).

The duration of immunity conferred by surviving an infection is unknown (Walker and Naugle in press, p. 20). It also is unclear whether sage-grouse have sub-lethal or residual effects resulting from a WNv infection, such as reduced productivity or overwinter survival (Walker *et al.* 2007b, p. 694). Other bird species infected with WNv have been documented to suffer from chronic symptoms, including reduced mobility, weakness, disorientation, and lack of vigilance (Marra *et al.* 2004, p. 397; Nemeth *et al.* 2006, p. 253), all of which may affect survival, reproduction, or both (Walker and Naugle in press, p. 20). Reduced productivity in American white pelicans has been attributed to WNv (Sovada *et al.* 2008, p.1030).

Several variants of WNv have emerged since the original identification of the disease in the United States in 1999. One variant, termed NY99, has proven to be more virulent than the original virus strain of WNv, increasing the frequency of disease cycling (Miller 2009, pers. comm.). This constant evolution of the virus could limit resistance development in the greater sage-grouse.

Walker and Naugle (in press, pp. 20-24) modeled variability in greater sage-grouse population growth for the next 20 years based on current conditions under three WNv impact scenarios. These scenarios included: (1) no mortalities from WNv; (2) WNv- related mortality based on rates of observed infection and mortality rate data from 2003 to 2007; and (3) WNv-related mortality with increasing resistance to the disease over time. The addition of WNv-related mortality (scenario 2) resulted in a reduction of population growth. The proportion of resistant individuals in the modeled population increased marginally over the 20–year projection periods, from 4 to 15 percent, under the increasing resistance scenario (scenario 3). While this increase in the proportion of resistant individuals did reduce the projected WNv rates, the authors caution that the presence of neutralizing antibodies in the live birds does not always indicate that these birds are actually resistant to infection and disease (Walker and Naugle in press, p. 25).

Additional models predicting the prevalence of WNv suggest that new sources of anthropogenic surface waters (e.g., coal-bed methane discharge ponds), increasing ambient temperatures, and a mosquito parasite that reduces the length of time the virus is present in the vector before the mosquito can spread the virus all suggest the impacts of this disease are likely to increase (Miller 2008, pers. comm.). However, the extent to which this will occur, and where, is unclear and difficult to predict because several conditions that support the WNv cycle must coincide for an outbreak to occur.

Human-created water sources in sage-grouse habitat known to support breeding mosquitoes that transmit WNv include overflowing stock tanks, stock ponds, irrigated agricultural fields, and coal-bed natural gas discharge ponds (Zou *et al.* 2006, p. 1035). For example, from 1999 through 2004, potential mosquito habitats in the Powder River Basin of Wyoming and Montana increased 75 percent (619 ha to 1084.5 ha; 1259 ac to 2680) primarily due to the increase of small coal-bed natural gas water discharge ponds (Zou *et al.* 2006, p. 1034). Additionally, water developments installed in arid sagebrush landscapes to benefit wildlife continue to be common. Several scientists have expressed concern regarding the potential for exacerbating WNv persistence and spread due to the proliferation of surface water features (e.g., Friend *et al.*, 2001, p. 298; Zou *et al.* 2006, p.1040; Walker *et al.* 2007b, p. 695; Walker and Naugle in press, p. 27). Walker *et al.* (2007a, p. 694) concluded that impacts from WNv will depend less on resistance to the disease than on temperatures and changes in vector distribution. Zou *et al.* (2006, p. 1040) cautioned that the continuing development of coal-bed natural gas facilities in Wyoming and Montana contributes to maintaining, and possibly increasing WNv on that landscape through the maintenance and proliferation of surface water.

The long-term response of different sage-grouse populations to WNv infections is expected to vary markedly depending on factors that influence exposure and susceptibility, such as temperature, land uses, and sage-grouse population size (Walker and Naugle in press, p. 25). Small, isolated, or genetically limited populations are at higher risk as an infection may reduce population size below a threshold where recovery is no longer possible, as observed with the extirpated population near Spotted Horse, Wyoming (Walker and Naugle in press, p. 25). Larger populations may be able to absorb impacts resulting from WNv as long as the quality and extent of available habitat supports positive population growth (Walker and Naugle in press, p. 25). However, impacts from this disease may act synergistically with other stressors resulting in reduction of population size, bird distribution, or persistence (Walker *et al.* 2007a, p. 2652). WNv persists on the landscape after it first occurs as an epizootic, suggesting this virus will remain a long-term issue in affected areas (McLean 2006, p. 50).

Proactive measures to reduce the impact of WNv on greater sage-grouse have been limited and are typically economically prohibitive. Fowl vaccines used on captive sage-grouse were largely ineffective (mortality rates were reduced from 100 to 80 percent in five birds) (Clark *et al.* 2006, p. 17; Walker and Naugle in press, p. 27). Development of a sage-grouse specific vaccine would require a market incentive and development of an effective delivery mechanism for large numbers of birds. Currently, the delivery mechanism is via intramuscular injection (Marra *et al.* 2004, p. 399; Walker and Naugle in press, p. 27), which is not feasible for wild populations. Vaccinations would likely only benefit the individuals receiving the vaccine, and not their offspring, so vaccination would have to occur on an annual basis (Walker and Naugle in press, p. 27, and references therein).

Mosquito production from human-created water sources could be minimized if water produced during coal-bed natural gas development were re-injected rather than discharged to the surface (Doherty 2007, p. 81). Mosquito control programs for reducing the number of adult mosquitoes may reduce the risk of WNv, but only if such methods are consistently and appropriately implemented (Walker and Naugle in press, p. 28). Many coal-bed natural gas companies in northeastern Wyoming (MZ I) have identified use of mosquito larvicides in their management plans (Big Horn Environmental Consultants in litt., 2009, p. 3). However, we could find no information on the actual use of the larvicides or their effectiveness. One experimental treatment in the area did report that mosquito larvae numbers were less in ponds treated with larvicides than those that were not (Big Horn Environmental Consultants in litt., 2009, pp. 5-7) but statistical analyses were not conducted. While none of the sage-grouse mortalities in the treated areas were due to WNv (Big Horn Environmental Consultants 2009, p.3), the study design precluded actual cause and effect analyses; therefore, the results are inconclusive. The benefits of mosquito control in potentially reducing the incidence of WNv in sage-grouse need to be considered in light of the potential detrimental or cascading ecological effects of widespread spraying (Marra *et al.* 2004, p. 401).

Small populations, such as the Columbia Basin area in Washington State or the subpopulations within the Bi-State area along the California and Nevada border also may be at high risk of extirpation simply due to their low population numbers and the additive mortality WNv causes (Christiansen and Tate, in press, p. 21). Larger populations may be better able to sustain losses from WNv (Walker and Naugle in press, p. 25) simply due to their size. However, as other impacts to grouse and their habitats described under Factor A affect these areas, these secure areas or sage-grouse "refugia" also may be at risk (e.g., southwestern Wyoming, south-central Oregon). Existing and developing models suggest that the occurrence of WNv is likely to increase throughout the range of the species into the future.

Summary of Disease

Although greater sage-grouse are host to a wide variety of diseases and parasites, few have resulted in population effects, with the exception of WNv. Many large losses from bacterial and coccidial infections have resulted when large groups of grouse were restricted to limited habitats, such as springs and seeps in the late summer. If these habitats become restricted due to habitat losses and degradation, or changes in climate, these easily transmissible diseases may become more prevalent. Sub-lethal effects of these disease and parasitic infections on sage-grouse have never been studied, and, therefore, are unknown.

Substantial new information on WNv and impacts on the greater sage-grouse has emerged since we completed our finding in 2005. The virus is now distributed throughout the species' range, and affected sage-grouse populations experience high mortality rates with resultant, often large reductions in local population numbers. Infections in northeastern Wyoming, southeastern Montana, and the Dakotas seem to be the most persistent, with mortalities recorded in that area every year since WNv was first detected in sage-grouse. Limited information suggests that sage-grouse may be able to survive an infection; however, because of the apparent low level of immunity and continuing changes within the virus, widespread resistance is unlikely.

There are few regular monitoring efforts for WNv in greater sage-grouse; most detection is the result of research with radio-marked birds, or the incidental discovery of large mortalities. In Saskatchewan, where the greater sage-grouse is listed as an endangered species, no monitoring for WNv occurs (McAdams 2009, pers. comm.). Without a comprehensive monitoring program, the extent and effects of this disease on greater sage-grouse rangewide cannot be determined. However, it is clear that WNv is persistent throughout the range of the greater sage-grouse, and is likely a locally significant mortality factor. We anticipate that WNv will persist within sage-grouse habitats indefinitely, and will remain a threat to greater sage-grouse until they develop a resistance to the virus.

The most significant environmental factors affecting the persistence of WNv within the range of sage-grouse are ambient temperatures and surface water abundance and development. The continued development of anthropogenic sources of warm standing water throughout the range of the species will likely increase the prevalence of the virus in sage-grouse, as predicted by Walker and Naugle (in press, pp. 20-24; see discussion above). Areas with intensive energy development may be at a particularly high risk for continued WNv mortalities due to the development of surface water features, and the continued loss and fragmentation of habitats (see discussion of energy development above). Resultant changes in temperature as a result of climate change also may exacerbate the prevalence of WNv and thereby impacts on greater sage-grouse unless they develop resistance to the virus.

With the exception of WNv, we could find no evidence that disease is a concern with regard to sage-grouse persistence across the species' range. WNv is a significant mortality factor for greater sage-grouse when an outbreak occurs, given the bird's lack of resistance and the continued proliferation of water sources throughout the range of the species. However, a complex set of environmental and biotic conditions that support the WNv cycle must coincide for an outbreak to occur. Currently the annual patchy distribution of the disease is keeping the impacts at a minimum. The prevalence of this disease is likely to increase across the species' range.

We find that the threat of disease is not significant to the point that the greater sage-grouse warrants listing under the Act as threatened or endangered at this time

Predation

Predation is the most commonly identified cause of direct mortality for sage-grouse during all life stages (Schroeder *et al.* 1999, p. 9; Connelly *et al.* 2000b, p. 228; Connelly *et al.* in press a, p. 23). However, sage-grouse have co-evolved with a variety of predators, and their cryptic plumage and behavioral adaptations have allowed them to persist despite this mortality factor (Schroeder *et al.* 1999, p. 10; Coates 2008 p. 69; Coates and Delehanty 2008, p. 635; Hagen in press, p. 3). Until recently, there has been little published information that indicates predation is a limiting factor for the greater sage-grouse (Connelly *et al.* 2004, p. 10-1), particularly where habitat quality has not been compromised (Hagen in press, p. 3). Although many predators will consume sage-grouse, none specialize on the species (Hagen in press, p. 5). However, generalist predators have the greatest effect on ground nesting birds because predator numbers are independent of prey density (Coates 2007, p. 4).

Major predators of adult sage-grouse include many species of diurnal raptors (especially the golden eagle), red foxes, and bobcats (*Lynx rufus*) (Hartzler 1974, pp. 532-536; Schroeder *et al.* 1999, pp. 10-11; Schroeder and Baydack 2001, p. 25; Rowland and Wisdom 2002, p. 14; Hagen in press, pp. 4-5). Juvenile sage-grouse also are killed by many raptors as well as common ravens, badgers (*Taxidea taxus*), red foxes, coyotes and weasels (*Mustela* spp.) (Braun 1995, entire; Schroeder *et al.* 1999, p. 10). Nest predators include badgers, weasels, coyotes, common ravens, American crows, and magpies (*Pica* spp.). Elk (Holloran and Anderson 2003, p.309) and domestic cows (*Bovus* spp.) (Coates *et al.* 2008, pp. 425-426), have been observed to eat sage-grouse eggs. Ground squirrels (*Spermophilus* spp.) also have been identified as nest predators (Patterson 1952, p. 107; Schroeder *et al.* 1999, p. 10; Schroeder and Baydack 2001, p. 25), but recent data show that they are physically incapable of puncturing eggs (Holloran and Anderson 2003, p 309; Coates *et al.* 2008, p 426; Hagen in press, p. 6). Several other small mammals visited sage-grouse nests monitored by videos in Nevada, but none resulted in predation events (Coates *et al.* 2008, p. 425). Great Basin gopher snakes (*Pituophis catenifer deserticola*) were observed at nests, but no predation occurred.

Adult male greater sage-grouse are very susceptible to predation while on the lek (Schroeder *et al.* 1999, p. 10; Schroeder and Baydack 2000, p. 25; Hagen in press, p. 5), presumably because they are very conspicuous while performing their mating displays. Because leks are attended daily by numerous birds, predators also may be attracted to these areas during the breeding season (Braun 1995). Connelly *et al.* (2000b, p.228) found that among 40 radio-collared males, 83 percent of the mortality was due to predation and 42 percent of those mortalities occurred during the lekking season (March through June). Adult female greater sage-grouse are susceptible to predators while on the nest but mortality rates are low (Hagen in press, p. 6). Hens will abandon their nest when disturbed by predators (Patterson 1952, p. 110), likely reducing this mortality (Hagen in press, p. 6). Connelly *et al.* (2000b, p. 228) found that among 77 radio-collared adult hens that died, 52 percent of the mortality was due to predation, and 52 percent of those mortalities occurred between March and August, which includes the nesting and brood-rearing periods. Because sage-grouse are highly polygynous with only a few males breeding per year, sage-grouse populations are likely more sensitive to predation upon females. Predation of adult sage-grouse is low outside the lekking, nesting, and brood-rearing season (Connelly *et al.* 2000b, p. 230; Naugle *et al.* 2004, p. 711; Moynahan *et al.* 2006, p. 1536; Hagen in press, p. 6).

Estimates of predation rates on juveniles are limited due to the difficulties in studying this age class (Aldridge and Boyce 2007, p. 509; Hagen in press, p.8). Chick mortality from predation ranged from 27 percent to 51 percent in 2002 and 10 percent to 43 percent in 2003 on three study sites in Oregon (Gregg *et al.* 2003a, p. 15; 2003b, p. 17). Mortality due to predation during the first few weeks after hatching was estimated to be 82 percent (Gregg *et al.* 2007, p. 648). Based on partial estimates from three studies, Crawford *et al.* (2004, p. 4 and references therein) reported survival of juveniles to their first breeding season was low, approximately 10 percent, and predation was one of several factors they cited as affecting juvenile survival. However, Connelly *et al*, (in press a, p. 19) point out that the estimate of 10 percent survival of juveniles likely is biased low, as at least two of the four studies that were the basis of this estimate were from areas with fragmented or otherwise marginal habitat.

Sage-grouse nests are subject to varying levels of predation. Predation can be total (all eggs destroyed) or partial (one or more eggs destroyed). However, hens abandon nests in either case (Coates, 2007, p. 26). Gregg *et al.* (1994, p. 164) reported that over a 3–year period in Oregon, 106 of 124 nests (84 percent) were preyed upon (Gregg *et al.* 1994, p. 164). Non-predated nests had greater grass and forb cover than predated nests. Patterson (1952, p.104) reported nest predation rates of 41 percent in Wyoming. Holloran and Anderson (2003, p. 309) reported a predation rate of 12 percent (3 of 26) in Wyoming. In a 3–year study involving four study sites in Montana, Moynahan *et al.* (2007, p. 1777) attributed 131 of 258 (54 percent) of nest failures to predation in Montana, but the rates may have been inflated by the study design (Connelly *et al.* in press a, p. 17). Re-nesting efforts may compensate for the loss of nests due to predation (Schroeder 1997, p. 938), but re-nesting rates are highly variable (Connelly *et al.* in press a, p. 16). Therefore, re-nesting is unlikely to offset losses due to predation. Losses of breeding hens and young chicks to predation potentially can influence overall greater sage-grouse population numbers, as these two groups contribute most significantly to population productivity (Baxter *et al.* 2008, p. 185; Connelly *et al*, in press a, p. 18).

Nesting success of greater sage-grouse is positively correlated with the presence of big sagebrush and grass and forb cover (Connelly *et al.* 2000, p. 971). Females actively select nest sites with these qualities (Schroeder and Baydack 2001, p. 25; Hagen *et al.* 2007, p. 46). Nest predation appears to be related to the amount of herbaceous cover surrounding the nest (Gregg *et al.* 1994, p. 164; Braun 1995; DeLong *et al.* 1995, p. 90; Braun 1998; Coggins 1998, p. 30; Connelly *et al.* 2000b, p. 975; Schroeder and Baydack 2001, p. 25; Coates and Delehanty 2008, p. 636). Loss of nesting cover from any source (e.g., grazing, fire) can reduce nest success and adult hen survival. However, Coates (2007, p. 149) found that badger predation was facilitated by nest cover as it attracts small mammals, a badger's primary prey. Similarly, habitat alteration that reduces cover for young chicks can increase their rate of predation (Schroeder and Baydack 2001, p. 27).

In a review of published nesting studies, Connelly *et al.* (in press a, p. 17) reported that nesting success was greater in unaltered habitats versus altered habitats. Where greater sage-grouse habitat has been altered, the influx of predators can decrease annual recruitment into a population (Gregg *et al.* 1994, p. 164; Braun 1995; Braun 1998; DeLong *et al.* 1995, p. 91; Schroeder and Baydack 2001, p. 28; Coates 2007, p. 2; Hagen in press, p. 7). Ritchie *et al.* (1994, p. 125), Schroeder and Baydack (2001, p. 25), Connelly *et al.* (2004, p. 7-23), and Summers *et al.* (2004, p. 523) have reported that agricultural development, landscape fragmentation, and human populations have the potential to increase predation pressure on all life stages of greater sage-grouse by forcing birds to nest in less suitable or marginal habitats, increasing travel time through habitats where they are vulnerable to predation, and increasing the diversity and density of predators.

Abundance of red fox and corvids, which historically were rare in the sagebrush landscape, has increased in association with human-altered landscapes (Sovada *et al.* 1995, p. 5). In the Strawberry Valley of Utah, low survival of greater sage-grouse may have been due to an unusually high density of red foxes, which apparently were attracted to that area by anthropogenic activities (Bambrough *et al.* 2000). Ranches, farms, and housing developments have resulted in the introduction of nonnative predators including domestic dogs (*Canis domesticus*) and cats (*Felis domesticus*) into greater sage-grouse habitats (Connelly *et al.* 2004, p. 7-23). Local attraction of ravens to nesting hens may be facilitated by loss and fragmentation of native shrublands, which increases exposure of nests to potential predators (Aldridge and Boyce 2007, p. 522; Bui 2009, p. 32). The presence of ravens was negatively associated with grouse nest and brood fate (Bui 2009, p. 27).

Raven abundance has increased as much as 1500 percent in some areas of western North America since the 1960s (Coates and Delehanty 2010, p. 244 and references therein). Human-made structures in the environment increase the effect of raven predation, particularly in low canopy cover areas, by providing ravens with perches (Braun 1998, pp.145-146; Coates 2007, p. 155; Bui 2009, p. 2). Reduction in patch size and diversity of sagebrush habitat, as well as the construction of fences, powerlines, and other infrastructure also are likely to encourage the presence of the common raven (Coates *et al.* 2008, p. 426; Bui 2009, p. 4). For example, raven counts have increased by approximately 200 percent along the Falcon-Gondor transmission line corridor in Nevada (Atamian *et al.* 2007, p. 2). Ravens contributed to lek disturbance events in the areas surrounding the transmission line (Atamian *et al.* 2007, p. 2), but as a cause of decline in surrounding sage-grouse population numbers, it could not be separated from other potential impacts, such as WNv.

Holloran (2005, p. 58) attributed increased sage-grouse nest depredation to high corvid abundances, which resulted from anthropogenic food and perching subsidies in areas of natural gas development in western Wyoming. Bui (2009, p. 31) also found that ravens used road networks associated with oil fields in the same Wyoming location for foraging activities. Holmes (unpubl. data) also found that common raven abundance increased in association with oil and gas development in southwestern Wyoming. The influence of synanthropic predators in the Wyoming Basin is important as this area has one of the few remaining clusters of sagebrush landscapes and the most highly connected network of sage-grouse leks (Knick and Hanser in press, p.18). Raven abundance was strongly associated with sage-grouse nest failure in northeastern Nevada, with resultant negative effects on sage-grouse reproduction (Coates 2007, p. 130). The presence of high numbers of predators within a sage-grouse nesting area may negatively affect sage-grouse productivity without causing direct mortality. Coates (2007, p. 85-86) suggested that ravens may reduce the time spent off the nest by female sage-grouse, thereby potentially compromising their ability to secure sufficient nutrition to complete the incubation period.

As more suitable grouse habitat is converted to oil fields, agriculture and other exurban development, grouse nesting and brood-rearing become increasingly spatially restricted (Bui 2009, p. 32). High nest densities which result from habitat fragmentation or disturbance associated with the presence of edges, fencerows, or trails may increase predation rates by making foraging easier for predators (Holloran 2005, p. C37). In some areas even low but consistent raven presence can have a major impact on sage-grouse reproductive behavior (Bui 2009, p. 32). Leu and Hanser (in press, pp. 24-25) determined that the influence of the human footprint in sagebrush ecosystems may be underestimated due to varying quality of spatial data. Therefore, the influence of ravens and other predators associated with human activities may be under-estimated.

Predator removal efforts have sometimes shown short-term gains that may benefit fall populations, but not breeding population sizes (Cote and Sutherland 1997, p. 402; Hagen in press, p. 9; Leu and Hanser in press, p. 27). Predator removal may have greater benefits in areas with low habitat quality, but predator numbers quickly rebound without continual control (Hagen in press, p. 9). Red fox removal in Utah appeared to increase adult sage-grouse survival and productivity, but the study did not compare these rates against other non-removal areas, so inferences are limited (Hagen in press, p. 11). Slater (2003, p. 133) demonstrated that coyote control failed to have an effect on greater sage-grouse nesting success in southwestern Wyoming. However, coyotes may not be an important predator of sage-grouse. In a coyote prey base analysis, Johnson and Hansen (1979, p. 954) showed that sage-grouse and bird egg shells made up a very small percentage (0.4-2.4 percent) of analyzed scat samples. Additionally, coyote removal can have unintended consequences resulting in the release of mesopredators, many of which, like the red fox, may have greater negative impacts on sage-grouse (Mezquida *et al.* 2006, p. 752). Removal of ravens from an area in northeastern Nevada caused only short-term reductions in raven populations (less than 1 year) as apparently transient birds from neighboring sites repopulated the removal area (Coates 2007, p. 151). Additionally, badger predation appeared to partially compensate for decreases in raven removal (Coates 2007, p. 152). In their review of literature regarding predation, Connelly *et al.* (2004, p. 10-1) noted that only two of nine studies examining survival and nest success indicated that predation had limited a sage-grouse population by decreasing nest success, and both studies indicated low nest success due to predation was ultimately related to poor nesting habitat. Bui (2009, pp. 36-37) suggested removal of anthropogenic subsidies (e.g., landfills, tall structures) may be an important step to reducing the presence of sage-grouse predators. Leu and Hanser (in press, p. 27) also argue that reducing the effects of predation on sage-grouse can only be effectively addressed by precluding these features.

Summary of Predation

Greater sage-grouse are adapted to minimize predation by cryptic plumage and behavior. Because sage-grouse are prey, predation will continue to be an effect on the species. Where habitat is not limited and is of good quality, predation is not a threat to the persistence of the species. However, sage-grouse may be increasingly subject to levels of predation that would not normally occur in the historically contiguous unaltered sagebrush habitats. The impacts of predation on greater sage-grouse can increase where habitat quality has been compromised by anthropogenic activities (such as exurban development, road development) (e.g. Coates 2007, p. 154, 155; Bui 2009, p. 16; Hagen in press, p. 12). Landscape fragmentation, habitat degradation, and human populations have the potential to increase predator populations through increasing ease of securing prey and subsidizing food sources and nest or den substrate. Thus, otherwise suitable habitat may change into a habitat sink for grouse populations (Aldridge and Boyce 2007, p. 517). Anthropogenic influences on sagebrush habitats that increase suitability for ravens may limit sage-grouse populations (Bui 2009, p. 32). Current land-use practices in the intermountain West favor high predator (in particular, raven) abundance relative to historical numbers (Coates *et al.* 2008, p. 426). The interaction between changes in habitat and predation may have substantial effects at the landscape level (Coates 2007, p. 3).

The studies presented here suggest that, in areas of intensive habitat alteration and fragmentation, sage-grouse productivity and, therefore, populations could be negatively affected by increasing predation. Predators could already be limiting sage-grouse populations in southwestern Wyoming and northeastern Nevada (Coates 2007, p. 131; Bui 2009, p. 33).

The influence of synanthropic predators in southwestern Wyoming may be particularly significant as this area has one of the few remaining sagebrush landscapes and the most highly connected network of sage-grouse leks (Wisdom *et al.* in press, p. 24). Unfortunately, except for the few studies presented here, data are lacking that definitively link sage-grouse population trends with predator abundance. However, where habitats have been altered by human activities, we believe that predation could be limiting local sage-grouse populations. As more habitats face development, even dispersed development, we expect the risk of increased predation to spread, possibly with negative effects on the sage-grouse population trends. Studies of the effectiveness of predator control have failed to demonstrate an inverse relationship between the predator numbers and sage-grouse nesting success or populations numbers.

Except in localized areas where habitat is compromised, we found no evidence to suggest predation is limiting greater sage-grouse populations. However, landscape fragmentation is likely contributing to increased predation on this species.

Summary of Factor C

With regard to disease, the only concern is the potential effect of WNv. This disease is distributed throughout the species' range and affected sage-grouse populations experience high mortality rates (near 100 percent lethality), with resultant reductions in local population numbers. Risk of exposure varies with factors such as elevation, precipitation regimes, and temperature. The continued development of anthropogenic water sources throughout the range of the species, some of which are likely to provide suitable conditions for breeding mosquitoes that are part of the WNv cycle, will likely increase the prevalence of the virus in sage-grouse. We anticipate that WNv will persist within sage-grouse habitats indefinitely and may be exacerbated by factors (e.g., climate change) that increase ambient temperatures and the presence of the vector on the landscape. The occurrence of WNv occurrence is sporadic across the species' range, and a complex set of environmental and biotic conditions that support the WNv cycle must coincide for an outbreak to occur.

Where habitat is not limited and is of good quality, predation is not a significant threat to the species. We are concerned that continued landscape fragmentation will increase the effects of predation on this species, potentially resulting in a reduction in sage-grouse productivity and abundance in the future. However, there is very limited information on the extent to which such effects might be occurring. Studies of the effectiveness of predator control have failed to demonstrate an inverse relationship between the predator numbers and sage-grouse nesting success or population numbers, i.e., predator removal activities have not resulted in increased populations. Mortality due to nest predation by ravens or other human-subsidized predators is increasing in some areas, but there is no indication this is causing a significant rangewide decline in population trends. Based on the best scientific and commercial information available, we conclude that predation is not a significant threat to the species such that the species requires listing under the Act as threatened or endangered.

Factor D: Inadequacy of Existing Regulatory Mechanisms.

Under this factor, we examine whether threats to the greater sage-grouse are adequately addressed by existing regulatory mechanisms. Existing regulatory mechanisms that could provide some protection for greater sage-grouse include: (1) local land use laws, processes, and ordinances; (2) State laws and regulations; and (3) Federal laws and regulations. Regulatory mechanisms, if they exist, may preclude listing if such mechanisms are judged to adequately address the threat to the species such that listing is not warranted. Conversely, threats on the landscape are exacerbated when not addressed by existing regulatory mechanisms, or when the existing mechanisms are not adequate (or not adequately implemented or enforced).

Local Land Use Laws, Processes, and Ordinances

Approximately 31 percent of the sagebrush habitats within the sage-grouse MZs are privately owned (Table 3; Knick in press, p. 39) and are subject only to local regulations unless Federal actions are associated with the property (e.g., wetland modification, Federal subsurface owner). We conducted extensive internet searches and contacted State and local working group contacts from across the range of the species to identify local regulations that may provide protection to the greater sage-grouse. We identified only one regulation at the local level that specifically addresses sage-grouse. Washington County, Idaho, Planning and Zoning has developed a draft Comprehensive Plan which states that "Sage Grouse leks...and a buffer around those leks, shall be protected from the disruption of development" (Washington County, 2009, p. 27). As this plan is still incomplete, and the final buffer distance has not been identified, it cannot currently provide the necessary regulatory provisions to be considered further. Sage-grouse were mentioned in other county and local plans across the range, and some general recommendations were made regarding effects to sage-grouse associated with land uses. However, we could find no other examples of county-planning and enforceable zoning regulations specific to sage-grouse.

State Laws and Regulations

State laws and regulations may impact sage-grouse conservation by providing specific authority for sage-grouse conservation over lands which are directly owned by the State; providing broad authority to regulate and protect wildlife on all lands within their borders; and providing a mechanism for indirect conservation through regulation of threats to the species (e.g. noxious weeds).

In general, States have broad authority to regulate and protect wildlife within their borders. All State wildlife agencies across the range of the species manage greater sage-grouse as resident native game birds except for Washington (Connelly *et al.* 2004, p. 6-3). In Washington, the species has been listed as a State-threatened species since 1998 and is managed in accordance with the State's provisions for such species (Stinson *et al.* 2004, p. 1). For example, killing greater sage-grouse is banned in Washington, and State-owned agricultural and grazing lands must adhere to standards regarding upland plant and vegetative community health that protect habitat for the species (Stinson *et al.* 2004, p. 55). However, lands owned by the Washington Department of Natural Resources continue to be converted from sagebrush habitat to croplands (Stinson *et al.* 2004, p. 55), which results in a loss of habitat for sage-grouse. Therefore, the provisions to protect sage-grouse in this State do not provide adequate protections for us to consider.

All States across the range of greater sage-grouse have laws and regulations that identify the need to conserve wildlife populations and habitat, including greater sage-grouse (Connelly *et al.* 2004, p. 2-22-11). As an example, in Colorado, "wildlife and their environment" are to be protected, preserved, enhanced and managed (Colorado Revised Statutes, Title 33, Article 1–101 in Connelly *et al.* 2004, p. 2-3). Laws and regulations in Oregon, Idaho, South Dakota, and California have similar provisions (Connelly *et al.* 2004, pp. 2-2 to 2-4, 2-6 to 2-8). However, these laws and regulations are general in nature and have not provided the protection to sage-grouse habitat necessary to protect the species from the threats described in Factor A above.

All of the states within the range of the sage-grouse have state school trust lands that they manage for income to support their schools. With the exception of Wyoming (see discussion below), none of the states have specific regulations to ensure that the management of the state trust lands is consistent with the needs of sage-grouse. Thus there are currently no regulatory mechanisms on state trust lands to ensure conservation of the species.

On September 26, 2008, the Governor of Nevada signed an executive order calling for the preservation and protection of sage-grouse habitat in the State of Nevada. The executive order directs the NDOW to "continue to work with state and federal agencies and the interested public" to implement the Nevada sage-grouse conservation plan. The executive order also directs other State agencies to coordinate with the NDOW in these efforts. Although directed specifically at sage-grouse conservation, the executive order is broadly worded and does not outline specific measures that will be undertaken to reduce threats and ensure conservation of sage-grouse in Nevada.

The California Environmental Quality Act (CEQA) (Public Resources Code sections 21000–21177), requires full disclosure of the potential environmental impacts of projects proposed in the State of California. Section 15065 of the CEQA guidelines requires a finding of significance if a project has the potential to "reduce the number or restrict the range of a rare or endangered plant or animal." Under these guidelines sage-grouse are given the same protection as those species that are officially listed within the State. However, the lead agency for the proposed project has the discretion to decide whether to require mitigation for resource impacts, or to determine that other considerations, such as social or economic factors, make mitigation infeasible (CEQA section 21002). In the latter case, projects may be approved that cause significant environmental damage, such as destruction of endangered species, their habitat, or their continued existence. Therefore, protection of listed species through CEQA is dependent upon the discretion of the agency involved, and cannot be considered adequate protection for sage-grouse.

In Wyoming, the Governor issued an executive order on August 1, 2008, mandating special management for all State lands within sage-grouse "Core Population Areas" (State of Wyoming 2008, entire). Core Population Areas are important breeding areas for sage-grouse in Wyoming as identified by the Wyoming "Governor's Sage-Grouse Implementation Team." In addition to identifying Core Population Areas, the Team also recommended stipulations that should be placed on development activities to ensure that existing habitat function is maintained within those areas. Accordingly, the executive order prescribes special consideration for sage-grouse, including authorization of new activities only when the project proponent can identify that the activity will not cause declines in greater sage-grouse populations, in the Core Population Areas. These protections will apply to slightly less than 23 percent of all sage-grouse habitats in Wyoming, but account for approximately 80 percent of the total estimated sage-grouse breeding population in the State. In February 2010, the Wyoming State Legislature adopted a joint resolution endorsing Wyoming's core area strategy as outlined in the Governor' Executive Order 2008-2.

On August 7, 2008, the Wyoming Board of Land Commissioners approved the application of the Implementation Team's recommended stipulations to all new development activities on State lands within the Core Population Areas. These actions provide substantial regulatory protection for sage-grouse in previously undeveloped areas on Wyoming State lands. However, as they only apply to State lands, which are typically single sections scattered across the State, the benefit to sage-grouse is limited.

The executive order also applies to all activities requiring permits from the Wyoming's Industrial Siting Council (ISC), including wind power developments on all lands regardless of ownership in the State of Wyoming. Developments outside of State land and not required to receive an ISC permit (primarily developments that do not reach a certain economic threshold) will not be required to follow the stipulations. The application of the Governor's order to the Wyoming ISC has the potential to provide significant regulatory protection for sage-grouse from adverse effects associated with wind development (see Energy, Factor A) and other developments.

There is still some uncertainty regarding what protective stipulations will be applied to wind siting applications. The State of Wyoming has indicated that it will enforce the Executive Order where applicable, and on August 7, 2009, the Wyoming State Board of Land Commissioners voted to withdraw approximately 400,000 ha (approximately 1 million ac) of land within the sage-grouse core areas from potential wind development (State of Wyoming 2008, entire). The withdrawal order states that "there is no published research on the specific impacts of wind energy on sage-grouse," and further states that permitting for wind development should require data collection on the potential effects of wind on sage-grouse. This action demonstrates a significant action in the State of Wyoming to address future development activities in core areas.

Wyoming's executive order does allow oil and gas leases on State lands within core areas, provided those developments adhere to required protective stipulations, which are consistent with published literature (e.g. 1 well pad per section). The Service believes that the core area strategy proposed by the State of Wyoming in Executive Order 2008-2, if implemented by all landowners via -regulatory mechanisms, would provide adequate protection for sage-grouse and their habitat in that State.

The protective measures associated with the Governor's order do not extend to lands located outside the identified core areas but still within occupied sage-grouse habitat. Where a siting permit is needed, the application is *de facto* applied to all landownerships as the Wyoming ISC cannot issue a permit without the protective stipulations in place. In non-core areas, the minimization measures would be implemented that are intended to maintain habitat conditions such that there is a 50 percent likelihood that leks will persist over time (WGFD 2009, pp. 30-35). This approach may result in adverse effects to sage-grouse and their habitats outside of the core areas (WGFD 2009, pp. 32-35).

The Wyoming executive order states that current management and existing land uses within the core areas should be recognized and respected, thus we anticipate ongoing adverse effects associated with those activities. The Service is working in collaboration with the State of Wyoming Sage Grouse Implementation team and other entities to continue to review and refine ongoing activities in the core areas, as well as the size and location of the core areas themselves to ensure the integrity and purpose of the core area approach is maintained. Although this strategy provides excellent potential for meaningful conservation of sage-grouse, it has yet to be fully implemented. We believe that when fully realized, this effort could ameliorate some threats to the greater sage-grouse.

On April 22, 2009, the Governor of Colorado signed into law new rules for the Colorado Oil and Gas Conservation Commission (COGCC), which is the entity responsible for permitting oil and gas well development in Colorado (COGCC 2009, entire). The rules went into effect on private lands on April 1, 2009, and on Federal lands July 1, 2009. The new rules require that permittees and operators determine whether their proposed development location overlaps with "sensitive wildlife habitat," or is within restricted surface occupancy (RSO) Area. For greater sage-grouse, areas within 1 km (0.6 mi) of an active lek are designated as RSOs, and surface area occupancy will be avoided except in cases of economic or technical infeasibility (CDOW, 2009, p. 12). Areas within approximately 6.4 km (4 mi) of an active lek are considered sensitive wildlife habitat (CDOW, 2009, p. 13) and the development proponent is required to consult with the CDOW to identify measures to (1) avoid impacts on wildlife resources, including sage-grouse; (2) minimize the extent and severity of those impacts that cannot be avoided; and (3) mitigate those effects that cannot be avoided or minimized (COGCC 2009, section 1202.a).

The COGCC will consider CDOW's recommendations in the permitting decision, although the final permitting and conditioning authority remains with COGCC. Section 1202.d of the new rules does identify circumstances under which the consultation with CDOW is not required; other categories for potential exemptions also can be found in the new rules (e.g., 1203.b). The new rules will inevitably provide for greater consideration of the conservation needs of the species, but the potential decisions, actions, and exemptions can vary with each situation, and consequently there is substantial uncertainty as to the level of protection that will be afforded to greater sage-grouse. It should be noted that leases that have already been approved but not drilled (e.g., COGCC 2009, 1202.d(1)), or drilling operations that are already on the landscape, may continue to operate without further restriction into the future.

Some States require landowners to control noxious weeds, a habitat threat to sage-grouse on their property, but the types of plants considered to be noxious weeds vary by State. For example, only Oregon, California, Colorado, Utah, and Nevada list *Taeniatherum asperum* as a noxious, regulated weed, but *T. asperum* is problematic in other States (e.g., Washington, Idaho). Colorado is the only western State that officially lists *Bromus tectorum* as a noxious weed (USDA 2009), but *B. tectorum* is invasive in many more States. These laws may provide some protection for sage-grouse in areas, although large-scale control of the most problematic invasive plants is not occurring, and rehabilitation and restoration techniques are mostly unproven and experimental (Pyke in press, p. 25).

State-regulated hunting of sage-grouse is permitted in all States except Washington, where the season has been closed since 1988 (Connelly *et al.* 2004, p. 6-3). In States where hunting sage-grouse is allowed, harvest levels can be adjusted annually, and the season and limits are largely based on trend data gathered from spring lek counts and previous harvest data. Management of hunting season length and bag limits varies widely between States (see discussion of hunting regulations in Factor B). States maintain flexibility in hunting regulations through emergency closures or season changes in response to unexpected events that affect local populations. For example, in areas where populations are in decline or threats such as WNv have emerged, some States have implemented harvest reductions or closures. There have not been any studies demonstrating that hunting is the primary cause of population declines in sage-grouse. Hunting regulations provide adequate protection for the birds (see discussion under Factor B), but do not protect the habitat. Therefore, the protection afforded through this regulatory mechanism is limited.

Federal Laws and Regulations

Because it is not considered to be a migratory species, the greater sage-grouse is not covered by the provisions of the Migratory Bird Treaty Act (16 U.S.C. 703-712). However, several Federal agencies have other legal authorities and requirements for managing sage-grouse or their habitat. Federal agencies are responsible for managing approximately 64 percent of the sagebrush habitats within the sage-grouse MZs in the United States (Knick in press, p. 39, Table 3). Two Federal agencies with the largest land management authority for sagebrush habitats are the BLM and USFS. The U.S. Department of Defense (DOD), DOE, and other agencies in DOI have responsibility for lands and/or decisions that involve less than 5 percent of greater sage-grouse habitat (Table 3).

Bureau of Land Management

Knick (in press, p. 39, Table 3) estimates that about 51 percent of sagebrush habitat within the sage-grouse MZs is BLM-administered land; this includes approximately 24.9 million ha (about 61.5 million ac). The Federal Land Policy and Management Act of 1976 (FLPMA) (43 U.S.C. 1701 *et seq.*) is the primary Federal law governing most land uses on BLM-administered lands, and directs development and implementation of Resource Management Plans (RMPs) which direct management at a local level. The greater sage-grouse is designated as a sensitive species on BLM lands across the species' range (Sell 2010, pers comm.). The management guidance afforded species of concern under BLM Manual 6840 – Special Status Species Management (BLM 2008f) states that "Bureau sensitive species will be managed consistent with species and habitat management objectives in land use and implementation plans to promote their conservation and to minimize the likelihood and need for listing under the ESA" (BLM 2008f, p. .05V). BLM Manual 6840 further requires that RMPs should address sensitive species, and that implementation "should consider all site-specific methods and procedures needed to bring species and their habitats to the condition under which management under the Bureau sensitive species policies would no longer be necessary" (BLM 2008f, p. 2A1). As a designated sensitive species under BLM Manual 6840, sage-grouse conservation must be addressed in the development and implementation of RMPs on BLM lands.

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

Of the existing 92 RMPs that include sage-grouse habitat, 82 contain specific measures or direction pertinent to management of sage-grouse or their habitats (BLM 2008g, p. 1). However, the nature of these measures and direction vary widely, with some measures directed at a particular land use category (e.g., grazing management), and others relevant to specific habitat use categories (e.g., breeding habitat) (BLM 2008h). If an RMP contains specific direction regarding sage-grouse habitat, conservation, or management, it represents a regulatory mechanism that has the potential to ensure that the species and its habitats are protected during permitting and other decision-making on BLM lands. This section describes our understanding of how RMPs are currently implemented in relation to sage-grouse conservation.

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

The BLM IM No. 2005-024 directed BLM State directors to "review all existing land use plans to determine the adequacy in addressing the threats to sage-grouse and sagebrush habitat," and then to "identify and prioritize land use plan amendments or land use plan revisions based upon the outcome." This IM instructed BLM State directors to develop a process and schedule to update deficient land use plans to adequately address sage-grouse and sagebrush conservation needs no later than April 1, 2005. The BLM reports that all land use plan revisions within sage-grouse habitat are scheduled for completion by 2015 (BLM, 2008g). To date, 14 plans have been revised, 31 are in progress, and 19 are scheduled to be completed in the future. However, the information provided to us by BLM did not specify what requirements, direction, measures, or guidance has been included in the newly revised RMPs to address threats to sage-grouse and sagebrush habitat. Therefore, we cannot assess their value or rely on them as regulatory mechanisms for the conservation of the greater sage-grouse.

On November 30, 2009, the BLM in Montana issued an IM that provides guidance for sage-grouse management on lands under their authority in MZs I and II (BLM 2009j, entire). The IM directs all state offices in Montana to develop alternatives in ongoing and future RMP revisions for activities that may affect the greater sage-grouse. The IM provides guidance to mitigate impacts and BMPs for all proposed projects and activities. While this IM will result in reduction of negative impacts of projects authorized by the Montana BLM on sage-grouse, the way in which the guidance will be interpreted and applied is uncertain and we do not have a basis to assess whether or the extent to which it might be effective in reducing threats. However, the IM is based on an approach based on core areas in Montana, similar to the approach implemented more formally in Wyoming. Therefore, it could be effective in reducing impacts to sage-grouse habitat in the short term on BLM lands in Montana. Unfortunately, the IM applies only to ongoing and future RMPs, and does not apply to activities authorized under existing RMPs. No expiration date was provided for this IM, but as discussed above typical life expectancy of IMs is rarely greater than 2 years.

The BLM has regulatory authority over livestock grazing, OHV travel and human disturbance, infrastructure development, fire management, and energy development through FLPMA and associated RMP implementation, and the Mineral Leasing Act (MLA) (30 U.S.C. 181 *et seq.*). The RMPs provide a framework and programmatic guidance for AMPs that address livestock grazing. In addition to FLPMA, BLM has specific regulatory authority for grazing management provided at 43 CFR 4100 (Regulations on Grazing Administration Exclusive of Alaska). Livestock grazing permits and leases contain terms and conditions determined by BLM to be appropriate to achieve management and resource condition objectives on the public lands and other lands administered by the BLM, and to ensure that habitats are, or are making significant progress toward being restored or maintained for BLM special status species (43 CFR 4180.1(d)). Terms and conditions that are attached to grazing permits are generally mandatory. Across the range of sage-grouse, BLM required each BLM state office to adopt rangeland health standards and guidelines by which they measure allotment condition (43 CFR 4180 2(b)). Each state office developed and adopted their own standards and guidelines based on habitat type and other more localized considerations.

The rangeland health standards must address restoring, maintaining or enhancing habitats of BLM special status species to promote their conservation, and maintaining or promoting the physical and biological conditions to sustain native populations and communities (43 CFR 4180.2(e)(9) and (10)). BLM is required to take appropriate action no later than the start of the next grazing year upon determining that existing grazing practices or levels of grazing use are significant factors in failing to achieve the standards and conform with the guidelines (43 CFR 4180.2(c)).

The BLM conducted national data calls in 2004 through 2008 to collect information on the status of rangelands, rangeland health assessments, and measures that have been implemented to address rangeland health issues across sage-grouse habitats under their jurisdiction. However, the information collected by BLM could not be used to make broad generalizations about the status of rangelands and management actions. There was a lack of consistency across the range in how questions were interpreted and answered for the data call, which limited our ability to use the results to understand habitat conditions for sage-grouse on BLM lands. For example, one question asked about the number of acres of land within sage-grouse habitat that was meeting rangeland health standards. Field offices in more than three States conducted the rangeland health assessments, and reported landscape conditions at different scales (Sell 2009, pers. comm.). In addition, the BLM data call reported information at a different scale than was used for their landscape mapping (District or project level versus national scale) (Buckner 2009b, pers. comm.). Therefore, we lack the information necessary to assess how this regulatory mechanism effects sage-grouse conservation.

The BLM's regulations require that corrective action be taken to improve rangeland condition when the need is identified; however, actions are not necessarily implemented until the permit renewal process is initiated for the noncompliant parcel. Thus, there may be a lag time between the allotment assessment when necessary management changes are identified, and when they are implemented. Although RMPs, AMPs, and the permit renewal process provide an adequate regulatory framework, whether or not these regulatory mechanisms are being implemented in a manner that conserves sage-grouse is unclear. The BLM's data call indicates that there are lands within the range of sage-grouse that are not meeting the rangeland health standards necessary to conserve sage-grouse habitats. In some cases management changes should occur, but such changes have not been implemented (BLM 2008i).

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

The BLM conducts treatments for noxious and invasive weeds on BLM lands, the most common being reseeding through the Emergency Stabilization and Burned Area Rehabilitation Programs. According to BLM data, 66 of 92 RMPs noted that seed mix requirements (as stated in RMPs, emergency stabilization and rehabilitation, and other plans) were sufficient to provide suitable sage-grouse habitat (e.g., seed containing sagebrush and forb species)(Carlson 2008a). However, a sufficient seed mix does not assure that restoration goals will be met; many other factors (e.g., precipitation) influence the outcome of restoration efforts.

Invasive species control is a priority in many RMPs. For example, 76 of the RMPs identified in the data call claim that the RMP (or supplemental plans/ guidance applicable to the RMP) requires treatment of noxious weeds on all disturbed surfaces to avoid weed infestations on BLM managed lands in the planning area (Carlson 2008a). Also, of the 82 RMPs that reference sage-grouse conservation, 51 of these specifically address fire, invasives, conifer encroachment, or a combination thereof (Carlson 2008, pers. comm.). We note that it is possible that more RMPs are addressing invasives under another general restoration category. In the 51 RMPs that address fire, invasives, and conifer encroachment, they typically provide nonspecific guidance on how to manage invasives. A few examples include: manage livestock in a way that enhances desirable vegetation cover and reduces the introduction of invasives, identify tools that may be used to control invasives (e.g., manual, mechanical, biological, or chemical treatments), utilize an integrated weed management program, and apply seasonal restrictions on fire hazards, among other methods (Carlson 2008, pers. comm.). As with other agencies and organizations, the extent to which these measures are implemented depends in large part on funding, staff time, and other regulatory and non-regulatory factors. Therefore, we cannot assess their value as regulatory mechanisms for the conservation of the greater sage-grouse.

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

The BLM has one documented regulatory action to address wildfire and protect of sage-grouse: National IM 2008-142 – 2008 Wildfire Season and Sage-Grouse Conservation. This IM was issued on June 19, 2008, and was

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effective through September 30, 2009. It provided guidance to BLM State directors that conservation of greater sage-grouse and sagebrush habitats should be a priority for wildfire suppression, particularly in areas of the Great Basin (portions of WAFWA MZ III, IV, and V) (BLM 2008j, entire). At least one BLM State office within the range of sage-grouse (Idaho) developed a State-level IM and guidance that prioritized the protection of sage-grouse habitats during fire management activities, in addition to the national IM which pertains to wildfire suppression activities (BLM 2008k, entire).

While we do not know the extent to which these directives alleviated the wildfire threat to sage-grouse (as described under Factor A) during the 2008 and 2009 fire seasons, we believe that this strategic approach to ameliorating the threat of fire is appropriate and significant. Targeting the protection of important sage-grouse habitats during fire suppression and fuels management activities could help reduce loss of key habitat due to fire if directed through a long-term, regulatory mechanism. Under Factor A, we describe why the threat of wildfire is likely to continue indefinitely. This foreseeable future requires a regulatory approach that addresses the threat over the long term. The use of IMs to increase protection of sage-grouse habitat during wildfire is not adequate to protect the species because IMs are both short-term and have discretionary renewal (decisions made on a case-by-case basis).

The BLM is the primary Federal agency managing the United States energy resources on 102 million surface ha (253 million ac) and 283 million sub-surface ha (700 million ac) of mineral estate (BLM 2010). Public sub-surface estate can be under public or private (i.e., split-estate) surface. Over 7.3 million ha (18 million ac) of sage-grouse habitats on public lands are leased for oil, gas, coal, minerals, or geothermal exploration and development across the sage-grouse range (Service 2008f). Energy development, particularly nonrenewable development, has primarily occurred within sage-grouse MZs I and II.

The BLM has the legal authority to regulate and condition oil and gas leases and permits under both FLPMA and the MLA. An amendment to the Energy Policy and Conservation Act of 1975 (42 U.S.C. 6201 *et seq.*) in 2000 (Energy Policy Act of 2000 (PL 106-469)) requires the Secretary of the Interior to conduct a scientific inventory of all onshore Federal lands to identify oil and gas resources underlying these lands (42 U.S.C. 6217). The Energy Policy Act of 2005 (42 U.S.C. 15801 *et seq.*) further requires the nature and extent of any restrictions or impediments to the development of such resources be identified and permitting and development be expedited on Federal lands (42 U.S.C. 15921). In addition, the 2005 Energy Policy Act orders the identification of renewable energy sources (e.g., wind, geothermal) and provides incentives for their development (42 U.S.C. 15851).

On May 18, 2001, President Bush signed Executive Order (E.O.) 13212 – Actions to Expedite Energy-Related Projects (May 22, 2001, 66 FR 28357), which states that the executive departments and agencies shall take appropriate actions, to the extent consistent with applicable law, to expedite projects that will increase the production, transmission, or conservation of energy. The Executive Order specifies that this includes expediting review of permits or taking other actions as necessary to accelerate the completion of projects, while maintaining safety, public health, and environmental protections. On October 23, 2009, nine Federal agencies signed a MOU to expedite the siting and construction of qualified electric transmission within the United States (Federal Agency MOU 2009). The MOU states that all existing environmental review and safeguard processes will be fully maintained. Therefore, we assume that this new MOU will not alter the regulatory processes (e.g., RMPs, project specific NEPA analysis) currently in place related to transmission siting on BLM lands.

Program-specific guidance for fluid minerals (including oil and gas) in the BLM planning handbook (BLM 2005b, Appendix C pp. 23-24) specifies that land use planning decisions will identify restrictions on areas subject to leasing, including closures, as well as lease stipulations. Stipulations are conditions that are made part of a lease when the environmental planning record demonstrates the need to accommodate various resources such as the protection of specific wildlife species. Stipulations advise the lease holder that a wildlife species in need of special management may be present in the area defined by the lease, and certain protective measures may be required in order to develop the mineral resource on that lease.

The handbook further specifies that all stipulations must have waiver, exception, or modification criteria documented in the plan, and notes that the least restrictive constraint to meet the resource protection objective should be used (BLM 2005b, Appendix C pp. 23-24). Waivers are permanent exemptions, and modifications are changes in the terms of the stipulation. The BLM reports the issuance of waivers and modifications as rare (BLM 2008i). Exceptions are a one-time exemption to a lease stipulation. For example, a company may be issued an exception to enter crucial winter habitat during a mild winter if an on-the-ground survey verifies that sage-grouse are not using the winter habitat or have left earlier than normal (BLM 2004, p. 86). In 2006 and 2007, of 1,716 mineral or right-of-way authorizations on Federal surface in 42 BLM planning areas no waivers were issued; 24 modifications were issued and 115 exceptions were granted, 72 of which were in the Great Divide planning area in Wyoming (BLM 2008i), one of the densest population concentrations for sage-grouse.

Although the restrictive stipulations that are applied to permits and leases vary, a 0.40-km (0.25-mi) radius around sage-grouse leks is generally restricted to "no surface occupancy" during the breeding season, and noise and development activities are often limited during the breeding season within a 0.80- to 3.22-km (0.5- to 2-mi) radius of sage-grouse leks. Although these are the most often-applied stipulations, site-specific application is highly variable. For example, language in the Randolph RMP in Utah states that no exploration, drilling, or other development activities can occur during the breeding season within 3.22 km (2 mi) of a known sage-grouse lek, and that there are "no exceptions to this stipulation" (BLM 2008h). Conversely, under the Platte River RMP in the Wind River Basin Management Area of Wyoming, "oil and gas development is a priority in the area" and "discretionary timing stipulations protecting sage-grouse nesting habitats...will not be applied" (BLM 2008h). Most of the RMPs that address oil, gas, or minerals development specify the standard protective stipulations (BLM 2008h). The stipulations do not apply to the operation or maintenance of existing facilities, regardless of their proximity to sage-grouse breeding areas (BLM 2008h). In addition, approximately 73 percent of leased lands in known sage-grouse breeding habitat have no stipulations at all (Service 2008f).

As noted above, a 0.4-km (0.25-mi) radius buffer is used routinely by BLM and other agencies to minimize the impacts of oil and gas development on sage-grouse breeding activity. The rationale for using a 0.4-km (0.25-mi) buffer as the basic unit for active lek protection is not clear, as there is no support in published literature for this distance affording any measure of protection (see also discussion under Energy Development, above). Anecdotally, this distance appears to be an artifact from the 1960s attempt to initiate planning guidelines for sagebrush management and is not scientifically based (Roberts 1991). The BLM stipulations most commonly attached to leases and permits are inadequate for the protection of sage-grouse, and for the long-term maintenance of their populations in those areas affected by oil and gas development activities (Holloran 2005, pp. 57-60; Walker 2007, p. 2651). In some locations, the BLM is incorporating recommendations and information from new scientific studies into management direction. Wyoming BLM issued an IM on December 29, 2009 (BLM 2009k, entire) to ensure their management of sage-grouse and their habitats are consistent with the State of Wyoming's core area populations (see discussion above). The IM applies to all BLM programs and activities within Wyoming, with the exception of livestock grazing management. A separate IM will be issued separately for this program. The December 2009 IM should have the same efficacy in ameliorating threats to the sage-grouse in Wyoming. However, the IM is scheduled to expire on Sept. 30, 2011, and therefore its life is far shorter than the foreseeable future (30 to 50 years, see discussion below) for energy development in that state. However, we are optimistic that this IM will result in short-term conservation benefits for sage-grouse in Wyoming.

As with fossil fuel sources, the production, purchase, and facilitation of development of renewable energy products by Federal entities and land management agencies is directed by the 2005 Energy Policy Act and Presidential E.O. 13212. The energy development section of Factor A describes in detail the development and operation of renewable energy projects, including recent increases in wind, solar and geothermal energy development. All of these activities require ground disturbance, infrastructure, and ongoing human activities that could adversely affect greater sage-grouse on the landscape. Recently the BLM has begun developing guidance to minimize impacts of renewable energy production on public lands. A ROD for "Implementation of a Wind Energy Development Program and Associated Land Use Plan Amendments" (BLM 2005a, entire) was issued in 2005. The ROD outlines best management practices (BMPs) for the siting, development and operation of wind energy facilities on BLM lands. The voluntary guidance of the BMPs do not include measures specifically intended to protect greater sage-grouse, although they do provide the flexibility for such measures to be required through site-specific planning and authorization (BLM 2005a, p. 2).

On December 19, 2008, the BLM issued IM 2009-043, which is intended to serve as additional guidance for processing wind development proposals. In that IM, which expires on September 30, 2010, BLM updates or clarifies previous guidance documentation, including the Wind Energy Development Policy, and best management practices from the wind energy development programmatic EIS of 2005. The new guidance does not provide specific recommendations for greater sage-grouse, and largely defers decision-making regarding project siting, including meteorological towers, to either the individual land use planning process, or to the standard environmental compliance (i.e., NEPA) process. In addition, it emphasizes the voluntary nature of the Service's 2003 interim guidelines for minimizing the effects of wind turbines on avian species and reiterates that incorporation of the guidelines in BLM agency decisions was not mandatory (BLM 2008e).

BLM State offices in Oregon and Idaho issued explicit guidance regarding siting of meteorological towers (IM OR-2008-014 and ID-2009-006, respectively) which required siting restrictions for towers around leks such that potential adverse effects to sage-grouse are avoided or minimized. These IMs provided substantial regulatory protection for sage-grouse; however, both of these IMs expired on September 30, 2009. We anticipate that they will be renewed in FY 2010, but that is an annual management decision by the respective State BLM offices, thus the long-term certainty that such measures will remain in place is unknown.

The BLM is currently in the process of developing programmatic-level guidance for the development of solar and geothermal energy projects. A draft programmatic EIS for geothermal development is currently available (BLM and USFS 2008a, entire), and the draft programmatic EIS for solar energy is under development (BLM and DOE 2008). We anticipate that solar and geothermal energy development will increase in the future (see discussion under energy in Factor A), and that the development of infrastructure associated with these projects could affect sage-grouse. Final environmental guidance for solar and geothermal energy development on BLM lands has not yet been issued or implemented; thus, we cannot assess its adequacy or implications for the conservation of sage-grouse.

Summary: BLM

The BLM manages the majority of greater sage-grouse habitats across the range of the species. The BLM has broad regulatory authority to plan and manage all land use activities on their lands including travel management, energy development, grazing, fire management, invasive species management, and a variety of other activities. As described in Factor A, all of these factors have the potential to affect sage-grouse, including direct effects to the species and its habitats. The ability of regulatory mechanisms to adequately address the effects associated with wildfire or invasive plant species such as *Bromus tectorum* is limited due primarily to the nature of those factors and how they manifest on the landscape. However, a regulatory mechanism that requires BLM staff to target the protection of key sage-grouse habitats during fire suppression or appropriate fuels management activities could help address the threat of wildfire in some situations. We recognize the use of IMs for this purpose, including both at the national and State level (Idaho) (BLM 2008j and 2008k); however, a long-term mechanism is necessary given the scale of the wildfire threat and its likelihood to persist on the landscape in the foreseeable future.

For other threats to sage-grouse on BLM lands, the BLM has the regulatory authority to address them in a manner that will provide protection for sage-grouse. However, BLM's current application of those authorities in some areas falls short of meeting the conservation needs of the species. This is particularly evident in the regulation of oil, gas, and other energy development activities, both on BLM-administered lands and on split-estate lands. Stipulations commonly applied by BLM to oil and gas leases and permits do not adequately address the scope of negative influences of development on sage-grouse (Holloran 2005, pp. 57-60, Walker 2007, pp. 2651; see discussion under Factor A), with the exception of the new 2010 IM issued by the BLM in Wyoming (see discussion below). In addition, BLM's ability to waive, modify, and allow exceptions to those stipulations without regard to sage-grouse persistence further limits the adequacy of those regulatory mechanisms in alleviating the negative impacts to the species associated with energy development.

For other threats, such as grazing, our ability to assess the application of existing regulatory mechanisms on a broad scale is limited by the way that BLM collected and summarized their data on rangeland health assessments and the implementation of corrective measures, where necessary. The land use planning and activity permitting processes, as well as other regulations available to BLM give them the authority to address the needs of sage-grouse. However, the extent to which they do so varies widely from RMP area to RMP area across the range of the species. In many areas existing mechanisms (or their implementation) on BLM lands and BLM-permitted actions do not adequately address the conservation needs of greater sage-grouse, and are exacerbating the effects of threats to the species described under Factor A.

USDA Forest Service

The USFS has management authority for 8 percent of the sagebrush area within the sage-grouse MZs (Table 3; Knick in press, p. 39). The USFS estimated that sage-grouse occupy about 5.2 million ha (12.8 million ac) on national forest lands in the western United States (USFS 2008 Appendix 2, Table 1). Twenty-six of the 33 National Forests or Grasslands across the range of sage-grouse contain moderately or highly important seasonal habitat for sage-grouse (USFS 2008 Appendix 2, Table 2). Management of activities on national forest system lands is guided principally by the National Forest Management Act (NFMA) (16 U.S.C. 1600-1614, August 17, 1974, as amended 1976, 1978, 1980, 1981, 1983, 1985, 1988, and 1990). NFMA specifies that the USFS must have a land and resource management plan (LRMP) (16 U.S.C. 1600) to guide and set standards for all natural resource management activities on each National Forest or National Grassland. All of the LRMPs that currently guide the management of sage-grouse habitats on USFS lands were developed using the 1982 implementing regulations for land and resource management planning (1982 Rule, 36 CFR 219).

Greater sage-grouse is designated as sensitive species on USFS lands across the range of the species (USFS 2008, pp. 25-26). Designated sensitive species require special consideration during land use planning and activity implementation to ensure the viability of the species on USFS lands and to preclude any population declines that could lead to a Federal listing (USFS 2008, p. 21). Additionally, sensitive species designations require analysis for any activity that could have an adverse impact to the species, including analysis of the significance of any adverse impacts on the species, its habitat, and overall population viability (USFS 2008, p. 21). The specifics of how sensitive species status has conferred protection to sage-grouse on USFS lands varies significantly across the range, and is largely dependent on LRMPs and site-specific project analysis and implementation. Fourteen forests identify greater sage-grouse as a Management Indicator Species (USFS 2008, Appendix 2, Table 2), which requires them to establish objectives for the maintenance and improvement of habitat for the species during all planning processes, to the degree consistent with overall multiple use objectives of the alternative (1982 Rule, 36 CFR 219.19(a)). Of the 33 National Forests that manage greater sage-grouse habitat, 16 do not specifically address sage-grouse management or conservation in their Forest Plans, and only 6 provide a high level of detail specific to sage-grouse management (USFS 2008, Appendix 2, Table 4).

Almost all of the habitats that support sage-grouse on USFS lands also are open to livestock grazing (USFS 2008, p. 39). Under the Range Rescissions Act of 1995 (P.L. 104-19), the USFS must conduct a NEPA analysis to determine whether grazing should be authorized on an allotment, and what resource protection provisions should be included as part of the authorization (USFS 2008, p. 33). The USFS reports that they use the sage-grouse habitat guidelines developed in Connelly *et al.* (2000) to develop desired condition and livestock use standards at the project or allotment level. However, USFS also reported that the degree to which the recommended sage-grouse conservation and management guidelines were incorporated and implemented under Forest Plans varied widely across the range (USFS 2008, p. 45). We do not have the results of rangeland health assessments or other information regarding the status of USFS lands that provide habitat to sage-grouse and, therefore, cannot assess the efficacy in conserving this species.

Energy development occurs on USFS lands, although to a lesser extent than on BLM lands. Through NFMA, LRMPs, and the On-Shore Oil and Gas Leasing Reform Act (1987; implementing regulations at 36 CFR 228, subpart E), the USFS has the authority to manage, restrict, or attach protective measures to mineral and other energy permits on USFS lands. Similar to BLM, existing protective standard stipulations on USFS lands include avoiding construction of new wells and facilities within 0.4 km (0.25 mi), and noise or activity disturbance within 3.2 km (2.0 mi) of active sage-grouse leks during the breeding season. As described both in Factor A and above, this buffer is inadequate to prevent adverse impacts to sage-grouse populations. For most LRMPs where energy development is occurring, these stipulations also apply to hard mineral extraction, wind development, and other energy development activities in addition to fluid mineral extraction (USFS 2008, Appendix 1, entire). The USFS is a partner agency with the BLM on the draft programmatic EIS for geothermal energy development described above. The Record of Decision for the EIS does not amend relevant LRMPs and still requires project-specific NEPA analysis of geothermal energy applications on USFS lands (BLM and USFS 2008b, p. 3).

The land use planning process and other regulations available to the USFS give it the authority to adequately address the needs of sage-grouse, although the extent to which they do so varies widely across the range of the species. We do not have information regarding the current land health status of USFS lands in relation to the conservation needs of greater sage-grouse; thus, we cannot assess whether existing conditions adequately meet the species' habitat needs.

Other Federal Agencies

Other Federal agencies in the DOD, DOE, and DOI (including the Bureau of Indian Affairs, the Service, and National Park Service) are responsible for managing less than 5 percent of sagebrush lands within the United States (Knick 2008, p. 31). Regulatory authorities and mechanisms relevant to these agencies' management jurisdictions include the National Park Service Organic Act (39 Stat. 535; 16 U.S.C. 1, 2, 3 and 4), the National Wildlife Refuge System Administration Act (16 U.S.C. 668dd-668ee), and the Department of the Army's Integrated Natural Resources Management Plans for their facilities within sage-grouse habitats. Due to the limited amount of land administered by these agencies, we have not described them in detail here. However, most of these agencies do not manage specifically for greater sage-grouse on their lands, except in localized areas (e.g., specific wildlife refuges, reservations). One exception is DOD regulatory mechanisms applicable within MZ VI, where half of the

LIST OF EXHIBITS TO REQUEST FOR STAY

Exhibit 1: BLM Maps

Exhibit 1A BLM Map of Rawlins Field Office May 2012 Parcels, including Sage-grouse Core Areas, Leks, Nesting and Winter Sitings (labeled "Map 3" to Rawlins FO EA) http://www.blm.gov/pgdata/etc/medialib/blm/wy/information/NEPA/og/2012/05may.Par.28015.File.dat/RFO-HistoricRaptors.pdf (viewing web versions of maps allow magnifying the image for greater clarity and resolution)

Exhibit 1B BLM Map of Rock Springs Field Office May 2012 Parcels, including Sage-grouse Core Areas, Leks, Nesting and Winter Sitings (labeled "Map 3" to Rock Springs FO EA)

Exhibit 1C BLM Map of Rawlins Field Office May 2012 Parcels, including September 2011 Oil and Gas Leases and Active Wells (labeled "Map 1" to Rawlins FO EA)

Exhibit 1D BLM Map of Rock Springs Field Office May 2012 Parcels, including September 2011 Oil and Gas Leases and Active Wells (labeled "Map 1" to Rock Springs FO EA)

Exhibit 1E BLM Map of Kemmerer Field Office May 2012 Parcels, including September 2011 Oil and Gas Leases and Active Wells (attachment to Kemmerer FO EA)

Exhibit 1F BLM Greater Sage-Grouse Range-wide Regional Breeding Density Thresholds map (2010), http://www.blm.gov/wo/st/en/prog/more/sagegrouse/documents_and_resources/greater_sage-grouse0.html

Exhibit 2: BLM Documents

Exhibit 2A BLM Sage-Grouse and Sagebrush Conservation summary (website homepage) http://www.blm.gov/wo/st/en/prog/more/sagegrouse.html

Exhibit 2B Rocky Mountain Region Greater Sage-Grouse Planning Process Strategy summary (November 2011) http://www.blm.gov/wo/st/en/prog/more/sagegrouse/eastern.html

Exhibit 2C BLM's Notice of Intent To Prepare Environmental Impact Statements and Supplemental Environmental Impact Statements To Incorporate Greater

Sage-Grouse Conservation Measures Into Land Use Plans and Land Management Plans (December 9, 2011), https://www.federalregister.gov/articles/2011/12/09/2011-31652/notice-of-intent-to-prepare-environmental-impact-statements-and-supplemental-environmental-impact

Exhibit 2D A Report on National Greater Sage-Grouse Conservation Measures (BLM Sage-Grouse National Technical Team, December 21, 2011) ("BLM Technical Team Report")

Exhibit 2E National Planning Strategy flow chart http://www.blm.gov/wo/st/en/prog/more/sagegrouse/documents_and_resources/greater_sage-grouse.html.

Exhibit 2F BLM National Greater Sage-Grouse Planning Strategy (fact sheet) http://www.blm.gov/or/news/files/sage-grouse_fact_sheet.pdf

Exhibit 2G BLM Sage-grouse Planning Documents and Resources http://www.blm.gov/wo/st/en/prog/more/sagegrouse/documents_and_resources.html

Exhibit 2H BLM Instruction Memorandum No. 2012-043, Greater Sage-Grouse Interim Management Policies and Procedures (December 22, 2011) http://www.blm.gov/wo/st/en/info/regulations/Instruction_Memos_and_Bulletins/national_instruction/2012/IM_2012-043.html

Exhibit 2I BLM Instruction Memorandum No. 2012-044, BLM National Greater Sage-Grouse Land Use Planning Strategy (December 27, 2011) http://www.blm.gov/wo/st/en/info/regulations/Instruction_Memos_and_Bulletins/national_instruction/2012/IM_2012-044.print.html

Exhibit 2J BLM WSO Competitive Oil and Gas Lease Sale Results: Date of Sale: May 1, 2012

Exhibit 2K BLM Protest Decision

Exhibit 2L The BLM's Balancing Act: Managing the Needs of People and Sage-grouse on Public Lands

http://www.blm.gov/wo/st/en/prog/more/fish__wildlife_and/sage-grouse-conservation/energy.html

Exhibit 2M Bureau of Land Management National Greater Sage-Grouse Planning Strategy Charter (August 22, 2011), http://www.blm.gov/pgdata/etc/medialib/blm/wo/Communications_Directorate/public_affairs/sage-grouse_planning/documents.Par.2415.File.dat/Final%20Signed%20GSG%20Planning%20Strategy%20Charter.pdf

Exhibit 3: **Audubon Protest (and lettered Exhibits to Protest)**

Exhibit 3A Spread sheet

Exhibit 3B Expert Comments of Alison Holloran, Audubon Rockies Director of Science: Regarding Proposed May 2012 BLM Wyoming State Office Oil & Gas Lease Sale

Exhibit 3C Audubon Map, WY BLM Lease Sale, Highlighting Parcels Within Core Areas and Within 25% Breeding Polygons (May 2012)

Exhibit 3D August 27, 2011 letter to Secretary Ken Salazar, re: Conservation community's interest in range-wide conservation of Greater Sage-Grouse

Exhibit 3E Audubon Map, WY BLM Lease Sale, Highlighting Parcels Southwest of Rawlins (May 2012)

Exhibit 4: **United States Fish & Wildlife Service documents**

Exhibit 4A 12-Month Findings for Petitions to List the Greater Sage-Grouse (Centrocercus urophasianus) as Threatened or Endangered: Notice of 12-month petition findings (March 23, 2010) (excerpt pages 1-72) http://ecos.fws.gov/docs/federal_register/fr5934.pdf

Exhibit 4B USFWS Greater Sage-Grouse Fact Sheet http://www.fws.gov/mountain-prairie/species/birds/sagegrouse/FactSheet03052010.pdf

Exhibit 4C Questions and Answers for the Greater Sage-Grouse Status Review, http://www.fws.gov/mountain-prairie/species/birds/sagegrouse/03052010Q&A.pdf

Exhibit 4D July 9, 2009 USFWS letter by FWS Wyoming Field Supervisor Brian Kelly to Steve Ferrell

Exhibit 5 State of Wyoming Executive Order 2011-5, Greater Sage-Grouse Core Area Protection (June 2, 2011)

Exhibit 6 Western Governors' Wildlife Council Report to Governors: Inventory of State and Local Governments' Conservation Initiatives for Sage Grouse (December 2011)

Exhibit 7 Mapping breeding densities of greater sage-grouse: A tool for range-wide conservation planning (September 2010)).

Exhibit 8 Energy Development and Conservation Tradeoffs:Systematic Planning for Greater Sage-Grouse in their Eastern Range (Kevin E. Doherty, David E. Naugle, Holly E March 1, 2011) http://www.nature.org/ourinitiatives/urgentissues/smart-development/publications/doherty-greater-sage-grouse-publication.pdf

Exhibit 9 Audubon

Exhibit 9A National Audubon Society Mission

Exhibit 9B Wyoming Audubon Vision

Exhibit 10

As to the cumulative impacts from other ongoing or reasonably foreseeable energy development issue raised by Audubon and discounted by BLM, UWFWS warned that wind development in sage-grouse habitat could result in additional adverse impacts and declines. Id. and see Exhibit 4A at 40-44. CIA***.

FWS listing decision supports WY core areas

a. Overview of NEPA

NEPA "require[s] agencies to consider environmentally significant aspects of a proposed action." Utahns for Better Transp. v. U.S. Dep't of Transp., 305 F.3d 1152, 1162 (10th Cir. 2002). "NEPA does not, however, require agencies to elevate environmental concerns over other appropriate considerations; it requires only that the agency take a 'hard look' at the environmental consequences before taking a major action." Krueger, 513 F.3d at 1178 (citation and internal quotation marks omitted).

Also, "NEPA dictates the process by which federal agencies must examine environmental impacts, but does not impose substantive limits on agency conduct." Utah Envtl. Cong. v.

Fact Sheet

Endangered Species Act Listing Decision for the Greater Sage-Grouse

March 5, 2010:
After thoroughly analyzing the best scientific and commercial information available, the Fish and Wildlife Service has concluded that the greater sage-grouse warrants protection under the Endangered Species Act. However, the Service has determined that proposing the species for protection is precluded by the need to take action on other species facing more immediate and severe extinction threats.

As a result, the sage-grouse will be added to the list of species that are candidates for Endangered Species Act protection. The Service will review the status of the sage-grouse annually, as we do all candidate species, to determine whether it warrants more immediate attention.

The Service analyzed potential factors that may affect the habitat or range of the greater sage-grouse and determined that habitat loss and fragmentation resulting from wildfire, energy development, urbanization, agricultural conversion, and infrastructure development are the primary threats to the species.

The negative effects of fragmentation on greater sage-grouse are diverse and include reduced courtship site persistence, courtship site attendance, winter habitat use, recruitment, yearling annual survival, and female nest site choice.

Greater sage-grouse populations have been declining since the 1960s. Population projections and our analysis of threats suggest the declining population trend will continue across the species' range, and extirpation is anticipated in areas affected by energy development and increased wildfire frequency within the next 30 to 100 years. The resulting landscape is likely to consist of scattered sage-grouse populations across the species range with minimal, if any, connectivity placing the species in danger of extinction.

Invasive plants are also a serious rangewide threat to greater sage-grouse habitat because they can out-compete sagebrush and are increasing wildfire frequencies, further contributing to direct loss of habitat. Once established, invasive plants reduce and eliminate vegetation essential for greater sage-grouse to use as food and cover. Sagebrush restoration techniques are limited and have generally been ineffective.

Research examining the effects of energy development (primarily oil, gas, and coal-bed methane) indicates that greater sage-grouse populations are negatively affected by energy development activities, especially those that degrade important sagebrush habitat, even when mitigative measures are implemented. Impacts can result from direct habitat loss, fragmentation of important habitats by roads, pipelines and powerlines, and direct human disturbance. The negative effects of energy development often add to the impacts from other human development resulting in declines in greater sage-grouse populations. For example, 12 years of coal-bed methane gas development in the Powder River Basin of Wyoming has coincided with a 79 percent decline in the greater sage-grouse population. Population declines associated with energy development results from abandonment of leks (courtship sites), decreased attendance at

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the leks that persist, lower nest initiation, poor nest success and chick survival, decreased yearling survival, and avoidance of energy infrastructure in important wintering habitat.

It is predicted that continued energy exploration and development will increase over the next 20 years. Greater sage-grouse populations are predicted to decline 7 to 19 percent due to the effects of oil and gas development in the eastern part of the range; this decline is in addition to the 45 to 80 percent decline that is estimated to have occurred rangewide.

Over 30 percent of the habitat in greater sage-grouse range has high potential for wind power. The effects of renewable energy development are likely to be similar to those of nonrenewable energy as similar types of infrastructure are required.

The Intergovernmental Panel on Climate Change concludes that global climate change is occurring and has published research that represents the best available science on the subject. Projected climate change and its associated consequences have the potential to affect the greater sage-grouse and increase its risk of extinction as the impacts of climate change interact with other stressors that are already affecting the species.

The long-term impact of climate change to greater sage-grouse is yet to be determined. However, climate change will facilitate the incursion of invasive plants and the associated changes in fire regime which currently pose significant threats to greater sage-grouse and the sagebrush ecosystem.

As there is some degree of uncertainty regarding the potential effects of climate change on greater sage-grouse, climate change in and of itself was not considered a significant factor in our determination whether greater sage-grouse is warranted for listing.

Federal agencies manage the majority of greater sage-grouse habitat in the United States. Overall, the ability of these agencies to adequately address the issues of wildfire and invasive plants across the landscape is limited. However, the Service believes new mechanisms could be adopted to target the protection of greater sage-grouse habitats from fire. Energy development and its associated infrastructure are expected to continue. Protective measures and strategic siting of energy developments away from core sage grouse habitats are needed to reduce this threat into the future.

This finding combined two additional and related actions into one range-wide status review: (1) whether there is a western subspecies of greater sage-grouse; and (2) if the sage-grouse populations in the Bi-State area of California and Nevada quality as Distinct Population Segments (DPS) and if they warrant listing.

The Service determined that the Bi-State population of greater sage-grouse constitutes a valid Distinct Population Segment (DPS) and thus is a listable entity under the Endangered Species Act (ESA). Further, after evaluating all the best available scientific and commercial information regarding the greater sage-grouse, including an analysis of the threats to sage-grouse and sagebrush habitat in the Bi-State area, the Service has determined that protection under the ESA is warranted. However, listing the Bi-State DPS of the greater sage-grouse at this time is

Questions and Answers for the
Greater Sage-Grouse Status Review

Q1: What is the U.S. Fish and Wildlife Service's determination regarding the status of the greater sage-grouse?

A1: After evaluating all the available scientific and commercial information regarding greater sage-grouse, including an analysis of the threats to the species and sagebrush habitat, the U.S. Fish and Wildlife Service has determined that protection under the Endangered Species Act (ESA) is warranted. However, listing the greater sage-grouse at this time is precluded by the need to address other listings of higher priority.

The greater sage-grouse will be added to the list of candidate species under the ESA and will be proposed for listing when funding and workload priorities for other listing actions allow.

Q2: What information did the Service use to make this decision?

A2: The Service based its final determination on the accumulated scientific data provided by State and Federal agencies and Tribes, as well as data and information provided through public comments. The review of relevant materials included 25 chapters of new information and or analyses contained in the peer-reviewed monograph entitled: *Ecology and Conservation of Greater Sage-Grouse: A Landscape Species and Its Habitats* which was edited by the U.S Geological Survey for a forthcoming publication by the Cooper Ornithological Society in their Studies in Avian Biology Series. Thirty-eight scientists from federal, state, and nongovernmental organizations collaborated to produce the analyses, synthesis, and findings presented in the chapters of this monograph.
The Service recognizes and thanks all the States within the range of the greater sage-grouse for their contributions to our knowledge of greater sage-grouse and sagebrush habitat.

Q3: During the previous Administration, the Service determined that the greater sage-grouse did not warrant proposal for listing. What are the principal reasons why FWS has now reached the opposite conclusion?

A3: Since our 2005 status review, a significant amount of new science is available concerning the status of the species and the effects of different land uses on the species' survival, including new information obtained from the Cooper Ornithological Society Monograph chapters the Service received in pre-publication form in 2008 and 2009. This information contained extensive scientific analysis that integrated the species' ecology with existing land uses and clearly documented that certain factors occurring on the landscape result in population declines and population extinctions.

Q4: If protecting the sage-grouse is warranted, why is taking action on the sage- grouse a lower priority than for other species? What criteria did the Service use to determine this lower priority?

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A4: In order to make the most effective use of its limited resources for listing species under the ESA, the Service has developed a priority system designed to direct its efforts towards the plants and animals in greatest need of protection. Candidate species are assigned a priority number from 1 to 12, with 1 being the highest priority, based on multiple criteria. The magnitude of threat is the most important consideration, followed by the immediacy of the threat and the taxonomic distinctiveness of the species (the most distinctive is a monotypic genus, then a full species, and lastly a subspecies, variety or vertebrate population).

The greater sage-grouse population as a whole remains large enough and is distributed across such a large portion of the western United States that the immediate threat of extinction is low. The Service has assigned it a listing priority number of 8, which indicated relatively lower priority when compared with most of the species on the candidate list. As a result, the needs of other species facing more immediate and severe threat of extinction must take priority for preparing listing proposals.

Q5: How many species are currently on the candidate list? How many candidate species will be addressed in the coming year?

A5: Currently, 249 species are candidates for listing, and due to pending petitions to list several hundred additional species, this number may increase by FY 2011. Despite this potential increase, the Service anticipates that the number of candidates in FY 2010 will decrease to approximately 186. This decrease is anticipated as the Listing Program completes proposed rules to list species or determinations that listing is not warranted in FY 2010.

Q6: Given how many species will remain on the candidate list after 2011, how long is it likely to be before the sage-grouse will be proposed for protection under the ESA?

A6: The Service has been making steady progress in recent years to prepare listing proposals for candidate species. In any given fiscal year, multiple factors dictate how much work the Service can undertake to prepare proposed listing documents. The resources available for listing actions are determined through the annual Congressional appropriations process. The number of listing actions the Service can undertake also is influenced by the complexity of those actions, which can vary widely. Thus, it is difficult to predict how long it might be before the Service prepares a proposed rule for the greater sage-grouse. We will, however, review its status annually and work with States, other Federal agencies, private landowners, and other partners to step up efforts to conserve the species.

Q7: Is it possible that, before the sage-grouse is actually proposed for listing, the Service might decide that it no longer warrants proposed listing, and if so, what would have to happen for that to be the case?

A7: Yes, it is possible that the Service might decide the greater sage-grouse no longer warrants listing. The Service is required to annually update a finding that a species is warranted but precluded for listing. During that process, we consider new information that becomes available about the species and its status, including new information about its biology, threats and their estimated impact and estimated risk to the species, and the effectiveness of conservation efforts.

This formal annual process allows the Service to review the status of the greater sage-grouse until such time as either a proposed listing rule is published or a finding is made that listing is not warranted.

Q8: What is being done now to conserve greater sage-grouse?

A8: Concern about long-term declines in greater sage-grouse populations was raised by State game and fish agencies more than a decade ago. In response, the Fish and Wildlife Service joined with the Western Association of Fish and Wildlife Agencies (WAFWA), representing all of the Western state wildlife agencies, in 2006 to develop the Greater Sage-Grouse Comprehensive Conservation Strategy. The release of this strategy marked a true turning point, enabling a shift from conservation planning to conservation implementation incorporating adaptive management principles to inform and guide future management practices.

In order to begin implementing the conservation strategy – which is aimed at jointly conserving and managing sagebrush habitat for the benefit of greater sage-grouse and other sagebrush-dependent species – WAFWA and federal agencies including the Bureau of Land Management, U.S. Forest Service, and U.S. Fish and Wildlife Service, Natural Resources Conservation Service, U.S. Geological Survey and Farm Services Agency joined together under a Memorandum of Agreement (MOA) in 2008.

As a result of these steps, Western states have begun to implement significant sage-grouse conservation efforts within their own borders. For example, in Wyoming, the state has developed the Wyoming sage grouse core area conservation strategy. This important strategy is designed to ensure a population objective of maintaining up to 80 percent of the breeding sage-grouse in the State. The state of Montana has developed a Management Plan and Conservation Strategies to direct sage-grouse management in the State. Montana has also developed a State core area strategy to focus management, and is developing an off-site mitigation and compensation system for sage-grouse. In addition, the state is supporting research on grazing strategies in sage-grouse habitats in coordination with University of Montana and NRCS. And in Idaho, the Fish and Wildlife Service and the Idaho Department of Fish and Game recently finalized the first ever CCAA (candidate conservation agreement with assurances) for the greater sage-grouse. Fish and Wildlife Service regulations allow for these agreements to be developed for potential candidate species. These are just a few examples of widespread actions being implemented to benefit the greater sage-grouse.

Q9: What is a candidate species?

A9: Candidate species are plants and animals for which the Service has sufficient information on their biological status and threats to propose them for listing as endangered or threatened under the ESA, but for which development of a proposed listing regulation is precluded by higher priority listing actions to address species in greater need.

Candidate species receive no statutory protection under the ESA. The Service encourages voluntary cooperative conservation efforts for these species because they are, by definition, species that warrant future protection under the ESA.

Q10: What conservation actions are encouraged for candidate species?

A10: Effective conservation actions for candidate species require a means of addressing immediate, long-term, and identifiable threats. Depending on the threats in a local area, specific on-the-ground activities could include: increasing the size of buffer zones around various types of development activities, such as oil and gas development; removal of pinyon-juniper woodland in areas where it is encroaching on sagebrush habitat important to greater sage-grouse, protecting riparian (streamside) or other moist areas from inappropriate levels of livestock grazing or other activities which impact habitat important for brood-rearing by greater sage-grouse, and a variety of habitat restoration or protection measures to reduce habitat fragmentation and maintain or restore habitat connectivity. These and other types of conservation actions maximize management options for landowners and for the species, minimize the cost of recovery, and reduce the potential for restrictive land use policies that may be necessary in the future if listing occurs. Addressing the needs of species before the regulatory requirements associated with listed species come into play often allows greater management flexibility to stabilize or restore these species and their habitats. Ideally, sufficient threats can be removed to eliminate the need for listing. State agencies and the Service offer technical expertise and provide funding for conservation of candidate and other species at-risk.

Q11: What tools are available for candidate species?

A11: The Service and other federal partners have greater ability to provide technical and financial assistance for conservation of candidate species on private land. The Service provides financial and technical assistance to landowners seeking to conserve candidate species on their land through its Partners for Fish and Wildlife Program. Additional financial assistance is available through various Service grants and agreements, as well as through Farm Bill and Department of Defense programs. In addition, the Service has the ability to take advantage of the additional management flexibility afforded to candidate species by facilitating development and implementation of Candidate Conservation Agreements (CCAs) and Candidate Conservation Agreements with Assurances (CCAAs).

CCAs are formal, voluntary agreements between the Service and one or more parties to address the conservation needs of one or more candidate species. Participants voluntarily commit to implement specific actions designed to remove or reduce threats to the covered species. CCAs can involve both federal and non-federal lands. In some cases, these agreements have been so successful that listing the species proved to be unnecessary. For non-federal landowners seeking regulatory assurances, CCAAs are an effective tool. A CCAA provides participating property owners with a permit containing assurances that if they engage in certain conservation actions for species included in the agreement, they will not be required to implement additional conservation measures beyond those in the CCAA in the event the species becomes listed. Also, additional land, water, or resource use limitations will not be imposed on them should the species become listed in the future, unless they consent to the change. For additional information on these tools, see **http://www.fws.gov/endangered/landowner/index.html**.

Q12: Why did the Service conduct a range-wide status review of the greater sage-grouse?

A12: The Service was sued by Western Watersheds Project on the merits of the 2005 finding which determined that listing the greater sage-grouse was not warranted based on the scientific information available at that time. In a stipulated agreement with the plaintiffs, we agreed to submit a new finding to the Federal Register by February 26, 2010; by mutual agreement and with approval of the involved court. That date was extended by one week to March 5, 2010.

Q13: What is a status review?

A13: A status review is an in-depth examination of all the scientific information relating to a species and its habitat. It provides the basis for making a finding as to whether listing is warranted.

The Service sought out all available scientific and commercial information on greater sage-grouse population trends, as well as information on the loss and modification of sagebrush habitat. The purpose of the status review was to determine whether the greater sage-grouse warranted listing as endangered or threatened under the ESA.

Q14: What is a greater sage-grouse and where do they live?

A14: Greater sage-grouse are large, rounded-winged, ground-dwelling birds, up to 30 inches long and two feet tall, weighing from two to seven pounds. They have a long pointed tail with legs feathered to the base of the toes. Females are a mottled brown, black, and white color. Males are larger and have a large white ruff around their neck and bright yellow air sacks on their breasts, which they inflate during their mating displays. They are found in 11 States: Washington, Oregon, California, Nevada, Utah, Colorado, Idaho, Montana, North Dakota, South Dakota, and Wyoming. Small populations are also found in the Canadian provinces of Alberta and Saskatchewan.

Q15: How did the Service determine the extinction risk for greater sage-grouse?

A15: A large volume of new information has been obtained, analyzed and published in peer reviewed scientific documents since the 2005 finding. As a result, the causes of population declines, and the loss of greater sage-grouse populations, are now better understood. This new scientific information, combined with updated information on the current status and the known and projected uses of sagebrush habitat, was evaluated by the Service in making the finding.

Q16: What are the primary threats to greater sage-grouse?

A16: Fragmentation of sagebrush habitats has been cited as the primary cause of the decline of greater sage-grouse populations. Greater sage-grouse are a landscape scale species, requiring large expanses of sagebrush to meet all seasonal habitat requirements.

The Service analyzed potential factors that may affect the habitat or range of the greater sage-grouse and determined that habitat loss and fragmentation resulting from wildfire, invasive plants, energy development, urbanization, agricultural conversion, and infrastructure development are the primary threats to the species. The negative effects of fragmentation on greater sage-grouse are diverse and include reduced lek (courtship site) persistence, lek attendance, winter habitat use, recruitment, yearling annual survival, and female nest site choice.

Fire: Fire is a primary cause of recent large-scale losses of habitat. Fire frequencies have increased as a result of the incursion of invasive plant species. As a result, this stressor is anticipated to increase.

Invasives:
Once established, invasive plants reduce and eliminate vegetation essential for greater sage-grouse to use as food and cover, and facilitate a shorter fire cycle. Techniques to control invasive plants on a landscape scale necessary to support the greater sage-grouse are limited and have generally been ineffective to date.

Energy Development:
Greater sage-grouse populations are negatively affected by energy development activities (primarily oil, gas, and coal-bed methane), especially those that degrade important sagebrush habitat, even when mitigative measures are implemented. Impacts can result from direct habitat loss, fragmentation of important habitats by roads, pipelines and powerlines, and direct human disturbance. The negative effects of energy development often add to the impacts from other human development, resulting in declines in greater sage-grouse populations.

Population declines associated with energy development results from abandonment of leks, decreased attendance at the leks that persist, lower nest initiation, poor nest success and chick survival, decreased yearling survival, and avoidance of energy infrastructure in important wintering habitat. Energy exploration and development is projected to increase over the next 20 years.

An estimated 30 percent of habitat in greater sage-grouse range has high potential for wind power. The effects of renewable energy development are likely to be similar to those of nonrenewable energy as similar types of infrastructure are required.

Urbanization:
Since 1950, the western United States has exceeded the national average in the population growth rate, with rural areas growing faster than urban areas in 60 percent of the counties in the Rocky Mountain States. This growth has led to increases in urban, suburban and rural development. In addition, the presence of domestic pets and predators associated with humans (e.g. foxes, skunks, ravens) also negatively affect the greater sage-grouse. Given the current demographic and economic trends in the Rocky Mountain West, we believe urbanization will continue to increase, resulting in further habitat fragmentation and degradation.

Agricultural conversion: Greater sage-grouse become locally extinct when the amount of tilled agriculture within an area exceeds 25 percent of the surrounding land cover. Agriculture also results in indirect effects to both the sage-grouse and sagebrush habitats due to the supporting infrastructure and the presence of human-associated predators.

Grazing: Grazing is the most extensive land use across the range of the greater sage-grouse. Grazing can be managed appropriately to be compatible with conservation of the sage-grouse. We caution that the removal of sagebrush to promote forage production is not compatible with greater sage-grouse conservation and should be avoided.

Infrastructure:
Infrastructure includes a broad array of structures necessary to support most kinds of energy and human developments (e.g., powerlines, pipelines, fences and roads). As an example, powerlines can directly affect greater sage-grouse by posing a collision and electrocution hazard and can have indirect effects by increasing predation by providing hunting perches for many species of raptors. Impacts from roads may include direct habitat loss, direct mortality, barriers to migration corridors, facilitation of predators and spread of invasive vegetative species and other indirect impacts such as noise.

Climate Change:
Projected climate change and its associated consequences have the potential to affect the greater sage-grouse and increase its risk of extinction as the impacts of climate change compound the effects of other stressors already impacting the species.

The long-term impact of climate change to greater sage-grouse is yet to be determined. However, changes in temperature and precipitation regimes associate with climate change are likely to facilitate the incursion of invasive plants and the associated changes in fire regime which currently pose significant threats to greater sage-grouse and the sagebrush ecosystem.

As there is some degree of uncertainty regarding the potential effects of climate change on greater sage-grouse, climate change in and of itself was not considered a significant factor in our determination whether greater sage-grouse is warranted for listing.

Regulatory Mechanisms:
Federal agencies manage the majority of greater sage-grouse habitat in the United States. Their participation in controlling greater sage-grouse habitat fragmentation is essential to long-term persistence. Overall, the ability of these agencies to adequately address the issues of wildfire and invasive plants across the landscape is limited. However, the Service believes a strategic conservation approach can be adopted to target the protection of greater sage-grouse habitats from fire and other forms of habitat loss and fragmentation. Energy development and its associated infrastructure are expected to continue. Protective measures and strategic siting of energy developments away from core sage grouse habitats are needed to reduce this threat into the future. Such efforts should be undertaken in collaboration with State Wildlife agencies who will continue to manage greater sage-grouse; and should be consistent with the Western Association of Fish and Wildlife Agencies 2006 Greater sage-grouse Rangewide Conservation Strategy developed jointly by WAFWA, the Service, Bureau of Land Management and U.S. Forest Service.

Q17: Is there an estimate of how many sage-grouse current exist?

A17: Population numbers are difficult to estimate due to the large range of the species and inconsistent sampling protocols for lek surveys. The annual counting of males on leks remains the primary approach to monitoring long-term trends of populations and standardized techniques are beginning to be implemented throughout the species' range.

Population projections suggest the population will decline across the species' range in coming years, and extirpation is anticipated in some areas affected by energy development and increased wildfire frequency within the next 30 to 100 years. The resulting landscape will consist of scattered sage-grouse populations across the species range with minimal, if any, connectivity, placing the species at increasing risk of at increasing risk of substantial decline or extirpation in additional areas.

Q18: How much sagebrush habitat is there?

A18: Current sagebrush habitat is estimated at approximately 160 million acres – about half of the estimated historic acreage.

Q19: Is the greater sage grouse the only wildlife dependent upon sagebrush habitats?

A19: No. In fact, the following wildlife species are either partially or entirely dependent upon sagebrush habitat: Pronghorn Antelope (also benefits from grassland habitats), the Sage Thrasher, the Gunnison Sage-Grouse (different species found in Utah and western Colorado), the Pygmy Rabbit, the Sage Sparrow, the Brewer's Sparrow, Ferruginous hawks, the Loggerhead Shrike, and the White-Tailed Prairie Dog.

Q20: How will today's action affect oil and gas development within the range of the sage grouse? What about wind power development and livestock grazing?

A20: As a candidate species, the greater sage-grouse does not have any regulatory protection. We recommend that project proponents wanting to conduct activities in occupied sage-grouse habitat coordinate with the Service and the States to develop projects that are compatible with greater sage-grouse conservation. Oil and gas development and wind power development is not compatible with the species unless done in a strategic way where key habitats are conserved. Livestock grazing can be managed in a manner compatible with sage-grouse conservation. Service biologists are available to assist project proponents in developing projects that are compatible with greater sage-grouse conservation.

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Ecological Services
5353 Yellowstone Road, Suite 308A
Cheyenne, Wyoming 82009

JUL 0 7 2009

Mr. Steve Ferrell
Director, Wyoming Game and Fish Department
5400 Bishop Blvd
Cheyenne, WY 82006

STEVE
Dear Director Ferrell:

Thank you for your letter of July 7, 2009, regarding the State of Wyoming's Greater sage-grouse "Core Population Area Strategy" (Strategy) (Executive Order 2008-2). Your letter requests clarification from the U.S. Fish and Wildlife Service (Service) regarding our endorsement of the Strategy. Specifically, you would like our view of whether wind power can be developed in core areas in a way that the Wyoming Game and Fish Department and the State of Wyoming would maintain our endorsement. This letter is responsive to your request and provides an explanation of our concern about wind development in core areas. In summary, constructing wind farms in core areas, even for research purposes, prior to demonstrating it can be done with no impact to sage-grouse, negates the usefulness of the core area concept as a conservation strategy and brings into question whether adequate regulatory mechanisms are in place to protect the species. Both of these factors are critical in the Endangered Species Act (ESA) listing decision currently facing the Service.

Following are some specific reasons why we endorsed the Strategy when asked by the Governor's Office in 2008:

A. In a general conservation context the Strategy is a science-driven, outcome-based and adaptive approach to the conservation of a species and its habitat. The Service is in the process of adopting a similar approach, currently called Strategic Habitat Conservation (SHC) for much of our conservation work. Therefore, as a general conservation paradigm we support such an approach.

B. In the context of a potential listing under the ESA, the State's sage-grouse Strategy provides a useful framework to show how the threats to the species are being managed; and if the Strategy is adopted across different land ownerships in the state, could provide an important regulatory mechanism as well. As you know, to preclude listing under ESA, we must be able to show that threats to the species are effectively addressed by science-based conservation measures, and that adequate regulatory mechanisms are in place to ensure those actions occur. In regard to the latter, the actions of the State Board of Land Commissioners to adopt a process that ensures sage-grouse conservation measures are implemented on state land within core areas, and the regulatory authority of the Department of Environmental Quality Industrial Sighting Council (ISC) are noteworthy.

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C. The Strategy provides the mechanism by which the state can be the most flexible in the application of the Statewide Candidate Conservation Agreement with Assurances (CCAA) that is currently being developed. The CCAA tool is important for private landowners in the state both for the conservation of the species and its habitat, and the assurances it provides the landowner if the species is ever listed.

In short, if implemented as envisioned by the State Sage-grouse Implementation Team (SGIT) and Governor's Executive Order, the Strategy is the type of action the Service looks for, both in conservation measures and regulatory process, to preclude listing a species under the ESA. However, it is important that I point out that these potential benefits of the Strategy will only be realized if the integrity of the core area approach is maintained. The Service feels that the greatest threats to the integrity of the core areas are: (1) not adhering to science-based conservation measures associated with development, and (2) allowing mitigation for impacts to core population areas as an option if the proposed development is counter to accepted conservation measures or when impacts are not known.

The foundation of the Strategy from the Service point of view is that development in the most important sage-grouse habitats (core areas and associated seasonal habitats) is done only when no impact to the species can be demonstrated. In essence, ensuring the conservation of sage-grouse in the core areas is mitigation for the greater development flexibility outside core areas provided for by the Strategy. Therefore, allowing impacts within core areas, for research or other reasons, destroys the function and value of the Strategy.

With respect to wind power development, your letter referenced the SGIT recommendations that were adopted by the State Board of Land Commissioners. Specifically, you asked whether we thought the reference in those recommendations to a "no impact/mitigation plan" as you termed it, was possible for wind power development. Your question is an excellent one, but the context of the SGIT's recommendations is critical to our answer to this question. The SGIT's recommendations, as noted in your letter, began by stating: *"Proposals to deviate from standard stipulations (emphasis added) will be considered by a team..."* Your letter appropriately raises questions about whether there is a scientific basis for standard stipulations for wind development different from other road-and-pad development on which the SGIT's recommendations are based, and therefore whether the ability to develop a mitigation plan even exists. In our judgment, we agree, no such data currently exist.

To the Service, the recommendations of the SGIT and Executive Order 2008-2 are clear with respect to deviation from standard stipulations. That is, the burden of proof that development does not affect sage-grouse rests with the industry or proponent in question, and any research they feel is necessary to convey this, should be conducted outside of core areas. This burden of proof to show that development in core areas can be done consistent with conserving sage-grouse underlies <u>all</u> forms of development—not just wind-power. The Strategy is clear on this point and is one of the key reasons for our endorsement.

In assessing the threats to sage-grouse to determine whether the species warrants listing under ESA, we view the science on the impacts of wind development on sage-grouse as being clearer than is being conveyed by some in the wind industry. While there is no doubt that we have more to learn, there exists a large body of empirical, peer reviewed, and published science on the negative impacts of road-and-pad based development on the behavior, movements, survival and productivity of this species. The Service in our 2005 decision to not list the species found that these developments, their associated infrastructure, and the fact such development enhanced the spread of invasive species were among the primary threats to the species. In the past 4 years, since our 2005 finding, we have seen no science to change this view, only more science affirming it, while at the same time witnessing a significant increase in this type of potential development.

Regarding your second specific question on development levels outside core areas, the March 25, 2008 letter from the SGIT to the Governor states development should attempt to maintain populations, habitats and essential migration routes outside core areas wherever possible. How low lek persistence or population numbers can decline outside of core areas needs to be consistent with the recommendations of the SGIT. We encourage you to direct your request for specific numbers to the Governor's SGIT (of which the Service is a member) and species experts. Having said this, the Service has been developing, and will continue to develop, means by which we can provide for more strategic conservation of our trust species (e.g., migratory birds) outside of core areas to help meet the intent of item #6 in Executive Order 2008-2. Item #6 as you note, states that incentives to develop outside of core areas are an important component of the Strategy. Some of the flexibility resulting from our efforts we feel will be helpful to the energy industry and other development in the State.

Wyoming has set a national example by signing a Memorandum of Agreement (MOA) between your department, my agency and the Governor's Office to work together to conserve species in a manner that hopefully precludes the need for Federal listing. The approach taken to develop and implement the core area Strategy to date exemplifies the vision shared among us in signing the MOA. However, constructing wind farms in core areas, even for research purposes, prior to demonstrating it can be done with no impact to sage-grouse, negates the usefulness of the core area concept as a conservation strategy and brings into question whether adequate regulatory mechanisms are in place to protect the species.

Please know that my office remains committed to playing our role in helping to implement the sage-grouse core areas strategy as envisioned by the SGIT and the Executive Order and to work within our authorities to collaborate with you and others in helping to develop an environmentally-responsible wind industry and other development in Wyoming.

Sincerely,

Brian T. Kelly
Field Supervisor
Wyoming Field Office

cc: Deputy Chief of Staff, Wyoming Governor's Office (R. Lance)
Chair, Wyoming Sage-grouse Implementation Team (B. Budd)