STOP! This document is being edited by Dawn Davis right now. If you need to make edits, please talk to Dawn first!!!!!

Sage-Grouse Friends –

Please note, there is a LOT of formatting in this document. If you could keep the section breaks in place, that would be super (this just means, don't delete between the citations of one page and the start of a new chapter/section). Any doubts- just turn on the "Show/Hide Formatting" button to the right of the sort button on the Home Tab.

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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*; hereafter sage-grouse) as endangered across its entire range. We received a second petition from the Institute for Wildlife Protection on March 24, 2003, requesting that the sage-grouse be listed rangewide. On December 29, 2003, we received a third petition from the American Lands Alliance and 20 additional conservation organizations to list the 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 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.

We delivered a 12-month finding to the Federal Register by this due date, and it was published on March 23, 2010 (75 FR 13910). The 12-month finding announced that listing the sage-grouse rangewide was warranted, but precluded by higher priority listing actions, and the species was added to the list of candidate species with a listing priority number of 8. As required by section 4(b)(3)(C) of the Act, we have subsequently made annual resubmitted petition findings, announced in conjunction with our Candidate Notices of Review, in which we continued to find that listing the sage-grouse rangewide was warranted but precluded by other higher priority listing actions (75 FR 69222, 76 FR 66370, 77 FR 69994, 78 FR 70104, 79 FR 72450).

On May 10, 2011, we filed a multiyear work plan as part of a proposed settlement agreement with Wild Earth Guardians and others in a consolidated case in the U.S. District Court for the District of Columbia. On September 9, 2011, the Court accepted our agreement with the plaintiffs in Endangered Species Act Section 4 Deadline Litig., Misc. Action No. 10–377 (EGS), MDL Docket No. 2165 (D. DC) (known as the ‘‘MDL case’’) on a schedule to publish proposed rules or not-warranted findings for the 251 species designated as candidates as of 2010 no later than September 30, 2016. The work plan included a deadline to submit a proposed rule or a not-warranted finding to the Federal Register for sage-grouse, including any Distinct Population Segments (DPSs), by the end of FY 2015.

Comment [Craig1]: Rider?

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 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.

Subsequently, in our March 23, 2010 12-month finding (75 FR 13910), we announced that listing the western subspecies of the sage-grouse was not warranted, based on our determination that the western subspecies is not a valid taxon and thus not a listable entity under the Act. We noted, however, that sage-grouse in the area covered by the putative western subspecies (except those in the Bi-State area, covered by a separate finding), were encompassed by our finding that listing the species rangewide was warranted but precluded.

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 annual 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, 75 FR 69222, 76 FR 66370, 77 FR 69994, 78 FR 70104, 79 FR 72450).

Subsequent to the March 2006 decision by the court on our 90–day finding on the petition to list the western subspecies of the 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 sage-grouse. Subsequently, in light of the conclusions in our March 2010 12-month finding regarding the invalidity of the western sage-grouse subspecies (the taxonomic entity we relied on in our DPS analysis for the Columbia Basin population), our resubmitted petition findings stated that the significance of the Columbia Basin DPS to the sage-grouse would require further review. We stated that we intended to complete an analysis to determine if this population continues to warrant recognition as a DPS in accordance with our Policy Regarding the Recognition of Distinct Vertebrate Population Segments (61 FR 4722; February 7, 1996) at the time we make a listing decision on the status of the sage-grouse. Until that time, the Columbia Basin DPS has remained a candidate for listing as a separate population of 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 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 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 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 sage-grouse as a threatened or endangered DPS of the sage-grouse 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 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 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 stated 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 sage-grouse no later than by February 26, 2010. The due date for submission of the document to the Federal Register was extended to March 5, 2010, and after we submitted the document to the Federal Register by this date, the document was subsequently published on March 23, 2010 (75 FR 13910), in a combined finding that also considered sage-grouse rangewide, as discussed above. In this document, we concluded, among other things, that the Mono Basin area population is a listable entity under

Service policy as a DPS and that the DPS warranted protection under the Act but that immediate action was precluded by higher listing priorities. This warranted-but- precluded finding placed the DPS on our candidate list.

Both the 2002 and 2005 petitions, as well as our 2002 and 2006 findings, use the term ‘‘Mono Basin area’’ and ‘‘Mono Basin population’’ to refer to 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. For consistency with ongoing planning efforts, we adopted the ‘‘Bi-State’’ nomenclature in our 2010 finding and consequently have referred to this DPS as the ‘‘Bi-State DPS’’ within subsequent documents.

As required by section 4(b)(3)(C) of the Act, we subsequently made annual resubmitted petition findings, announced in conjunction with our Candidate Notices of Review, in which we continued to find that listing the Bi-State DPS was warranted but precluded by other higher priority listing actions (75 FR 69222, 76 FR 66370, 77 FR 69994). On May 10, 2011, we filed a multiyear work plan as part of a proposed settlement agreement with Wild Earth Guardians and others in a consolidated case in the U.S. District Court for the District of Columbia. On September 9, 2011, the Court accepted our agreement with the plaintiffs in the MDL case (as described above) on a schedule to publish proposed rules or not-warranted findings for the 251 species designated as candidates as of 2010 no later than September 30, 2016.

In compliance with our MDL work plan, on October 28, 2013, we published a proposed rule to list the Bi-State DPS of sage-grouse as threatened under the Act and establish a 4(d) special rule (78 FR 64358), and a proposed rule to designate critical habitat for the Bi-State DPS (78 FR 64328).

Process for 2015 status review

Comment [SB2]: Drawn heavily from the Process Analytical Framework document.

Per Jesse’s comment, I am flagging this to be potentially updated at a later time, since the process seems to keep evolving!

As described above, the Service must evaluate the status and submit a proposed rule or a not-warranted finding to the Federal Register for sage-grouse, including the Columbia Basin population, by September 2015. Since the 2010 finding that sage-grouse warranted Federal protection under the Act, but was precluded by higher priority actions, considerable progress has been made to address the threats and provide additional information regarding the species. In this status review, the Service will evaluate the best available scientific and commercial information to determine whether the species is in danger of extinction or is likely to become endangered in the foreseeable future throughout all or a significant portion of its range.

Comment [Craig3]: Tense?

We are committed to building the most transparent, thorough, and scientifically defensible status review in the agency's history. We intend to achieve this goal by incorporating the robust modeling efforts of our partners, requesting information on the ongoing and future conservation efforts, and working with the states to understand the current status of the sage-grouse. The information available on sage-grouse comprises a huge amount of data; we will structure our analysis to best utilize the available information.

Comment [Craig4]: Tense?

The Service relies on a number of foundational elements for our status assessment, primarily the language of the Act, its implementing regulations, and agency policy, as well as previous work and assessments of the species' status, including the 2010 finding, and the Greater Sage-Grouse Conservation Objectives (COT) Report (FWS 2013, entire). The principle factors leading to the 2010 warranted but precluded finding were habitat loss and fragmentation, principally due to invasive species and fire, energy development and associated infrastructure, sagebrush conversion due to agricultural practices, and a lack of adequate regulatory mechanisms to address those threats. These threats will be a focus of the analysis we are conducting for the current species status review. The final COT report, a product of state and Federal collaboration, outlined the key areas for conservation of the species, the key threats in those areas, and conservation objectives involving reduction of those threats. The COT report identified the most important areas needed for long-term persistence of the species, which were termed Priority Areas for Conservation (PACs). The COT report has served as the basis for our technical advice regarding current regulatory and voluntary planning efforts and is a lens through which we are analyzing conservation measures during this status review.

In this review, the Service will apply the statute, regulations, and appropriate policies in the context of previous decisions for sage-grouse and other similar species that we have evaluated under the Act, and we will explain meaningful differences based on species, threat impacts, or scale. We will use a structured analytical framework and process to assess the scientific, commercial, and legal information we must consider when making a listing decision.

A foundational element of our analysis is a current understanding of the status of the species, against which we will evaluate the impacts of threats and beneficial actions. We have worked with states and other partners to gather the most recent information to understand the current status and trend of the species at various spatial scales, including across the remainder of the range. The Service will assess all of the best available scientific and commercial information about the sage-grouse, the species' habitat needs, and potential impacts. We will address any new information and explain how our understanding of available scientific information may or may not have changed since the 2010 finding.

The sage-grouse's expansive range makes the evaluation of population, habitat, threats, and conservation efforts in a geospatial context a preferred option for assessing information. We have conducted all spatial analyses to predict indices of distribution and relative abundance of sage-grouse where possible. Our base spatial level of analysis is the PACs; our analyses are scale-able to populations, other potential areas of interest, and the remainder of the range.

In this species report, we assess the degree to which the major threats of habitat loss and fragmentation and inadequacy of regulatory mechanisms have been addressed since 2010. We also evaluate any new threats to the species. For each of the major threats identified from 2010 finding and in the COT report and any significant new threats identified, we assess their impacts to both relative abundance and distribution of sage-grouse at multiple spatial scales.

Just as we attempt to quantify threats and predict their impacts, we also attempt in this species report to quantify the degree to which state and Federal plans, and local and other conservation efforts have already ameliorated threats to sage-grouse or are likely to do so into the future. We seek to understand how state and Federal plans, local conservation efforts, and other conservation efforts put in place since 2010 have removed or reduced impacts from threats, particularly within PACs. Management direction described in recently revised or amended Federal Land Management Plans is evaluated under Factor D based upon the likelihood of effectiveness in ameliorating known threats to sage-grouse. Appropriate management actions that target high-priority threats receive greater analysis; actions that target more localized or minor threats may not be analyzed in as great detail. In addition to Federal plans, other conservation actions are also assessed. Where appropriate, the Service's Policy for Evaluation of Conservation Efforts (68 FR 15100, March 28, 2003) is used to assess actions that may be relied on in the listing decision.

Impacts of threats and regulatory and voluntary conservation actions are forecast using an analytical framework to assess percent of populations or degree of habitat persisting over time by comparing current with future situation. Since the species is not evenly distributed across the landscape, we do not believe that bird numbers or habitat acres in and of themselves are the appropriate predictors of the overall species status and its likely persistence into the future.

The spatial analyses used in the 2010 status review were simple and assumed 100 percent impact. For example, if an area could be developed, it was assumed that it would be developed completely. It was further assumed that developed areas would not be able to support any sage-grouse, or would be significantly degraded such that sustaining current populations would not be likely. This estimate of impact was based upon predictions in the literature. Our new analyses include multiple scenarios and may be at a finer scale (e.g., PAC, population). This finer scale allows us to analyze changes at population levels or management zones. The Service has used a number of analytical methods, including a Spatially Explicit Modelling (SEM) framework focused on current and future threats and conservation actions, using the COT spatial geography (i.e., PACs) and population data to project various outcomes, as measured by abundance and distribution; using U.S. Geological Survey facilitators to employ modeling techniques such as Bayesian belief networks to increase transparency and help produce defensible decisions; using expert elicitation with outside parties to solicit input about the degree to which threats will be relevant and impact sage-grouse into the future; and using peer-reviewed quantitative spatial models that

Comment [Craig5]: ? not spatial? Spatially explicit? Less complex?

Perhaps, "assumed that all potential threats impacted the species and its habitats equally across the range, at 100 percent" ?

Comment [Craig6]: ?

incorporate stated assumptions, knowledge of existing threat reduction measures, a range of potential input values, and all best available science.

The SEMs, expert elicitation, and internal decision analysis require the highest level of effort and are used on those threats that have been identified as the most important drivers for the conservation of the species (long-term persistence). These, at a minimum, include invasive species and fire, energy development and associated infrastructure, and habitat conversion due to tilled agriculture. The remaining threats from the COT report, 2010 finding, and other information collected are evaluated and considered across the remainder of the range, populations, PACs, and individuals within this species report. Areas of interest are areas where threats may be concentrated, populations may have limited connectivity to neighboring populations, or the value of the birds in that area may be exceptionally high as it relates to the rest of the range.

The ultimate evaluation of listing status (i.e., whether the species is warranted for listing or not) will be informed in large part by the current status and trend of the species in the rest of the range, and the degree to which we predict the species, populations, and PACs will persist into the future. Given the number of threats and the uncertainty around those threats as they are likely to persist or increase into the future, as well as the evaluation of regulatory and non-regulatory conservation actions, we anticipate a wide range of modeling outcomes of abundance and distribution. These various outcomes, along with the qualitative evaluation of other threats and conservation actions, as summarized in this species report, will be the basis of one or more structured discussions regarding the reasonableness of our assumptions, risk to the species, exposure to threats, how far into the future that our predictions are reliable, the likelihood of the species persistence and the degree of persistence into the future.

The various outcomes from our structured prediction processes, along with the qualitative evaluation of other threats and conservation actions, as described and summarized in this species report, will be the basis of a structured workshop for Service personnel during which we will present, evaluate, analyze, and discuss the best available scientific and commercial information. After reviewing this information, Service personnel will evaluate whether the sage-grouse meets the definition of “threatened species” or “endangered species.” Within the range of the sage-grouse, one DPS has previously been identified (Bi-State). Through our analysis, we will determine whether the remainder of the range, in whole or in part, warrants listing as threatened or endangered, and resolve the status of the Columbia Basin population.

Species report overview

Comment [SB7]: Based on the GRSG Species Report Outline document.

I have made a couple updates based on the latest version of the Species Report Outline, but I am flagging this to be updated at a later time too, since the process and organization of the species report seem to keep evolving!

This species report is intended to summarize the best available scientific and commercial information regarding sage-grouse and its habitat, including current status and trend of the species, and an evaluation of potential threats and conservation actions that may affect the species’ ability to persist. In the Introduction and Background section of this species report, we first describe the history of Federal regulatory actions related to the species’ status under the Act, and explain the process we have used to conduct this status review. In the Species Description chapter, we provide basic scientific background information about sage-grouse, including a description of the species, a basic overview of information related to taxonomy, and information about genetics. We also discuss the life history and ecology of sage-grouse, providing an overview of the basic biological needs and life history of the species. In this section, we discuss each life stage of sage-grouse, and describe lekking behavior and breeding, nesting, brood rearing, wintering, and movement patterns and migration corridors. The Current Biological Status chapter focuses on the best available information about the current status of the sage-grouse, including its historical and current range, distribution, and population status for each population of sage-grouse, organized by Management Zone. This section outlines what we know about the current condition of the species, particularly as it relates to the species’ needs discussed in the previous section.

The Potential Threats section provides detailed information about potential threats to the species, including agricultural conversion, renewable and non-renewable energy development, contaminants, fences, fire, invasives, conifer encroachment, infrastructure, exurban development, free-roaming equids, grazing and rangeland management, climate change, disease, drought, hunting, mining, pesticides, small population size, predation, and recreation. Each potential threat is discussed in a separate chapter, using Management Zones as a common spatial scale. For each potential threat, we describe the stressor, including its historical and current sources. Then we describe its current impacts on sage-grouse, including the mechanism by which it may affect the species, the results of the impact to sage-grouse persistence, and the timing, location and extent of the impact, and whether it has synergistic effects with other threats. Then we project the future impacts of each potential threat. We describe the timeframe for projecting the impact, the likelihood of future impacts, and whether the impacts are expected to change from their present level or scope. Finally, we describe any conservation efforts or management actions that are occurring that may ameliorate the potential threat, and their implementation and effectiveness. Each of these components feeds into an overall assessment of each potential threat to sage-grouse.

In the Cumulative Effects section, we summarize the threats, actions or measures in place to ameliorate the threats, and the overall species' status in each management zone. In the Cumulative and Compounding Threats chapter, we give a big picture assessment for each Management Zone of the combined impacts of all of the threats, considered collectively. In the Threat Amelioration chapter, we summarize activities that are reducing or ameliorating potential threats discussed in the previous section for each Management Zone. We also include a discussion of regulatory mechanisms that may address potential threats. This section provides a programmatic discussion of regulations and conservation efforts (their effectiveness at ameliorating individual threats is discussed under the appropriate threat chapter). We describe conservation measures, as well as relevant laws, regulations, policies, and management plans, including local land use laws; state laws; Federal laws implemented by the Bureau of Land Management, Forest Service, and other Federal agencies; and Canadian Federal and Provincial laws and regulations. In the Overall Summary of Species Status and Impacts chapter, we provide an overview of changes in the species' status that have occurred since the 2010 finding in each Management Zone. This section focuses on the key elements of the 2010 finding and any new important elements that have arisen since then, and discusses how those elements have changed over time, and the reason for those changes, if known. Finally, this chapter summarizes the main points of the analysis done in this species report and what they collectively mean for the overall biological status of the species as a whole.

Citations

U.S. Fish and Wildlife Service. 2013. Greater Sage-grouse (*Centrocercus urophasianus*) Conservation Objectives: Final Report. U.S. Fish and Wildlife Service, Denver, CO. February 2013.

Chapter 3: Species Description, Range, and Distribution

Greater Sage-grouse Species Description

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

Taxonomy

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

In 1957, prior to the Gunnison sage-grouse being described as a distinct species, the American Ornithologists' Union (AOU) recognized two subspecies of sage-grouse, the eastern sage-grouse (*Centrocercus urophasianus urophasianus*) and the western sage-grouse (C. u. phaios) (AOU 1957, p. 139). This subspecies

Comment [Craig8]: "…which includes grouse, turkeys, pehesants…"

Comment [Craig9]: "found in"

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Comment [Craig10]: ?

Comment [Craig11]: is

Comment [Craig12]: check citation formatting.

classification was based solely on differences in coloration (specifically, reduced white markings and darker feathering on western birds) among 11 museum specimens collected from 8 locations in Washington, Oregon and California (Aldrich 1946, p. 129).

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

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

Greater sage-grouse habitat–The sagebrush ecosystem

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

Comment [Craig13]: Missing ( ) check. Also FR citation page numbers.

Comment [Craig14]: Check this, the page number can go after the FR.

Comment [Craig15]: In 2010, this was a subsection of the taxonomy section needed to explain the genetic evidence for not recognizing the subspecies. It did not address small populations, barriers, or gene flow across the range.

Comment [KNorman16]: Craig, Jesse, reusing 2010 and DPS

Formatted: Highlight

Comment [DMD17]: I suggest updating this with the citation from SAB, which provides a summary of site fidelity (e.g., leks, females to nesting areas).

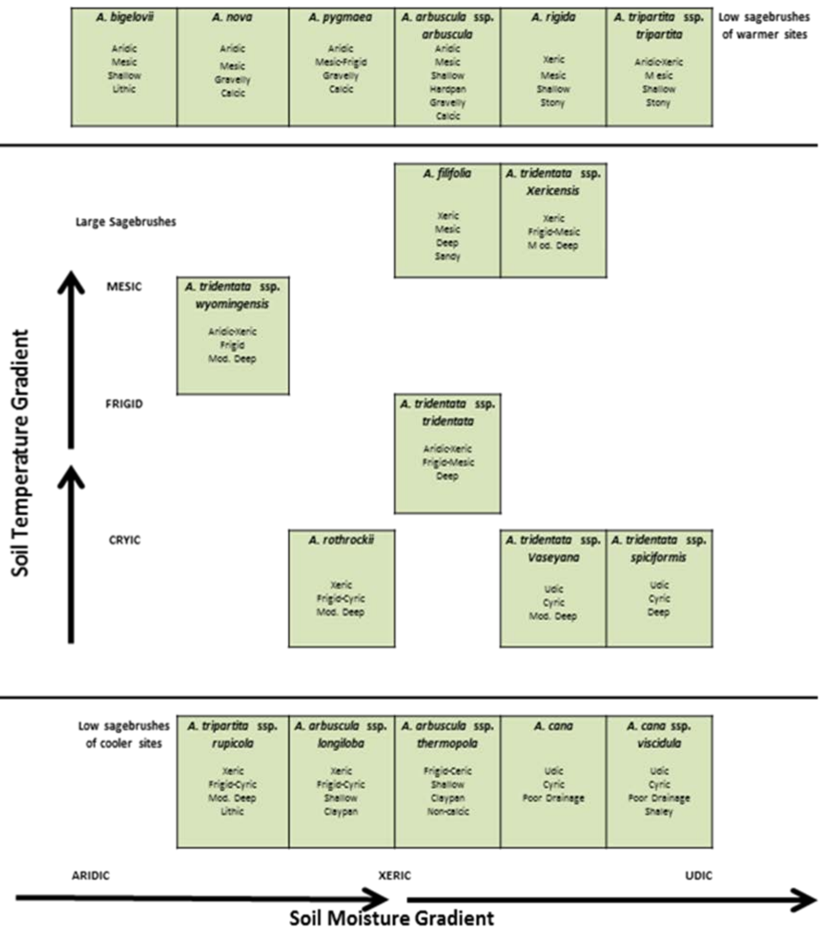


Figure 3-1. Ordination of major sagebrush taxa in the Intermountain Region against gradients of soil temperature and moisture (From Miller *et al.* 2011)

Comment [acn18]: I created this draft figure after Miller, I'm not married to it though. And will make better/prettier figure if we decide to keep.

Sage-grouse are dependent on large areas of contiguous sagebrush (Patterson 1952, p. 48; Connelly *et al.* 2004, p. 4-1; Connelly *et al.* 2011, pp. 82–83; Wisdom *et al.* 2011, p. 465), and large-scale characteristics within surrounding landscapes influence sage-grouse habitat selection (Knick and Hanser 2011, pp. 396–405). Sagebrush is the most widespread vegetation in the intermountain lowlands in the western United States (West and Young

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

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

Comment [LW 19]: Highlighting these could devalue the numerous other dozen(s) type of sagebrush and hybrids used by grouse.

All species of sagebrush produce large ephemeral leaves in the spring, which persist until reduced soil moisture occurs in the summer. Most species also produce smaller, over-wintering leaves in the late spring that last through summer and winter. Sagebrush have fibrous tap root systems, which allow the plants to draw surface soil moisture, and also to access water deep within the soil profile when surface water is limited (West and Young 2000, p. 259). Most sagebrush flower in the fall. However, during years of drought, or other moisture stress, flowering may not occur. Although seed viability and germination are high, seed dispersal is limited (citation?).

Additionally, , sagebrush seeds typically do not remain viable for more than one growing season and evidence suggests seed banks are transient (i.e., seeds persist in the soil less than one year); however, seeds have higher odds of persisting in the seed bank if they are buried (Wijayratne and Pyke 2012, p. 438). (West and Young 2000, p. 260).

Comment [DMD20]: Wijayratne, U. P., and D. A. Pyke.   2012. Burial increases seed longevity of two *Artemisia tridentata* (Asteraceae) subspecies. American Journal of Botany 99:438-447.

Sagebrush is long-lived, with plants of some species surviving up to 150 years (West 1983, p. 340). Sagebrush exhibit allelopathic effects, producing chemicals that reduce seed germination, seedling growth and root respiration of competing plant species and inhibit the activity of soil microbes and nitrogen fixation. Sagebrush has resistance to environmental extremes, with the exception of fire and occasionally defoliating insects (e.g., the webworm (Aroga spp.); West 1983, p. 341). Most species of sagebrush are killed by fire (Miller and Eddleman 2000, p. 17; West 1983, p. 341; West and Young 2000, p. 259), Depending on the species of sagebrush and other site-specific characteristics, fire return intervals from 10 to well over 300 years have been reported (McArthur 1994, p. 347; Peters and Bunting 1994, p. 33; Miller and Rose 1999, p. 556; Kilpatrick 2000, p. 1; Frost 1998, in Connelly *et al*. 2004, p. 7-4; Zouhar *et al*. 2008, p. 154; Baker 2011, pp. 190–197; Bukowski and Baker 2013, entire). In general, mean fire return intervals in low-lying, xeric, big sagebrush communities range from over 100 to 350 years, and return intervals decrease to 50 to over 200 years in more mesic areas, mountain sagebrush communities at higher elevations, during wetter climatic periods, and in locations associated with grasslands (Baker 2006, p. 181; Mensing *et al*. 2006, p. 75; Baker 2011, pp. 194-195; Miller *et al*. 2011, p. 166; Bukowski and Baker 2013, entire). Natural sagebrush re-colonization in burned areas depends on the presence of adjacent live plants for a seed source or on the seed bank, if present (Miller and Eddleman 2000, p. 17).

Comment [acn21]: I copied this directly from fire chapter.

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

Very little sagebrush within its extant range is undisturbed or unaltered from its condition prior to EuroAmerican settlement in the late 1800s (Knick *et al*. 2003, p. 612, and references therein). Due to the disruption of primary patterns, processes and components of sagebrush ecosystems since EuroAmerican settlement (Knick *et al*. 2003, p. 612; Miller *et al*. 2011, p. 147), the large range of abiotic variation, the minimal short-lived seed banks, and the long generation time of sagebrush, restoration of disturbed areas is very difficult. Not all areas previously dominated by sagebrush can be restored because alteration of vegetation, nutrient cycles, topsoil, and cryptobiotic soil crusts have exceeded recovery thresholds (Knick *et al*. 2003, p. 620). Additionally, processes to restore sagebrush ecology are relatively unknown (Knick *et al*. 2003, p.620). Active restoration activities are often limited by financial and logistic resources and lack of political motivation (Knick *et al*. 2003, p.620; Miller *et al*. 2011, p. 147) and may require decades or centuries (Knick *et al*. 2003, p.620, and references therein). Meaningful restoration for sage-grouse requires landscape, watershed, or eco-regional scale context rather than individual, unconnected efforts (Knick *et al*. 2003, p.623, and references therein; Wisdom *et al*. 2011, p. 469). Landscape restoration efforts require partnerships across multiple ownerships and jurisdictions in order to restore and maintain a connective network of intact vegetation (Knick *et al*. 2003, p. 623; Pyke 2011, p. 548; see discussion of landownership below). Except for areas where active restoration is attempted following disturbance (e.g., mining, wildfire), management efforts in sagebrush ecosystems are usually focused on maintenance (Miller *et al*. 2011, p. 183; Wisdom *et al*.2011, pp. 470, 472).

Comment [DMD22]: Also see Pyke 2011, p. 544 who found that rehabilitation and restoration efforts are also hindered by cost and the ability to procure the equipment and seed needed for projects.

Although sage-grouse require large, interconnected expanses of sagebrush with healthy, native understories (Patterson 1952; Connelly *et al*. 2004, pp. 4-15; Knick *et al*. 2003, p. 623; Connelly *et al*. 2011b, p. 80; Pyke 2011, p. 540; Wisdom *et al*. 2011, p. 461), there is little information available regarding minimum sagebrush patch sizes required to support populations of sage-grouse. This is due in part to the migratory nature of some, but not all sage-grouse populations, the lack of juxtaposition of seasonal habitats, and differences in local, regional and range-wide ecological conditions which influences the distribution of sagebrush and associated understories. Where home ranges have been reported (Connelly *et al*. 2011a, p. 60 and references therein) they are extremely variable (4 to 615 km2 range [1.5 to 237.5 mi2]). Occupancy of a home range is also based on multiple variables, associated with both local vegetation characteristics and landscape characteristics (Knick *et al.* 2003, p. 621). Pyke (2011, p. 540) estimated that a minimum of 4,000 ha (9,884 acres) was necessary for population sustainability. However, he did not indicate whether this value was for migratory or non-migratory populations, nor if this included juxtaposition of all seasonal habitats. Large seasonal and annual movements emphasize the landscape nature of the sage-grouse (Knick *et al.* 2003, p. 624; Connelly *et al.* 2011a, p. 60).

Comment [DMD23]: This estimate is not from Pyke, instead he cites Leonard et al (2000) who reports values for migratory sage-grouse populations in Idaho and Walker et al. (2007).

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

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

Seasonal Habitat Selection and Life History Characteristics

Sage-grouse are dependent of seasonal habitats for persistence..say something here about how critical each of these seasonal habitats are for sage-grouse persistence.

Breeding habitat

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

Comment [DMD24]: Bush et al. (2013) The secret lives of sage-grouse: multiple paternity and intraspecific nest parasitism revealed through genetic analysis. Behavioral Ecology 24:29-38.

Nesting habitat

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 miles) to 7.8 km (4.8 miles) in five studies examining 301 nest locations (Schroeder *et al*. 1999 p. 12). Other studies have reported the average lek-to-nest distance was larger for the lek of capture compared with the distance to the nearest lek (Petersen 1980, Wakkinen *et al*. 1992a, Fischer 1994, Schroeder *et al*. 1999, Herman-Brunson 2007). In northeastern California (Davis *et al*. 2014) the average distance between a female's nest and the nearest lek was 3.69 km ± 2.94 SD (n = 74) and ranged from 0.14 km to 14.10 km. These results are consistent with other studies conducted in peripheral populations (Aldridge and Brigham 2001, Herman-Brunson *et al*. 2009, Wiechman 2013),

Comment [LW 25]:
We can probably update that…
I'll look for a few citations.
AMY: yah, there was a recent presentation, can't remember who?? That had distances for success full nest, renest, ect,

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

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

Productive nesting areas are typically characterized by sagebrush with an understory of native grasses and forbs, with horizontal and vertical structural diversity that provides an insect prey base, herbaceous forage for pre-laying and nesting hens (Barnett and Crawford 1994, p. 116), and cover for the hen while she is incubating (Gregg 1991, p. 19; Schroeder *et al*. 1999, p. 4; Connelly *et al*. 2000a, p. 971; Connelly *et al*. 2004, pp.4-17, 18). Sage-grouse may also use other shrub or bunchgrass species for nest sites (Klebenow 1969, p. 649; Connelly *et al*. 2000a, p.970; Connelly *et al*. 2004, p. 4-4, Davis *et al*. 2014, p. 5). Shrub canopy and grass cover provide concealment for sage-grouse nests and young (Gregg *et al*. 1994, p. 164; DeLong *et al*.1995, p. 90; Connelly *et*

Comment [DMD26]: Davis et al. 2014. Demography, reproductive ecology, and variation in survival of greater sage-grouse in NE California. JWM DOI: 10.1002/jwmg.797

al. 2004, p. 4-4), and forb availability and abundance are critical for reproductive success (Barnett and Crawford 1994, p.116; Gregg *et al*. 2008, p. 539)). Published vegetation characteristics of successful nest sites included a sagebrush canopy cover of 15-25 percent, sagebrush heights of 30 – 80 cm (11.8 – 31.5 in), and grass/forb cover of 18 cm (7.1 in; Connelly *et al*. 2000a, p. 977).

Sage-grouse clutch size ranges from 6 to 9 eggs with an average of 7 eggs. (Connelly *et al*. 2011a, p.62). The likelihood of a female nesting in a given year averages 82 percent in the eastern portion of the range and 78 percent in the western portion of the range (Connelly *et al*. 2011a, p. 63). Adult females have higher nest initiation rates than yearling females (Connelly *et al*. 2011a, p. 58). Nest success (one or more eggs hatching from a nest), as reported in the scientific literature, varies widely (reported as 15 to 86 percent of initiated nests Schroeder *et al*. 1999, p. 11; 12 to 71 percent of initiated nests in Connelly *et al*. 2011a, p. 58). Overall, the average nest success for sage-grouse in non-altered habitats is 51 percent and for sage-grouse in altered habitats is 37 percent (Connelly *et al*. 2011a, p. 58). Re-nesting only occurs if the original nest is lost (Schroeder *et al*. 1999, p. 11). Sage-grouse re-nesting rates average 28.9 percent (based on 9 different studies) with a range from 5 to 41 percent (Connelly *et al*. 2004. p. 3-11). Other game bird species have much higher re-nesting rates, often exceeding 75 percent. The impact of re-nesting on annual productivity for most sage-grouse populations is unclear and thought to be limited (Crawford *et al*. 2004, p. 4). In north-central Washington State, re-nesting contributed to 38 percent of the annual productivity of that population (Schroeder 1997, p. 937). However, the author postulated that the re-nesting efforts in this population may be greater than anywhere else in the species' range because environmental conditions allow a longer period of time to successfully rear a clutch (Schroeder 1997, p. 939).

Little information is available on the level of productivity (number of chicks per hen that survive to fall) that is necessary to maintain a stable population (Connelly *et al*. 2000b, p. 970). However, Connelly *et al*. (2000b, p. 970, and references therein) suggest that 2.25 chicks per hen are necessary to maintain stable to increasing populations. Long-term productivity estimates of 1.40 to 2.96 chicks per hen across the species range have been reported (Connelly and Braun 1997, p. 20). Productivity declined slightly after 1985 to 1.21 to 2.19

Comment [DMD27]: Gregg et al. (2008) Temporal variation in diet and nutrition of preincubating greater sage-grouse. Rangeland Ecology and Management 61:535-542.

Comment [DMD28]: Also see the meta-analysis by Hagen et al. (2007).

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

Comment [LW 29]: We can update from SAB…

Comment [LW 30]: Update from SAB

Comment [acn31]: I think we have some new info here, but was transmitter surgically on chicks which really makes me question results, but should mention. Find paper..

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

chicks per hen (Connelly and Braun 1997, p. 20). A recent study assessing the population structure of sage-grouse based on the collection and analysis of over 67,000 wings from hunter harvested birds in Colorado and Oregon during 1973-1998 and 1993-2013 found the average number of juveniles in the harvest per female varied from 1.2 to 2.4 (Braun *et al*. 2015, p. 10). Despite average clutch sizes of 7 eggs (Connelly *et al*. 2011a, p.62) due to low chick survival and limited re-nesting, there is little evidence that populations of sage-grouse produce large annual surpluses (Connelly *et al*. 2011a, p. 67).

Comment [DMD32]: Braun et al. 2015. Fall population structure of sage-grouse in Colorado and Oregon. Wildlife Technical Report 005-2015.

Brood-rearing habitat

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

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

Comment [DMD33]: Early and late brood-rearing periods have typically been based on observations on habitat use by hens with 6-week-old broods (Martin 1970) and information from Peterson (1970), who found a dietary change in juvenile sage-grouse approximately 6 weeks after Hatching. But see Blomberg et al. 2013

Winter habitat

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

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

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

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

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

The distribution and abundance of suitable winter habitats is limited. In northern Colorado, only 6.8 percent of the area was intensively used by sage-grouse during the winter (Beck 1977, p. 20). In south-central Wyoming, only 7-18 percent of a 4,328 km2 study area was identified as having characteristics suitable for severe winter habitat (Dzialak *et al*. 2013, p. 10). Similarly, winter habitat was limited in northwest Colorado and south-central Wyoming, representing only 17.1 percent of the 6,093 km2 study area (Smith *et al*. 2014, p. 12) In south central Montana, the numbers of males counted on leks declined by 73 percent following a 30 percent loss of winter habitat to cropland conversion (Swenson *et al*. 1987, p. 128). This significant decline happened despite the fact that 84 percent of the total area remained unploughed sagebrush-steppe (Swenson *et al*. 1987, p. 128).

Comment [DMD34]: Smith et al. 2014. Prioritizing winter habitat quality for greater sage-grouse in a landscape influenced by energy development. Ecosphere 5:15. http://dx.doi.org/10.1890/ES13-00238.

The above information highlights the importance of winter habitats to sage-grouse persistence. Clearly loss of these essential winter habitats can have impacts disproportionate to their makeup on the landscape

(Swenson *et al.* 1987, p. 128). Winter habitat can be even more limited during severe winters when heavy snow fall further decreases or even eliminates access to sagebrush (as a consequence of increasing snow depth). During such times birds become even more concentrated in the few remaining areas of exposed sagebrush critical for shelter and foraging (Beck 1977, p. 24; Hupp and Braun 1987, p. 828). Thus, areas critical to survival during winters with heavy snowfall, may not be the same areas the birds regularly occupy during an average winter (Caudill *et al.* 2013, p. 256).

Migratory Corridors

Many populations of sage-grouse migrate between seasonal ranges in response to habitat distribution (Connelly *et al.* 2004, p. 3-5). Migration can occur between winter and breeding/summer areas, between breeding, summer and winter areas, or not at all. Migration distances of up to 161 kilometers (km) (100 mi) have been recorded (Patterson 1952, p.189); however, distances vary depending on the locations of seasonal habitats (Schroeder *et al.* 1999, p. 3). Migration distances for female sage-grouse generally are less than for males (Connelly *et al.* 2004, p. 3-4), but in one study in Colorado, females travelled further than males (Braun and Beck, 1976). Almost no information is available regarding the distribution and characteristics of migration corridors for sage-grouse (Connelly *et al.* 2004, p. 4-19). Sage-grouse dispersal (permanent moves to other areas) is poorly understood (Connelly *et al.* 2004, p. 3-5) and appears to be sporadic (Dunn and Braun 1986, p. 89). Despite the documentation of extensive seasonal movements in this species (Fedy *et al.* 2012, p. 1066; Tack *et al.* 2012, p. 65; Davis *et al.* 2014, pp. 5–7), the dispersal abilities of sage-grouse are assumed to be low (e.g., median natal dispersal distance = 8.8 km for females versus 7.4 km for males [Dunn and Braun 1985, p. 622] and 3.8 ± 1.3 km and 2.7 ± 0.3 km, for males and females, respectively [Thompson 2012, p. 193]). 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 - 615 km2 (1.5 – 237.5 mi2; Connelly *et al.* 2011a, p.60).

Historical and Current Range

Comment [LW 35]: Add in description of: nonmigratory, 1-stage, and 2-stage migratory individuals as well as that multiple can be present in any one population.

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

Comment [acn36]: Note for later, we can't use special characters in FR docs, so I was trying to keep them out of report also (to facilitate future cut and paste into FR doc)

Comment [DMD37]: Previous investigations describing space use by sage-grouse have been constrained by highly variable seasonal movement patterns within and among populations, limited sample size, variation in the duration of the study, and variation in methods of home range estimation (e.g., Hagen 1999, Leonard et al. 2000, Hausleitner 2003, Fedy et al. 2012). Moreover, the extensive movements between seasonal ranges and highly clustered distributions of sage-grouse (Hagen et al. 2001) have made estimating home range size and comparisons between studies difficult.

Range and Distribution of Sage-Grouse and Sagebrush

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

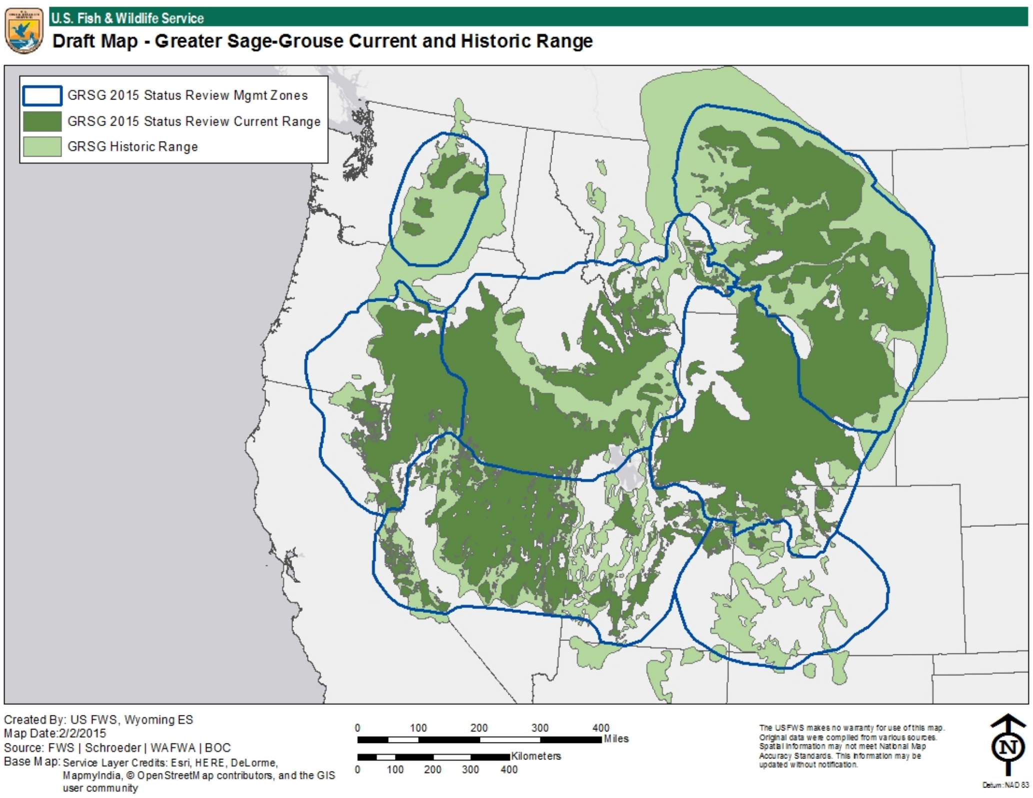


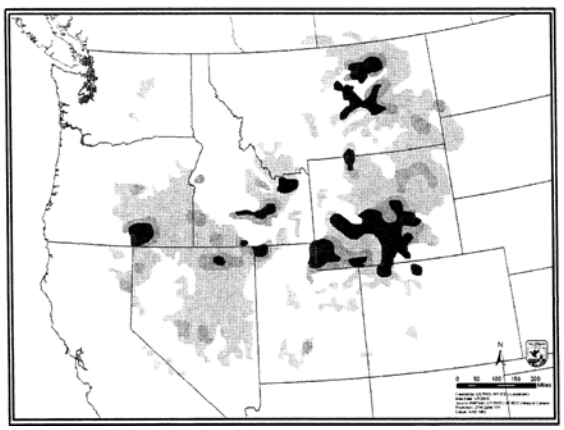
Figure 3-2. Placeholder DRAFT Map

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

Comment [acn38]: Use jim's numbers?? Of occupied habitat?

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

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



PLACEHOLDER: Get new density layer from Kevin

Sagebrush occurs in two natural vegetation types that are delineated by temperature and patterns of precipitation (Miller *et al*. in press, p. 7). Sagebrush steppe ranges across the northern portion of sage-grouse range, from British Columbia and the Columbia Basin, through the northern Great Basin, Snake River Plain, and Montana, and into the Wyoming Basin and northern Colorado. Great Basin sagebrush occurs south of sagebrush steppe, and extends from the Colorado Plateau westward into Nevada, Utah, and California (Miller *et al*. in press, p. 7). Other sagebrush types within greater sage-grouse range include mixed-desert shrubland in the Bighorn

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

Comment [acn39]: Revise using new guidance for plants.

Current Range Distribution-PLACEHOLDER

Annual Lek Counts/Surveys-PLACEHOLDER

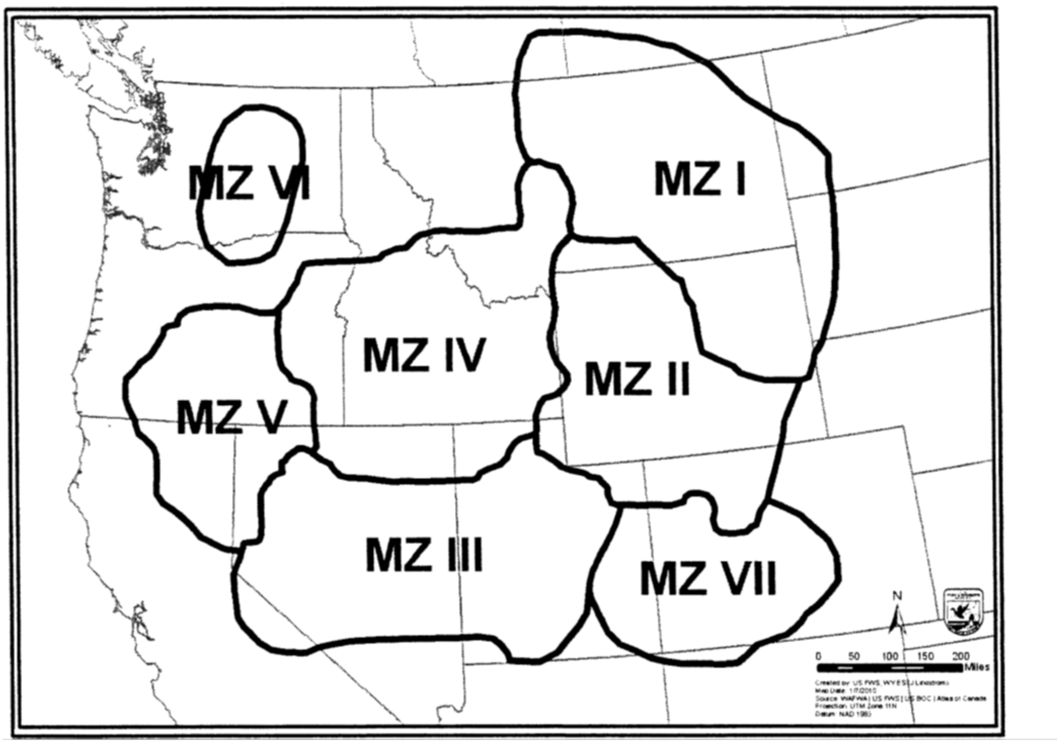
Management Zone Discussion/Description

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

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

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

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



PLACEHOLDER MAP—NEED NEW MAP FROM JIM

PLACEHOLDER FOR FIGURES BELOW AS PER REVISED OUTLINE

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

[Figure – PACs map]

[Figure – Strongholds map]

[Figure - Distribution models by MZ]

[Table - Numbers from Distribution models by MZ]

[Figure – Abundance models by MZ]

[Table - Numbers from Abundance models by MZ]

Chapter 4: Land Ownership and Management – PLACEHOLDER (Jesse D'Elia) -

Summary (2-3 pages) of Ownership, and types of decisions and management actions (regulatory mechanisms) that are associated with each agency/owner

  - [Figure - Land Ownership status by MZ]
  - [Table – Land Ownership status by MZ]

- Federal Plans
  - USFS/BLM
    - LUP Amendments / Planning efforts
      - Disturbance Monitoring
      - Adaptive Management
      - Mitigation
      - FIAT
  - FWS/Refuges
  - NPS
  - DOD/DOE
- Tribal Lands and Plans
- State Plans
- Private Lands
  - FWS CCAA
  - NRCS SGI

IMPACTS ANALYSIS

Habitat Loss and Fragmentation

Chapter 5: Wildfire (Altered Fire Regime)

Introduction

Fire is the principle natural disturbance in the sagebrush (Artemisia spp.) ecosystem, causing loss and fragmentation of these habitats. Most varieties of sagebrush that greater sage-grouse (*Centrocercus urophasianus*; hereafter sage-grouse) depend upon are typically killed by fire and take decades to recover (Young and Evans 1989, p. 204; Maier *et al*. 2001, p. 701; Ziegenhagen and Miller 2009, p. 201; Baker 2011, pp. 189–196). Although fire is a natural disturbance process in sagebrush ecosystems, the introduction of invasive annual grasses has altered the fire return interval, particularly in the drier portions of the Great Basin and Columbia Basin (MZs III, IV, V, and VI) and can effectively prevent sagebrush recovery after burning (Miller *et al*. 2011, pp. 179–184). In these areas fire has been identified as a primary factor associated with sage-grouse population declines (Hulet 1983, in Connelly *et al*. 2001, p. 973; Connelly and Braun 1997, p. 232; Connelly *et al*. 2000a, p. 973; Connelly *et al*. 2000c, p. 93; Miller and Eddlemen 2000, p. 24; Johnson *et al*. 2011, pp. 424–425; Knick and Hanser 2011, pp. 395, 399–403). Furthermore, climate change (see Climate Change Chapter) interacts with the dual stressors of wildfire and invasive species to compound and increase the severity of impacts to sage-grouse from the stressor of fire (see Compounded Effects Chapter).

Our knowledge of wildfire as an ecological process and how it affects sage-grouse has not changed significantly since our 2010 warranted but precluded finding. On the other hand, updates to wildfire management strategies and planning tools have occurred. A new National Strategy solidified local guidance to consider sage-grouse habitat as part of fire management. Fuel treatments in sage-grouse habitats are prioritized over treatments in other areas (Murphy *et al*. 2013, p. 4). Additionally, protocols have been developed to ensure that plans are current and include guidance for fire management in relation to sage-grouse and sage-grouse habitats. These changes have affected what areas are prioritized for fire-fighting resources during periods of fire activity (Murphy *et al.* 2013, p. 4).

Between 2006 and 2014, wildfire response has been able to extinguish 97 percent of all fires occurring in sage-grouse habitat in initial attack. In other words, most fires that start in sage-grouse habitat are extinguished before they exceed 404.7 hectares (ha) (1,000 acres (ac)) (Havlina *et al.* 2014, pp. 2–4). Furthermore, another 2 percent of wildfires are stopped prior to exceeding 4046.9 ha (10,000 ac) in size. Federal, State, and local fire personnel work together to manage wildfire and they continue to work to improve coordination. Wildfire management staff has access to predictive services and is relying more on geospatial layers (including sage-grouse habitat) to predict fire spread and to analyze where to place resources, suppression strategies, and other potential scenarios. Additionally, a recent report provides an analysis of the resistance to disturbance and resilience to invasive annual grasses in sagebrush ecosystems and provides guidance for conducting fuels management, fire rehabilitation, and restoration treatments. However, approximately 3 percent of wildfires do escape initial attack. These fires affect significant acreages within the range of sage-grouse (3,768,918 ha (9,313,199 ac) escaped initial attack between 2000 and 2014)) (Service 2015x, p. 1). These escaped fires accounted for 85 percent of fires within the current range of sage-grouse and thus have a negative impact on sage-grouse individuals and populations (Service 2015y, p. 1).

Comment [GS40]: GIS info – 2 spreadsheets, maps

Threat description

Historical source(s)

Historically, humans and lightning strikes caused fires throughout the range of sage-grouse. In the arid west, European explorers documented American Indian use of fire to manipulate the landscape as early as the 1500s (Williams 2004, p. 10). These human-caused fires were not ubiquitous across the West (Griffin 2002, pp. 84–85; Barrett *et al.* 2005, p. 33). American Indians inhabited the Great Basin at relatively low levels and typically moved seasonally (Griffin 2002, pp. 81–82). Some areas would have been burned regularly, such as well-traveled valleys in the Northern Rockies (Barrett and Arno 1982, 1999 in Barrett *et al.* 2005, p. 32) and the prairies and low hills of the arid West (Williams 2004, p. 12). Historic accounts suggest that fires set by American Indians occurred primarily in grasslands and adjacent dry forests (Barrett *et al*. 2005, pp. 32–33). Lightning ignitions were the primary source of fires in the West prior to European settlement (Barrett *et al*. 2005, pp. 32–33).

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

Mean fire return interval, or the average number of years between two successive fires, is difficult to quantify in large sagebrush expanses. Because fire kills most sagebrush species, they do not record evidence of prior burns (i.e., fire scars) as do forested systems (Bukowski and Baker 2013, p. 547). As a result, a clear picture of the complex spatial and temporal pattern of historical fire regimes in most sagebrush communities is not available. Widely variable estimates of historical fire return intervals have been described in the literature. Depending on the species of sagebrush and other site-specific characteristics, fire return intervals from 10 to well over 300 years have been reported for sagebrush habitat (McArthur 1994, p. 347; Peters and Bunting 1994, p. 33; Miller and Rose 1999, p. 556; Kilpatrick 2000, p. 1; Frost 1998, in Connelly *et al*. 2004, p. 7-4; Zouhar *et al*.

2008, p. 154; Baker 2011, pp. 190–197; Bukowski and Baker 2013, entire). In general, mean fire return intervals in low-lying, xeric, Wyoming big sagebrush communities range from over 100 to 350 years, and return intervals decrease to 50 to over 200 years in more mesic areas, mountain big sagebrush (Artemisia tridentata ssp. vaseyana) communities at higher elevations, during wetter climatic periods, and in locations associated with grasslands (Baker 2006, p. 181; Mensing *et al*. 2006, p. 75; Baker 2011, pp. 194-195; Miller *et al*. 2011, p. 166; Bukowski and Baker 2013, entire).

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

Current source(s)

Current fire regimes were impacted by the influx of Euro-Americans to the western US, in the mid- to late 1800s, who caused significant changes to the vegetation composition and structure of the sagebrush ecosystem (Chambers *et al*. 2014, p. 3). Inappropriate grazing practices (timing, duration, and/or intensity) led to a decrease in native perennial grasses and forbs, reducing the abundance of fine fuels (Knapp 1996 in Chambers *et al*. 2014, p. 3; Miller and Eddleman 2001, p. 17; Miller *et al*. 2011, p. 181). This decreased competition from native perennials, in combination with climatic fluctuations favorable to tree regeneration (i.e. increased water use efficiency associated with carbon dioxide fertilization), and recovery from past disturbance resulted in an increased abundance of shrubs and trees at mid to high elevations (i.e., more mesic mountain big sagebrush communities), including juniper (Juniperus occidentalis, J. osteosperma) and piñon pine (Pinus monophylla) (Baker 2011, pp. 197–199; Miller *et al*. 2011, pp. 168–169; Chambers *et al*. 2014, p. 3). The change in vegetation and fuel structures initially caused a reduction in fire frequency and size (Chambers *et al*. 2014, p. 3). Others researchers cite the practice of fire suppression as a cause of conifer encroachment (Miller *et al*. 2011, p. 167; Davies *et al*. 2011, p. 2574). However, extensive stands of mature sagebrush were evident during settlement times despite historical fire rotation being sufficiently long to allow for conifer encroachment into these sagebrush stands (Vale 1975, p. 33; Baker 2011, p. 199; Bukowski and Baker 2013, p. 560). Comparing GLO survey data of areas of woodlands interspersed with sagebrush to current vegetation data does not show a consistent pattern of expansion to woodlands (Bukowski and Baker 2013, p. 560). This suggests that causes other than active fire suppression must largely explain recent conifer encroachments into sagebrush ecosystems (Baker 2011, p. 199; Bukowski and Baker 2013, pp. 560–561). It is likely that all of the factors discussed above played a part in the dramatic expansion of conifer woodlands over the last century. Regardless of the cause, this encroachment of conifers into sagebrush is continuing and is resulting in the loss and fragmentation of sagebrush habitats (see discussion in the Conifer Chapter).

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

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

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

In addition to wildfires occurring in sagebrush habitat throughout the range of sage-grouse, land managers use prescribed fire to obtain desired management objectives for a variety of wildlife species and domestic livestock. While the efficacy of such treatments in sagebrush habitats to enhance sage-grouse populations has been questioned (Peterson 1970, p. 154; Swensen *et al*. 1987, p. 128; Connelly *et al*. 2000c, p. 94; Nelle *et al*. 2000, p. 590; WAFWA 2009, p. 12; Connelly *et al*. 2011c, p. 552), as with wildfire, an immediate and potentially long-term result is the loss and possible fragmentation of sage-grouse habitat (Beck *et al*. 2009, p. 400). However, prescribed fire treatments reduce fire risk in the presence of housing developments or intact expanses of sagebrush habitat and in these instances, benefits may be realized. There remains the potential for future use of prescribed fire (or other methods of sagebrush treatment) as all management agencies retain this tool.

In upland Wyoming big sagebrush communities, fire is used as a tool to break-up fuel continuity and prevent large fires in otherwise undisturbed habitat. This method may offer utility, but in areas with limited sagebrush habitat or sites that are exposed to invasive annuals, the negative aspects of this approach outweigh the positive (Baker 2011, p. 201). Fire treatment to thin or reduce sagebrush, with its potential negative effects, would not be as beneficial to the species as efforts made to expand areas of contiguous sagebrush. Likewise, using fire to remove trees in sagebrush habitats is likely not appropriate based on the historical presence of pinyon-juniper in these communities, the possibility of invasive species establishing after a fire, and mechanical means of removal being available. Pinyon-juniper abundance likely fluctuated over time in response to fire and other environmental conditions, at times occupying approximately 20 percent of the sagebrush landscape historically (Baker 2013, p. 8).

Between 1997 and 2006, more than 370,000 ha (914,000 ac) of public lands were treated with prescribed fire to address management objectives for many different species, mostly in Oregon and Idaho, and an additional 124,200 ha (306,900 ac) were treated with mechanical means over this same time period, primarily in Utah and Nevada (Knick *et al*. 2011, pp. 224–228). However, these acreages represent all habitat types and thus overestimate negative impacts to sage-grouse and sagebrush ecosystems. Quantifying the amount of sagebrush-specific habitat treatments is difficult as centralized reporting by Federal agencies is not typically categorized by habitat. However, agencies under the Department of the Interior (DOI) report species of special interest, including sage-grouse, which may occur in proximity to a prescribed treatment. Between 2003 and 2008, approximately 133,500 ha (330,000 ac) of sage-grouse habitat have been burned by land managers within the DOI, that is approximately 22,000 ha (55,000 ac) annually. In 2012, the BLM treated 12,706 ha (31,398 ac) with prescribed fire. In 2013, they reported 2,348 ha (5,803 ac) treated with prescribed fire for sage-grouse fuels treatments and 9,784 ha (24,177 ac) in 2014 (Havlina *et al*. 2014, p. 22). The BLM lands burned in 2014 were predominately in Oregon and Montana (Havlina *et al*. 2014, p. 22). These acreages do not reflect lands burned by agencies under the USDA (e.g., USFS). Although much of the land under USFS jurisdiction lies outside sage-grouse range, the USFS 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.

Comment [KNorman41]: If this is a relatively minor issue compared to wildfire, could we condense this section a bit?

GS – I feel that it is important enough to call out, but will leave the decision for the SpLeads April Team.

In the CED, there were projects that burned P-J (no details on amount of P-J burned or other site characteristics) and projects that mowed or otherwise took out sagebrush.

Current impacts

Mechanism

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

Nelle *et al*. (2000, p. 586) and Beck *et al*. (2009, p. 400) reported loss of nesting habitat from fire, creating a long-term negative impact that will likely require decades before sufficient canopy cover becomes available for nesting sage-grouse in Wyoming big sagebrush ecosystems. Additionally, the subsequent invasion by nonnative annual grasses in more xeric ecosystems has negatively affected some sage-grouse populations through degradation and loss of habitat (Connelly *et al*. 2000c, p. 93). These negative effects in these Wyoming big sagebrush ecosystems are likely to persist long-term because of the increased fire frequency associated with annual grass invasion. Fire can also alter the annual and perennial vegetation and invertebrate communities of the sagebrush ecosystems, both of which can affect sage-grouse as they serve as food sources. Furthermore, some highly disturbed xeric ecosystems can become monocultures of nonnative invasive annual grasses where recovery potential of the site is low due to low precipitation and warm soil temperatures (Chambers *et al*. 2014, p. 73). In these monocultures, fire potential is higher and further degradation of the site is possible.

Results of impact

Wildfire is associated with sage-grouse population declines across the West (Connelly and Braun 1997, p. 232; Connelly *et al*. 2000a, p. 973; Connelly *et al*. 2000c, p. 93; Miller and Eddlemen 2000, p. 24; Johnson *et al*. 2011, p. 424; Knick and Hanser 2011, p. 395). 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; Doherty *et al*. 2008, p. 191; Johnson *et al*. 2011, p. 424; Knick and Hanser 2011, pp. 403–404; Wisdom *et al*. 2011, p. 461).

Most sagebrush species are killed by fire and require decades to recover. Prior to recovery, burnt areas of sagebrush in xeric Wyoming big sagebrush ecosystems 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. 590; Beck *et al*. 2009, p. 9). An individual burnt area may seem inconsequential in relation to the wide range of sage-grouse, but the cumulative effects of fires and other factors that degrade the sagebrush ecosystem can have detrimental consequences to individual sage-grouse and sage-grouse populations.

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

Throughout the breeding season, herbaceous understory vegetation plays a critical role as a source of forage and cover for sage-grouse females and chicks. The response of herbaceous understory vegetation to fire varies with differences in species composition, pre-burn site condition, fire intensity, and pre- and post-fire patterns of precipitation. The few studies that have suggested fire may be beneficial for sage-grouse were primarily conducted in mesic areas used for brood-rearing (Klebenow 1970, p. 399; Pyle and Crawford 1996, p. 323; Gates 1983, in Connelly *et al*. 2000c, p. 90; Sime 1991, in Connelly *et al*. 2000a, p. 972). In mountain big sagebrush communities, Davis and Crawford (2014, pp. 3–6) found that forbs did increase in years 2 to 3 post-burn.

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

In general, any short-term flush of understory perennial grasses and forbs within burned sites is essentially lost after only a few years (Cook *et al*. 1994, p. 298; Fischer *et al*. 1996, p. 196; Crawford 1999, p. 7; Wrobleski 1999, p. 31; Nelle *et al*. 2000, 588; Paysen *et al*. 2000, p. 154; Wambolt *et al*. 2001, p. 250). Any short-term benefits gained by releasing understory vegetation from competition with a shrub overstory to produce additional food sources are negated by the loss of overstory sagebrush structure essential to sage-grouse life-history needs. For example, prescribed fires in mountain big sagebrush 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). Small fires may maintain a suitable habitat mosaic by reducing shrub encroachment and encouraging understory growth. However, without nearby sagebrush cover, the utility of these sites is questionable (Woodward 2006, p. 65; Nelle *et al*. 2009, p. 590). Slater (2003, p. 63) reported that sage-grouse using burned areas were rarely found more than 60 m (200 ft) from the edge of the burn and may preferentially use the burned and unburned edge habitat. Additionally, Byrne (2002, p. 27) reported avoidance of burned sagebrush habitat by nesting, brood-rearing, and broodless females. Disturbances, such as fire, that remove sagebrush extent and limit habitat availability (cover and forage) appear to strongly influence the probability of local sage-grouse population persistence (Beck *et al*. 2012, p. 452).

In addition to altering plant community structure, fires can influence invertebrate food sources (Schroeder *et al*. 1999, p. 5). Ants (Hymenoptera), grasshoppers (Orthoptera), and beetles (Coleoptera) are an essential component of juvenile sage-grouse diets, especially in the first 3 weeks of life (Johnson and Boyce 1991, p. 90). The effect of fire on insect populations likely varies due to a host of environmental factors. Because few studies have been conducted and the results of those available vary, the specific magnitude and duration of the effects of fire on insect communities is still uncertain, as is the effect any changes may have on sage-grouse populations.

Davis and Crawford (2014) reported that the abundance of arthropods did not decline following wildfire in mountain big sagebrush communities. Additionally, Pyle (1992, p. 14) reported no apparent effect to beetles from prescribed burning in mountain big sagebrush communities. Conversely, Nelle *et al*. (2000, p. 589) reported the abundance of beetles and ants was significantly greater 1 year after a burn in mountain big sagebrush, but returned to pre-burn levels by years 3 to 5. Overall, these researchers found no long-term effect of fire on invertebrate abundance (Nelle *et al*. 2000, pp. 589–590). However in Wyoming big sagebrush ecosystems, Fischer *et al*. (1996, p. 197) found that the abundance of insects was significantly lower 2 to 3 years post-burn. Also, Connelly *et al*. (2000c, p. 90) found that insect populations declined on prescribed burns in Wyoming big sagebrush ecosystems.

Timing

Fire danger is highest June to September with parts of the range having a heightened fire danger March to November within the range of the sage-grouse, (NIFC 2015b, entire); although fire, both natural and anthropogenic, can occur at any time throughout the year. Fire seasons vary greatly year to year and strongly reflect trends in weather patterns. Large fires typically occur where fuels are continuous, winds are strong, topography is level or rolling, and natural firebreaks are rare or lacking (Baker 2011, p. 197). Large fires frequently occur the year after cool, wet years, likely because cool, wet years increase fine-fuel production. Weather conditions in the fire year appear less important (Baker 2011, p. 197 and references therein).

Location and extent

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

The USGS analyzed data from the National Interagency Fire Center (NIFC) on fires within designated sage-grouse habitat (Preliminary Priority Habitat (PPH) and Preliminary General Habitat (PGH)) from 2000 through 2012. Fires occurring during this time frame and within the range of sage-grouse, disproportionately affected the Great Basin region (MZ III, IV, and V; data from MZ VI was not included)) and will likely influence the persistence of sage-grouse populations in this region. From 2000 through 2012,, 14.2 percent of PPH and 17.1 percent of PGH burned in the Snake River Plain (MZ IV). Within the Northern Great Basin (MZ V), 17.5 percent of PPH and 5.8 percent of PGH burned. For the Southern Great Basin (MZ III), 1.8 percent of PPH and 5.8 percent of PGH burned (Manier *et al.* 2013).

According to another review, range fires destroyed 30 to 40 percent of sage-grouse habitat in southern Idaho (MZ IV) in a 5-year period (1997 to 2001) (Healy 2001, p. 3). 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 (Healy 2001, p. 3). 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 through 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 invasion by nonnative annual grasses.

More recently, from 2009 through 2013 in Nevada, 326,675 ha (807,232 ac) of sage-grouse habitat have been affected by wildfire. Of the acres burned in the most important sage-grouse habitats in Nevada, about 27 percent have burned at elevations below 1,798 m (5,900 ft) (NDOW 2014b, p. 6). In general, areas at these elevations in Nevada are more likely to be of low resistance and resilience and therefore, more likely to be invaded by nonnative annuals and other weeds and be more challenging to restore to functional sagebrush ecosystem (NDOW 2014b, p. 6; Chambers *et al*. 2014, entire).

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

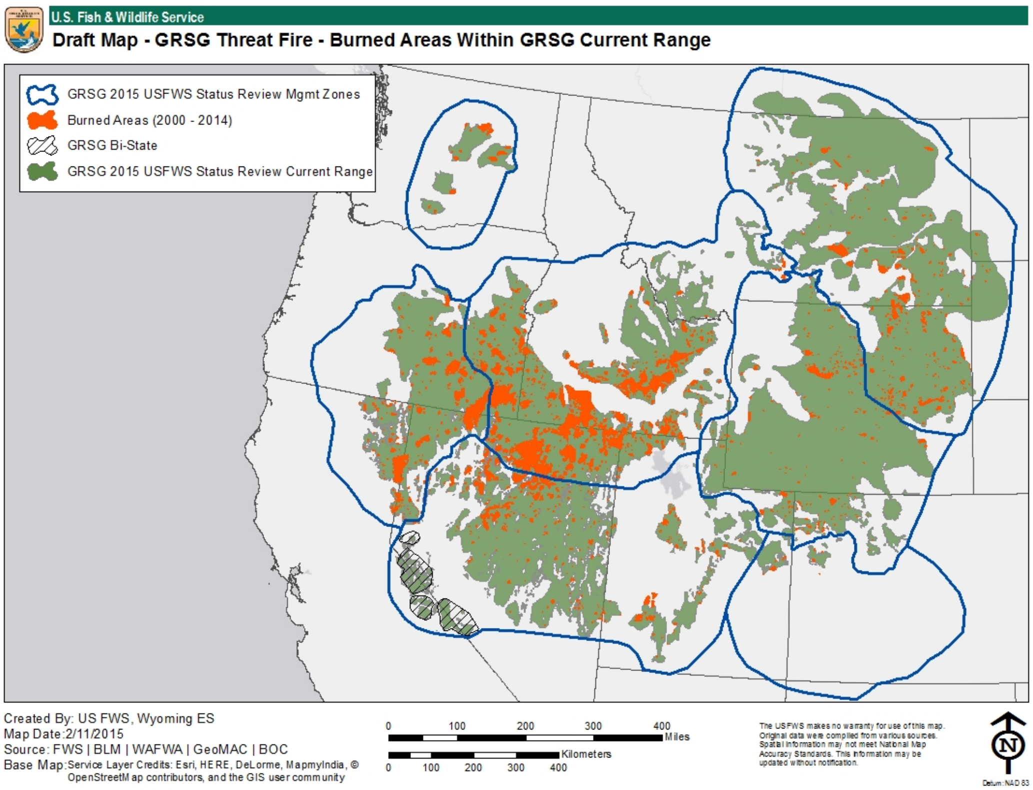


Figure 5-1: Fire Threat, Areas directly impacted by fires occurring between 2000 and 2014 within the current sage-grouse range

Table X-5-1: Impacts by Management Zone

Comment [GS42]: Commenter stated that impacts by MZ was not clear – continuing to work on updating from GIS information.

Management Zone	Timing of Impacts	Immediacy of Impacts	Severity of Impacts	Extent of Impacts	Resource or Life stage impacted
1	March	Imminent	Low	Low	Lekking/Nestin

Management Zone	Timing of Impacts	Immediacy of Impacts	Severity of Impacts	Extent of Impacts	Resource or Life stage impacted
					g
	April	Imminent	Low	Low	Lekking/Nesting
	May	Imminent	Low	Low	Nesting/Brood-rearing
	June	Imminent	Moderate	Low	Brood-rearing
	July	Imminent	Moderate	Moderate	Brood-rearing
	August	Imminent	Moderate	Moderate	Late Brood-rearing
	September	Imminent	Low	Low	Late Brood-rearing

Management Zone	Timing of Impacts	Immediacy of Impacts	Severity of Impacts	Extent of Impacts	Resource or Life stage impacted
	October	Imminent	Low	Low	Wintering
2	May	Imminent	Low	Low	Nesting/Brood-rearing
	June	Imminent	Moderate	Low	Brood-rearing
	July	Imminent	Moderate	Moderate	Brood-rearing
	August	Imminent	Moderate	Moderate	Late Brood-rearing
	September	Imminent	Low	Low	Late Brood-rearing
3	March	Imminent	Low	Low	Lekking/Nesting

Management Zone	Timing of Impacts	Immediacy of Impacts	Severity of Impacts	Extent of Impacts	Resource or Life stage impacted
	April	Imminent	Moderate	Low	Lekking/Nesting
	May	Imminent	High	Low	Nesting/Brood-rearing
	June	Imminent	Moderate	Moderate	Brood-rearing
	July	Imminent	High	High	Brood-rearing
	August	Imminent	High	High	Late Brood-rearing
	September	Imminent	Moderate	Moderate	Late Brood-rearing
	October	Imminent	Moderate	Low	Wintering

Management Zone	Timing of Impacts	Immediacy of Impacts	Severity of Impacts	Extent of Impacts	Resource or Life stage impacted
	November	Imminent	Low	Low	Wintering
4	June	Imminent	Low	Low	Brood-rearing
	July	Imminent	Moderate	High	Brood-rearing
	August	Imminent	High	High	Late Brood-rearing
	September	Imminent	Moderate	Moderate	Late Brood-rearing
	October	Imminent	Low	Low	Wintering
5	March	Imminent	Low	Low	Lekking/Nesting
	April	Imminent	Moderate	Low	Lekking/Nestin

Management Zone	Timing of Impacts	Immediacy of Impacts	Severity of Impacts	Extent of Impacts	Resource or Life stage impacted
					g
	May	Imminent	High	Moderate	Nesting/Brood-rearing
	June	Imminent	High	Moderate	Brood-rearing
	July	Imminent	High	High	Brood-rearing
	August	Imminent	High	High	Late Brood-rearing
	September	Imminent	High	Moderate	Late Brood-rearing
	October	Imminent	High	Moderate	Wintering

Management Zone	Timing of Impacts	Immediacy of Impacts	Severity of Impacts	Extent of Impacts	Resource or Life stage impacted
	November	Imminent	Low	Low	Wintering
6	April	Imminent	Low	Low	Lekking/Nesting
	May	Imminent	Low	Low	Nesting/Brood-rearing
	June	Imminent	Low	Moderate	Brood-rearing
	July	Imminent	Moderate	High	Brood-rearing
	August	Imminent	High	High	Late Brood-rearing
	September	Imminent	Moderate	High	Late Brood-rearing

Management Zone	Timing of Impacts	Immediacy of Impacts	Severity of Impacts	Extent of Impacts	Resource or Life stage impacted
	October	Imminent	Low	Moderate	Wintering
7	April	Imminent	Low	Low	Lekking/Nesting
	May	Imminent	Low	Moderate	Nesting/Brood-rearing
	June	Imminent	Moderate	High	Brood-rearing
	July	Imminent	High	High	Brood-rearing
	August	Imminent	Moderate	High	Late Brood-rearing
	September	Imminent	Low	Moderate	Late Brood-rearing

Compounded effects

The compounding effects will be discussed in further in the Compound Effects Chapter. In brief, the following impacts are likely to interact with the stressor described in this chapter.

- Inappropriate grazing can lead to invasions of nonnative annual grasses in Wyoming big sagebrush communities and conifer encroachment in mountain big sagebrush communities;
- Increase in invasive annual grasses leads to increased fire frequency, which can lead to further increases in invasive annual grasses causing an even greater increase in fire severity, which can lead to overall degraded site conditions (soil, biotic crusts, nutrient availability);
- Increase in invasive annual grasses and conifers into sagebrush communities causes fragmentation and loss of sage-grouse habitat;
- Conifer encroachment into sagebrush ecosystems can decrease the fire frequency, but also increase the fire severity, if a fire does occur;
- Drought can increase fire probability as it can lead to an increase in readily burnable (dry/low moisture) fuel;
- Climate change can cause drought, but it can also change the frequency and severity of precipitation events. A higher than normal precipitation can increase the vegetation production, which will subsequently dry out and be available as burnable fuel;
- Infrastructure; wind and solar; oil and gas; mining; ex-urban development; recreation; hunting; etc. can all increase the amount of vehicles and human-caused fires. Oil and gas activities and mining can have explosions or flammable contaminant spills.

Of 8,028 fires that burned from 2005 through 2014 in priority and general sage-grouse habitats, 72 percent (5,760) were lightning caused and 28 percent (2,268) were human caused. The most common human-caused fire starts were from powerlines, vehicles, and equipment use (e.g., welding, cutting torches, chainsaws). These were followed by fires caused by railroads, warming/cooking fires, agricultural/debris burning, and fireworks (Havlina *et al*. 2014, pp. 2, 23).

Contaminants/pesticides/herbicides – flammable contaminant spills.

Fire is one of the primary factors linked to population declines of sage-grouse because of long-term loss of sagebrush and conversion to invasive annual grasses. Loss of sagebrush habitat to wildfire has been increasing in the Great Basin region of the sage-grouse's range due to an increase in fire frequency and size. This change is the result of incursion of invasive annual grasses, primarily cheatgrass, into sagebrush ecosystems. The positive feedback loop between invasive annual grasses and fires facilitates future fires and precludes the opportunity for sagebrush, which is killed by fire, to reestablish. Cheatgrass and other invasive species also alter habitat suitability for sage-grouse by reducing or eliminating native forbs and grasses essential for food and cover. Invasive annual grasses and invasive 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 annual grasses has mostly been focused in the Great Basin portion of the species' range, but is a localized concern across much of the range (Service 2013, entire). Furthermore, climate change may alter the range of invasive plants, potentially expanding this stressor. The expansion and establishment of these invasive annual grasses will then contribute to increased fire frequency in those areas, further compounding habitat loss and fragmentation. In addition, functional habitat loss is occurring from the expansion of conifers into sagebrush ecosystems facilitated by inappropriate grazing practices, increases in global carbon dioxide concentrations, and climate change.

Comment [GS43]: Information after bullets was included for the compounding effects chapter.

In addition to loss of habitat and its influence on sage-grouse population persistence, fragmentation and isolation of populations presents a higher probability of extirpation (Knick and Hanser 2011, pp. 391–396; Wisdom *et al*. 2011, pp. 461–472). Knick and Hanser (2011, p. 404) suggest extinction is currently more probable than colonization for many 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 stressor beyond the physical fire perimeter.

We anticipate the loss of sage-grouse habitat from wildland fire to increase due to the intensifying synergistic interactions among fire, people, invasive species, and climate change (Miller *et al*. 2011, pp. 179–184). The recent past- and present-day fire regimes across the sage-grouse range have changed with a demonstrated increase in the more xeric Wyoming big sagebrush communities and a decrease across many mountain big sagebrush communities. Both scenarios of altered fire regimes have caused significant losses to sage-grouse habitat through facilitating invasive annual grass encroachment at lower elevation Wyoming big sagebrush sites and conifer expansion at higher elevation mountain big sagebrush sites (Miller *et al*. 2011, pp. 181–184). We also anticipate both of these scenarios to worsen in the face of climate change (Baker 2011, p. 200; Miller *et al*. 2011, p. 183). Predicted changes in temperature, precipitation, and carbon dioxide are all anticipated to influence vegetation dynamics and alter fire patterns resulting in the increasing loss and conversion of sagebrush habitats (Neilson *et al*. 2005, p. 157). Researchers have suggested that future drought simulations may underestimate decade-scale droughts and larger mega-droughts (Ault *et al*.2014, pp. 7545–7548). Further, 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). Lightning strikes are predicted to increase approximately 50 percent in the twenty-first century (Romps *et al*. 2014, p. 853). 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*. 2011, p. 171). The most common human-caused fire starts were from powerlines, vehicles, and equipment use (e.g., welding, cutting torches, chainsaws). These were followed by fires caused by railroads, warming/cooking fires, agricultural/debris burning, and fireworks (Havlina *et al*. 2014, pp. 2, 23). Additionally, given the popularity of off-highway vehicles (OHV) and the ready access to lands in the Great Basin, the increasing trend in both fire ignitions by people and loss of habitat will likely continue.

Projected Future impacts

Timescale for projecting this threat; likelihood of future impacts

It is not currently possible to predict the exact extent or location of future fire events due to complicated interactions of weather, vegetation, and ignition. However, the best scientific and commercial information available indicates that fire frequency is likely to increase into the future due to increases in cover of invasive annual grasses and the projected effects of climate change (see the Invasives and the Climate Change Chapters). Given the history of invasive annual grasses on the landscape, the continued challenges to controlling these species, the expansive infestation of invasive annual grasses across the species' range, and our knowledge of fire return intervals in Wyoming big sagebrush ecosystems, we anticipate the invasive species and associated fires will continue to compromise the sagebrush ecosystems that sage-grouse depend upon for the next 70 years or longer.

Anticipated changes from present

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

Table 5-2: Burn probability by Management Zone for Preliminary Priority Habitat (PPH) and Preliminary General Habitat (PGH)

Comment [GS44]: Continuing to work on based on GIS/modeling info. Also was toying with changing how this was laid out, need to add hectare data.

Management Zone	Preliminary Priority Habitat (PPH) Sage-grouse Habitat (acres)	PPH High Burn Probability (acres)	High Burn Probability (%)	Preliminary General Habitat (PGH) Sage-grouse Habitat (acres)	PGH High Burn Probability (acres)	PGH High Burn Probability (%)
MZ I – Great Plains	11,636,400	1,921,000	16.5	34,663,300	6,140,700	17.7
MZs II and VII – Wyoming Basin and Colorado Plateau	17,476,000	2,104,300	12.0	19,200,200	1,678,400	8.7
MZ III – Southern Great Basin	10,028,500	6,312,300	62.9	3,970,100	2,391,600	60.2
MZ IV – Snake River Plain	21,930,600	18,423,300	84.0	10,958,500	8,305,700	75.8
MZ V – Northern Great Basin	7,097,200	4,858,900	68.5	5,808,000	3,729,300	64.2

Threat amelioration

Active Conservation

Through the Conservation Efforts Database (CED), the Service collected information relating to conservation actions that were completed, in progress, or planned. Based on a summary report of that information created on February 24, 2015, the following table indicates the number of actions and approximate areas for amelioration of fire impacts to sage-grouse and their habitat. These numbers are self-reported; the Service will further review and certify these actions if they are pivotal to any determination.

The Service addresses regulatory actions in a separate chapter????

Table 5-3: List of Conservation Efforts (ameliorating stressors described in this chapter) by management zone (project proponent listed as implemented and effective, typically over 500 acres, and evaluated to be effective by the Service).

Management Zone	Type of Conservation Effort	Sum of Acres or Miles	Number of Actions	Notes
1	Fire not determined to be a primary threat for this management zone.			
2	Fire not determined to be a primary threat for this management zone.			
3	Conifer Removal	37,164.2 ac	29	Mixed Phase 1 & 2; Phase 2; Phase 3
	Habitat Restoration	4,945.7 ac	5	Thin decadent sagebrush, seedings
4	Conifer Removal	6,040.3 ac	8	Mixed Phase 1 & 2; Phase 3
	Habitat Restoration	145,256.5 ac	51	Seedings, sagebrush treatments, herbicide treatments
	Fuel Breaks	12,870.3 ac	5	Mechanical, some with herbicide treatments
5	Conifer Removal	2,911.0 ac	7	Mixed Phase 1 & 2
	Habitat Restoration	87.0 ac	1	BAR plan
	Fuel Breaks	71.0 mi	1	Reduce conifer encroachment, greenstrip, herbicide treatments
	Fuel Reduction Treatments	550.0 ac	1	
6	No projects submitted for this management zone that meet criteria (deemed effective by project proponent and over 500 acres).			
7	Fire not determined to be a primary threat for this management zone.			

MZ 4: 4,720.29814 acres appear to be listed twice (3 projects double counted) in habitat restoration

Wildland Fire Management

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

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

Fuels Management

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

In addition to land use planning, BLM uses Instruction Memoranda (IM) to provide instruction to district and field offices regarding specific resource issues. IMs are short duration (1 to 2 years) and are intended to

Comment [GS45]: This section was provided for the reg mechs chapter, but possibly should just be deleted as they are using a different format.

immediately address resource concerns or provide direction to staff until the issue is resolved or can be addressed in a long-term planning document. Because of their short duration, their utility and certainty as a long-term regulatory mechanism may be limited if not regularly renewed. Several BLM IMs relevant to sage-grouse conservation include:

- IM-2011-138: Sage-grouse Conservation Related to Wildland Fire and Fuels Management. Replaced IM 2010-149: Sage-grouse Conservation Related to Wildland Fire and Fuels Management.
- IM-2012-017: Use of Revised Sage-Grouse Habitat Maps in Fire Operations and Fuels
- IM-2012-043: This IM provides interim conservation policies and procedures to the BLM field officials to be applied to ongoing and proposed authorizations and activities that affect the sage-grouse and its habitat. This direction ensures that interim conservation policies and procedures are implemented when field offices authorize or carry out activities on public land while the BLM develops and decides how to best incorporate long-term conservation measures for sage-grouse into applicable Land Use Plans (LUP). This direction promotes sustainable sage-grouse populations and conservation of its habitat while not closing any future options before the planning process can be completed.
- This IM supplements the direction for sage-grouse contained in Washington Office (WO) IM 2010-071 (Gunnison and Greater Sage-Grouse Management Considerations for Energy Development) and is consistent with WO-IM-2011-138 (Sage-Grouse Conservation Related to Wildland Fire and Fuels Management). The Gunnison Sage-Grouse, bi-state distinct population segment in California and Nevada, and the Washington State distinct population segment are not covered by this IM and will be address through other policies and planning efforts. WO-IM-2010-071 remains applicable to the Gunnison Sage-Grouse.

- IM-2013-128: Sage-Grouse Conservation in Fire Operations and Fuels Management – This IM provides direction on sage-grouse conservation during fire operations and fuels management activities.
- WO IM-2014-114: This IM establishes BLM guidance for management actions in renewable resource programs, fuels management, fire operations, and emergency stabilization and rehabilitation (ESR) related to habitat protection, conservation, and restoration for all species of sage-grouse (Gunnison and Greater Sage-grouse, including the Bi-State and Columbia Basin distinct population sub-groups).
- BLM IM 2014-134: Completion of FIAT assessments in sage-grouse habitat

Fire and Invasive Species Assessment Team

The BLM commissioned a federally-led team (the Fire and Invasive Species Assessment Team, or FIAT) to identify priority landscapes within the Great Basin relative to sage-grouse conservation and to develop spatial planning tools for local assessments. These local assessments are now underway, with the Service providing input. These assessments incorporate data such as, sage-grouse breeding bird densities and the management strategies identified in the "Resistance and Resilience Report" (Chambers *et al*. 2014, entire) along with local knowledge of the landscape (Service 2015, p. 1). The BLM fuels funding for fiscal year 2015 (see Fuels Management discussion above) is earmarked for projects near or within the sage-grouse habitat and emphasis areas identified in the FIAT process. Many projects resulting from the FIAT assessments will be fuels treatments designed to improve initial attack effectiveness (Havlina *et al*. 2014, p. 20).

Secretarial Order No. 3336 – Rangeland Fire Prevention, Management, and Restoration

Secretary of the Interior Sally Jewell issued a Secretarial Order (Order) on January 6, 2015, calling for a comprehensive science-based strategy to address the more frequent and intense wildfires that are damaging vital sagebrush landscapes and productive rangelands, particularly in the Great Basin region of Idaho, Utah, Nevada, Oregon, and California. The strategy will begin to be implemented during the 2015 fire season. Goals include reducing the size, severity, and cost of rangeland fires, addressing the spread of cheatgrass and other invasive species, and positioning wildland fire management resources for more effective rangeland fire response. This Order builds on wildland fire prevention, suppression, and restoration efforts to date (DOI 2015, entire).

State Fire Management Programs

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

Local Fire Management Programs

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

Comment [GS46]: I need to see what other information was provided on RFPAs and include.

Post-fire

When wildfires occur on Federal lands, the Burned Area Emergency Stabilization and Rehabilitation (BAER) Program on USFS managed lands and Emergency Stabilization and Rehabilitation (ESR) on BLM-administered lands initiates an evaluation of habitat impacts and determines the most appropriate rehabilitation treatments. The main purpose of these two programs is to stabilize soils and maintain site productivity (Pyke 2011, p. 542). Consequently, in areas that experience active post-fire restoration efforts, emphasis is often placed on nonnative grass species that establish quickly. Only recently has a modest increase in use of native species for rehabilitation been reported (Richards *et al*. 1998, p. 630; Pyke 2011, p. 542). Further complicating our understanding of the effectiveness of these treatments is that most land managers do not systematically collect and track monitoring data (U.S. GAO 2003, p. 5). A recent assessment by Arkle *et al*. (2014, p. 16), found these programs were largely ineffective at providing suitable sage-grouse habitat, at least over the short-term (20 years). Assuming complete success of restoration efforts on targeted areas, however likely, the return of a shrub-dominated community such as sagebrush will still require several decades, and landscape restoration may require centuries or longer (Knick 1999, p. 55; Hemstrom *et al*. 2002, p. 1,252). Even longer time periods may be required for sage-grouse to use recovered or restored landscapes (Knick *et al*. 2011, p. 233).

Restoration of sagebrush habitat is challenging, and restoring habitat function may not be possible in some locations because alteration of vegetation, nutrient cycles, topsoil, and/or cryptobiotic crusts have exceeded recovery thresholds (citation?). Even if possible, restoration can require decades and may be cost-prohibitive. To provide habitat for sage-grouse, restoration must include all seasonal habitats and occur on a large scale (4,047 ha (10,000 ac) or more) to provide all necessary habitat components (citation?). Restoration may never be achieved in some locations with low resistance to invasive grass species and low resilience given existing soil, moisture, and temperature regimes (Chambers *et al*. 2014, entire).

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 (2011, pp. 189–196) reports that full recovery to pre-burn conditions in mountain big sagebrush communities ranges between 25 and 100 years and in Wyoming big sagebrush communities between 50 and 120 years. However, the researcher cautions that data pertaining to the latter community is sparse. What is known is that by 25 years post-fire, Wyoming big sagebrush typically has less than 5 percent pre-fire canopy cover (Baker 2011, p. 195). In mountain big sagebrush communities across 8 burn sites in eastern Oregon, northwestern Nevada, and northeastern California, full shrub cover was achieved 14 to 27 years post-burn (Ziegenhagen *et al*. 2000, p?). However, Nelle *et al*. (2000, p. ?) found burning resulted in long-term negative impact on sage-grouse nesting habitat because mountain big sagebrush communities required greater than 20 years for canopy cover to re-establish at levels sufficient for nesting. The findings of Nelle *et al*. (2000, p. ?) are consistent with other studies, which found that the canopy cover of mountain big sagebrush reached levels similar to adjacent unburned areas within 25 to 35 years, but this can take greater than 75 years where initial post-fire recruitment is low (Lesica *et al*. 2007, Sankey *et al*. 2008, Ziegenhagen and Miller 2009, Baker 2011).

A variety of techniques have been employed to restore sagebrush communities following a fire event (Cadwell *et al*. 1996, p. 143; Quinney *et al*. 1996, p. 157; Livingston 1998, p. 41). The extent and efficacy of restoration efforts is variable and complicated by limitations in capacity (personnel, equipment, funding, seed availability, and limited seeding window), incomplete knowledge, invasive 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 2011, pp. 544–545). While post-fire rehabilitation efforts have benefited from additional resources in recent years, resulting in an increase of treated acres from 28,100 ha (69,436 ac) in 1997 to 1.6 million ha (3.9 million ac) in 2002 (Connelly *et al*. 2004, p. 7-35), acreage treated annually remains far outpaced by acreage disturbed. 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 BLM successfully suppresses about 97 percent of all wildfire ignitions in sagebrush ecosystems. The three percent of wildfires that escape usually occur under the most extreme environmental conditions. This, coupled with vegetation changes over time (conifer encroachment and/or invasive annual plant establishment), has caused these fires to grow larger and become more environmentally destructive than historical fires that occurred under more moderate conditions without suppression.

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

While we do not know the extent to which these regulatory mechanisms alleviated the wildfire impact to sage-grouse, we believe that this strategic approach to ameliorating the impact 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. We describe the impact of wildfire as likely to continue indefinitely. This foreseeable future requires a regulatory approach that addresses the impact 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).

Comment [GS47]: Commenter stated - Needs to be updated based on results of analysis of regulatory mechanisms of SG updates to LUPAs and RMPs.

Threat Amelioration Summary

Comment [GS48]: Didn't have this info at submittal of draft, will be adding.

Assessment of Potential Threat

Comment [GS49]: Commenter stated we should consider what BLM is proposing in their RMP revisions for fire and wildfire abatement. Recognizing those plans are not yet final, but we have likely seen enough to make an estimation whether the draft plans are improvements over the existing plans for this threat.

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

Fire continues to impact sage-grouse individuals and be associated with sage-grouse population declines. The impact of fire to sage-grouse and their habitats is compounded by its interactions with the dual stressors of invasive plants and climate change.

Management of wildfires has been successful in extinguishing 98 percent of fires in sagebrush ecosystems before they consume large areas, defined as fires greater than 4,047 ha (10,000 ac). Federal, State, and local wildfire management teams have effective coordination in many areas. They are working to improve the coordination and strategies to improve the odds of preventing additional large wildfires in sagebrush ecosystems.

In 2010 we said x. Based on new information, we believe that fire may be impacting individuals, populations, and management zones in a negative way now and likely into the future. The impacts are severe and potentially impact X percent of habitat/range/abundance. In the future, and based upon modeling efforts, we anticipate this will continue/expand.

Comment [KNorman50]: I'll let you figure out the text, but this is kind of what we're hoping for here.

Here are the new sideboards:
Per conversations on 2/26/2015- this should now include the following pieces:

- Quote 2010 conclusion (e.g. "We find that the threat of disease is not significant to the point that the greater sage-grouse warrants listing at this time.")
- What are the impacts at various scales:
  - Individuals
  - Populations
  - Management Zone
  - "Range"
- Regulatory mechanisms may be ameliorating these impacts including x, y z. See cumulative effects and/or regulatory mechanisms chapter for further explanation.
- Based on the new science, we conclude that THIS STRESSOR is affecting the species in X way.

Language

- Avoid the terms "threatened or threatening" as a verb or adverb and "threat" as noun; may consider using:
  - Impact
  - Stressor
  - Negatively affecting
  - Negligible impact (on its own), but could have cumulative impacts

Citations

Comment [GS51]: There are still a few holes in the Lit Cited and I have not checked to see if/uploaded all literature reviewed to RefWorks. Continuing to work on.

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Chapter 6: Noxious Weeks and Invasives

Introduction

THREAT DESCRIPTION

Invasive plants (invasives)[1] alter plant community structure and composition, productivity, nutrient cycling, and hydrology (Vitousek 1990, p. 7) and may cause declines in native plant populations through competitive exclusion and niche displacement, among other mechanisms (Mooney and Cleland 2001, p. 5446). Invasive plants reduce and, in cases where monocultures occur, eliminate vegetation that greater sage-grouse (*Centrocercus urophasianus*, hereafter sage-grouse) use for food and cover and fragment existing sage-grouse habitat (Miller *et al*. 2011, pp. 160–164). Invasives do not provide quality sage-grouse habitat and where invasive plants are present, sage-grouse are potentially impacted both seasonally (e.g., loss of forbs and associated insects) and long-term (e.g., functional habitat loss; Manier *et al*. 2013, p. 88). Sage-grouse depend on herbaceous forage for pre-laying and nesting hens (e.g. Barnett and Crawford 1994, p. 116),a variety of native forbs (e.g., Klebenow and Gray 1968, p. 81; Drut *et al*. 1994, p. 91,) and the insects (e.g., Klebenow and Gray 1968, p. 81; Johnson and Boyce, 1990, p. 91 ; Drut *et al*. 1994, p. 91, Gregg and Crawford, p. 909) associated with them for chick and brood survival, and Artemisia spp. (sagebrush), which is used exclusively throughout the winter for food and cover (Connelly *et al*. 2000a, p. 972). Invasives impact the entire range of sage-grouse, although not all given species are distributed across the entire range (Miller *et al*. 2011, p. 160). Leu *et al*. (2008, pp. 1119–1139) modeled the risk of invasion by invasive plant species (including annual grasses) for the entire range of sage-grouse. Subsequent analysis by Miller *et al*. 2011 (see figure 10.6, p. 161) mapped the probability of presence of

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

cheatgrass within the Intermountain West. Areas at high risk for invasion were distributed throughout the range, but were especially concentrated in eastern Washington (MZ VI), southeastern Oregon (MZs IV and V), southern Idaho (MZ IV), Nevada (MZs III, IV, and V), central Utah (MZ III) and northeast Montana (MZ I) (Leu *et al.* 2008, pp.1119–1139; Miller *et al.* 2011, p. 160). Although nonnative annual grasses occur throughout the sage-grouse's range, they are more pervasive in the western part of the species' range (MZs III, IV, V, and VI) than in the Rocky Mountain States (MZs I and II) (Connelly *et al.* 2004, p. 5–9; Miller *et al.* p. 160). However, in recent years, cheatgrass (and other annual grasses) has increased its abundance and distribution in the eastern portion of the species' range (Mealor *et al.* 2012, p. 427), particularly in Montana, Wyoming, and Colorado (MZs I and II) (Miller *et al.* 2011, p.160). Although the magnitude of the threat of cheatgrass invasion in the Rocky Mountain states is unknown, without a cost-effective method to eliminate or reduce the distribution and abundance of invasive plants, and with the expansion of invasives due to climate change, the invasion of cheatgrass into the eastern portion of the species range is likely to continue, particularly where disturbance such as wildfire creates suitable conditions (Mealor *et al.* 2012, p. 427). For example, an ensemble of six future climate scenarios indicated cheatgrass may increase from approximately 5.5% currently to 20.4% of the Rocky Mountain National Park by the year 2050 (West *et al.* 2015, p. 1). For example, a bioclimatic envelope model for cheatgrass indicated decreases in summer precipitation could cause an expansion of suitable habitat for cheatgrass up to 45%, elevating the invasion risk in large portions of Montana, Wyoming, Utah, and Colorado (Bradley 2009, p. 204).

Along with replacing or removing vegetation essential to sage-grouse, invasives fragment existing sage-grouse habitat. They can create long-term changes in ecosystem processes, such as fire-cycles (see discussion under Fire chapter) and other disturbance regimes that persist even after an invasive plant is removed (Zouhar *et al.* 2008, p. 33). A variety of nonnative annuals and perennials are invasive to sagebrush ecosystems (Connelly *et al.* 2004, pp. 7–107 and 7–108; Zouhar *et al.* 2008, p. 144; Miller *et al.* 2011, pp. 158–159) but cheatgrass is the most widespread invasive within the Intermountain West and Great Basin (Miller *et al.* 2011, p. 145). This is especially true within A. tridentata tridentata (basin big sagebrush) and xeric A. t. wyomingensis (Wyoming big sagebrush) communities, which are at the most risk to displacement by cheatgrass (Miller and Eddleman 2001, p. 21; Connelly *et al*. 2004, p. 5–9; Chambers *et al*. 2007, p. 141). Taeniatherum caput-medusae (medusahead) fill a similar niche in more mesic communities with heavier clay soils (Dahl and Tisdale 1975, p. 464). Medusahead can also become abundant on some A. arbuscula (little sagebrush) sites below 1500 m in elevation (Miller and Eddleman 2001, p. 21), as well as some big sagebrush communities (Miller at al. 1999 pp. 271–281). Other invasives include Euphorbia esula (leafy spurge), Centaurea solstitialis (yellow star-thistle), C. stoebe (spotted knapweed), C. diffusa (diffuse knapweed), and a number of other Centaurea species (DiTomaso 2000, p. 255; Davies and Svejcar 2008, pp. 623–629).

Nonnative annual grasses (primarily cheatgrass and medusahead) have caused extensive sagebrush habitat loss in the Intermountain West and Great Basin (Connelly *et al*. 2004, pp. 1–2 and 4–16) and have substantially altered regional fire regimes (Balch *et al*. 2013, p. 179). Cheatgrass-dominated rangelands impact sagebrush ecosystems by shortening fire return intervals and perpetuating their own persistence and intensifying the role of fire (Whisenant 1990, p. 4). Balch *et al*. (2013, p. 178) estimated a fire return interval of 78 years in cheatgrass-grasslands compared to 169 in native vegetation. Sites dominated by cheatgrass were considered four times more likely to burn than native sagebrush (Balch *et al*. 2013, p. 178). Between 2000 and 2009, 6.6 million ha (16.2 million ac) burned in the Great Basin. Of the estimated 6.6 million ha, about 0.8 million ha (2 million ac) re-burned due to the positive feedback between cheatgrass and fire (Weltz *et al*. 2014, p. 39A), resulting in ecosystem-level impacts (Billings 1994, pp. 22–30; Mack 2011, pp. 253–265).

Historical source(s)

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

Current source(s)

Facilitated by repeated anthropogenic and wildfire disturbance, invasive annual grasses (especially cheatgrass and medusahead), have invaded vast portions of sage-grouse range and present a formidable challenge to sagebrush ecosystem conservation (D'Antonio and Vitousek 1992, p. 79; Miller *et al*. 2011, pp. 157–164). Of utmost concern are the synergistic effects of the annual grass-wildfire cycle. Although the historical frequency of fire continues to be debated (Baker 2011, pp. 194–196; Miller *et al*. 2011, pp. 164–171), most agree the role of fire in the sagebrush-steppe ecosystem has changed significantly since post-European settlement (Crawford *et al*. 2004, p. 7). If sagebrush-steppe ecosystems, particularly Wyoming big sagebrush communities, lack resilience to invasive annual grasses, conversion to a novel annual grassland steady-state is likely (Miller *et al*. 2011, p. 183; Pyke *et al*. 2014, p. 455). Exacerbating the problem is our current inability to effectively restore sites to native sagebrush communities once the transition to an annual-dominated alternative state has occurred (Davies *et al*. 2011, p. 2577).

The effects of fire on noxious weeds typically promote the dominance of these plants, establishing an invasive plant-fire regime cycle (Brooks *et al*. 2004; pp. 677–688). Invasive perennial forbs are generally unharmed or may increase following fire due to life history traits, such as prolific seed production, persistent seed banks, and rooting characteristics, including the ability to sprout from rhizomes, root crowns, or adventitious buds (Ielmini *et al*. 2015, p. 8). Conversely, annual invasive forbs with transient seed banks may be vulnerable to, and controlled by, fire during certain life history stages. Deep-rooted, creeping invasive perennials such as C. repens (Russian knapweed), C. virgata ssp. squarrosa (squarrose knapwed), Linaria dalmatica (dalmation toadflax), and Cirsium arvense (Canada thistle) do not impact sagebrush-steppe ecosystems on a landscape scale but these invasive perennials can pose a significant threat to native sagebrush habitats on a local scale (Ielmini *et al*. 2015, p. 8).

Current impacts

Mechanism

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

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

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

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

Results of impact

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

Sage-grouse population demographic studies in northern Nevada found that recruitment and annual survival were impacted by the presence of invasive annual grasses at larger spatial scales. Blomberg *et al*. (2012, p. 7) analyzed land cover with a 5-km radius of leks (n = 13) and found that leks impacted by invasive annual grasses experienced lower recruitment than non-impacted leks, even following years of high precipitation. Leks that were not impacted by invasive annual grasses exhibited recruitment rates nearly twice as high as the population average and nearly six times greater than impacted leks during years of high precipitation (Blomberg *et al*. 2012, p. 7). Lek-level survival of adult males was also reduced in areas where leks were impacted by invasive annual grasses (Blomberg *et al*. 2012, p. 8).

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

Timing

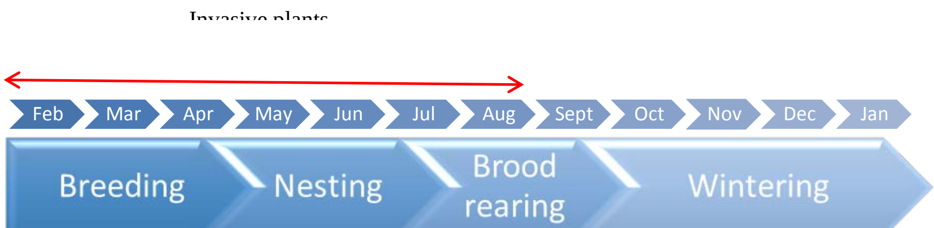

Figure X-1. Annual life cycle of sage-grouse. Direct impacts from invasive plants occur mainly during the breeding, nesting, and brood-rearing season, indicated by the red bar. Indirect effects can occur year round.

Resistance to invasive annual grasses depends on environmental factors and ecosystem attributes and is a function of: (1) the invasive species' physiological and life history requirements for establishment, growth, and reproduction, and (2) interactions with the native perennial plant community, including interspecific competition and response to herbivory and pathogens (Chambers *et al*. 2014c, p. 10). In cold desert ecosystems, resistance is strongly influenced by soil temperature and precipitation regimes (Chambers *et al*. 2007, p. 141; Meyer *et al*. 2001, p. 231). Germination, growth, and reproduction of cheatgrass is physiologically limited at lower elevation Wyoming big sagebrush vegetation types by frequent, low precipitation years, constrained at higher elevation mountain big sagebrush communities by low soil temperatures, and optimal at mid elevations under relatively moderate temperature and water availability (Chambers *et al*. 2007, pp. 139–140). Slope, aspect, and soil characteristics modify soil temperature and water availability and influence resistance to cheatgrass at landscape to plant community scales (Chambers *et al*. 2007, pp. 139–140; Condon *et al*. 2011, pp. 601–602; Reisner *et al*. 2013, p. 1047). Genetic variation in cheatgrass results in phenotypic traits that increase survival and persistence in populations from a range of environments, and is likely contributing to the recent range expansion of this highly inbreeding species into marginal habitats (Ramakrishnan *et al*. 2006, p. 71; Merrill *et al*. 2012, pp. 535–536).

The occurrence and persistence of invasive annual grasses in sagebrush habitats is strongly influenced by interactions with the native perennial plant community (Chambers *et al*. 2014c, p. 10). Cheatgrass, a facultative winter annual that can germinate from early fall through early spring (Mack and Pyke 1983, pp. 87–88), exhibits root elongation at low soil temperatures (Arredondo *et al*. 1998, p. 585), and has higher nutrient uptake and growth rates than most native species (James *et al*. 2011, p. 497). Seedlings of native, perennial plant species are generally poor competitors with cheatgrass, but adults of native, perennial grasses and forbs, especially those with similar growth forms and phenology, can be highly effective competitors with the invasive annual (Booth *et al*. 2003, p. 46; Chambers *et al*. 2007, p. 142; Blank and Morgan 2012, p. 5). Also, biological soil crusts, which are an important component of native plant communities, can reduce germination and establishment of cheatgrass, particularly in warmer and drier sagebrush ecosystems (Eckert *et al*. 1986, p. 420; Kaltenecker *et al*. 1999, cited in Chambers *et al*. 2014c, p. 17). Disturbances or management treatments that reduce abundance of native perennial plants and biological soil crusts and increase the distances between perennial bunchgrasses often are associated with higher resource availability and increased competitive ability of cheatgrass (Chambers *et al*. 2007, p. 141; Reisner *et al*. 2013, p. 1048; Roundy *et al*. 2014, pp. 502–503).

Location and extent

Quantifying the total amount of sage-grouse habitat impacted by invasives is difficult due to differing sampling methodologies, incomplete sampling, inconsistencies in species sampled, and varying interpretations of what constitutes an infestation (Miller *et al*. 2011, p. 160). In addition, comprehensive landscape-scale maps of the distribution of invasives in the western U.S. do not currently exist, and the total acreage of noxious weed infestations that have been reported at the local, State, and Federal levels is incomplete and widely variable (Ielmini *et al*. 2015, p. 9).

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

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

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

Cheatgrass is just one of a number of other invasive plant species increasing in extent within the range of sage-grouse (Miller *et al*. 2011, pp. 158–159; Ielimini *et al*. 2015, p. 58). An analysis by Ielmini *et al*. (2015, p. 40) ranked the relative invasion risk and estimated the abundance of invasives within the range of sage-grouse (Table X-2), concluding that the five highest ranked invasives plants for risk to sage-grouse were cheatgrass, spotted knapweed, Cardaria spp. (whitetop), leafy spurge, and Russian knapweed. The five most abundant invasive plant species were cheatgrass, Canada thistle, whitetop, spotted knapweed, and Russian knapweed (Figure X-2). Additionally, Ielmini *et al*. (2015, p. 40) determined other invasive species (e.g., Chondrilla juncea [rush skeletonweed], yellow star-thistle) were likely to have small infestations or be absent across much of the range of sage-grouse but remain a high concern to land managers.

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

Table X-1. Acres of upland herbaceous invasives1 within the current range2 of the greater sage-grouse in the conterminous United States3.

[redacted]								
Introduced Upland Vegetation-Annual and Biennial Forbland	2,184	746,832	552,369	155,590	64,806			1,521,782
Introduced Upland Vegetation-Annual Grassland	194,806	457,903	1,475,783	4,671,863	1,264,744	195,762	44,369	8,305,230
Introduced Upland Vegetation-Perennial Grassland and Forbland	222,078	42,859	42,146	463,310	288,763	28,026	2	1,087,183
Total	41	1,24	2,07	5,29	1,61	22	4	10,914

	9,068	7,594	0,298	0,763	8,313	3,787	4,372	,195

1 Based on LANDFIRE 2012 (LF2012 - LF_1.3.0), CONUS mosaic for Existing Vegetation Type [us_130evt] downloaded from http://landfire.cr.usgs.gov/lf_mosaics.php.

2 Current Range from USFWS 2014 update to Schroeder 2004 greater sage-grouse current range.

3 LANDFIRE CONUS mosaics are only for the Conterminous United States. These acreage numbers do not reflect the Canadian portion of Management Zone I.

4 Management Zones from USFWS 2014 update to WAFWA 2006 greater sage-grouse management zones.

Table X-2. Highest mean (± SE) ranks for relative invasion risk of priority plants and mean abundance estimates grouped by management zone. Invasion risk values indicate these plants may continue to spread. Risk and abundance values were estimated by survey respondents based on the scale and site conditions of their management or administrative unit (from Ielmini *et al*. 2015, pp. 65–66).

Mgmt. zone/plant	Rank a	Risk category	Rank b	Abundance category
	Mean (SE)		Mean (SE)	
MZ I - Great Plains				
Leafy spurge	4.6 (0.12)	Mod high to high	6.3 (0.19)	Many small infestations
Canada thistle	4.2 (0.17)	Moderately high	6.5 (0.09)	Large infestations
Spotted knapweed	4.1 (0.20)	Moderately high	5.2 (0.26)	Few small infestations

Cheatgrass	3.9 (0.21)	Moderately high	6.1 (0.24)	Many small infestations
Russian knapweed	3.6 (0.19)	Mod to moderately high	4.9 (0.22)	Few small infestations

MZ II - Wyoming Basin

Cheatgrass	4.4 (0.12)	Moderately high	6.4 (0.11)	Large infestations
Whitetop	3.8 (0.15)	Mod to moderately high	5.8 (0.16)	Many small infestations
Perennial pepperweed	3.8 (0.18)	Mod to moderately high	5.3 (0.24)	Few small infestations
Leafy spurge	3.8 (0.18)	Mod to moderately high	4.9 (0.24)	Few small infestations
Russian knapweed	3.7 (0.17)	Mod to moderately high	5.2 (0.23)	Few small infestations

MZ III - Southern Great Basin

Cheatgrass	4.4 (0.17)	Moderately high	6.8 (0.07)	Large infestations
Whitetop	4.2 (0.15)	Moderately high	6.1 (0.17)	Many small infestations
Perennial pepperweed	4.0 (0.17)	Moderately high	5.5 (0.26)	Few to many small
Russian knapweed	4.0 (0.16)	Moderately high	5.6 (0.20)	Few to many small
Spotted knapweed	3.8 (0.18)	Mod to moderately high	5.0 (0.22)	Few small infestations

MZ IV - Snake River Plain

Cheatgrass	4.2 (0.13)	Moderately high	6.3 (0.13)	Many small infestations
Spotted knapweed	4.1 (0.15)	Moderately high	5.6 (0.20)	Many small infestations
Rush	4.	Moderately high	4.	Few small

skeletonweed	0 (0.19)		7 (0.29)	infestations
Leafy spurge	3.8 (0.16)	Mod to moderately high	5.2 (0.21)	Few small infestations
Medusahead	3.6 (0.18)	Mod to moderately high	4.1 (0.30)	Rare and high concern

MZ V - Northern Great Basin

Medusahead	4.5 (0.24)	Moderately high	6.1 (0.39)	Many small infestations
Cheatgrass	4.3 (0.29)	Moderately high	6.5 (0.34)	Few large infestations
Spotted knapweed	3.7 (0.36)	Mod to moderately high	4.6 (0.54)	Few small infestations
Perennial pepperweed	3.6 (0.34)	Mod to moderately high	5.4 (0.44)	Few small infestations
Whitetop	3.4 (0.30)	Moderate	5.3 (0.42)	Few small infestations

MZ VI - Columbia Basin

Cheatgrass	4. 2 (0.24)	Moderately high	6. 3 (0.22)	Many small infestations
Whitetop	3. 8 (0.26)	Mod to moderately high	5. 3 (0.28)	Few small infestations
Rush skeletonweed	3. 4 (0.47)	Moderate	4. 0 (0.53)	Rare and high concern
Diffuse knapweed	3. 3 (0.28)	Moderate	5. 9 (0.14)	Many small infestations
Perennial pepperweed	3. 2 (0.37)	Moderate	4. 2 (0.37)	Rare and high concern

MZ VII - Colorado Plateau

Cheatgrass	4. 2 (0.19)	Moderately high	6. 5 (0.12)	Few to many large
Yellow toadflax	4. 0 (0.20)	Moderately high	5. 9 (0.24)	Many small infestations

Russian knapweed	4.0 (0.16)	Moderately high	5.6 (0.28)	Many small infestations
Spotted knapweed	4.0 (0.19)	Moderately high	4.9 (0.26)	Few small infestations
Canada thistle	3.9 (0.17)	Moderately high	6.3 (0.11)	Many small infestations

a Relative invasion risk ranks: 1, low risk; 2, moderately low risk; 3, moderate; 4, moderately high risk; 5, high risk.

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

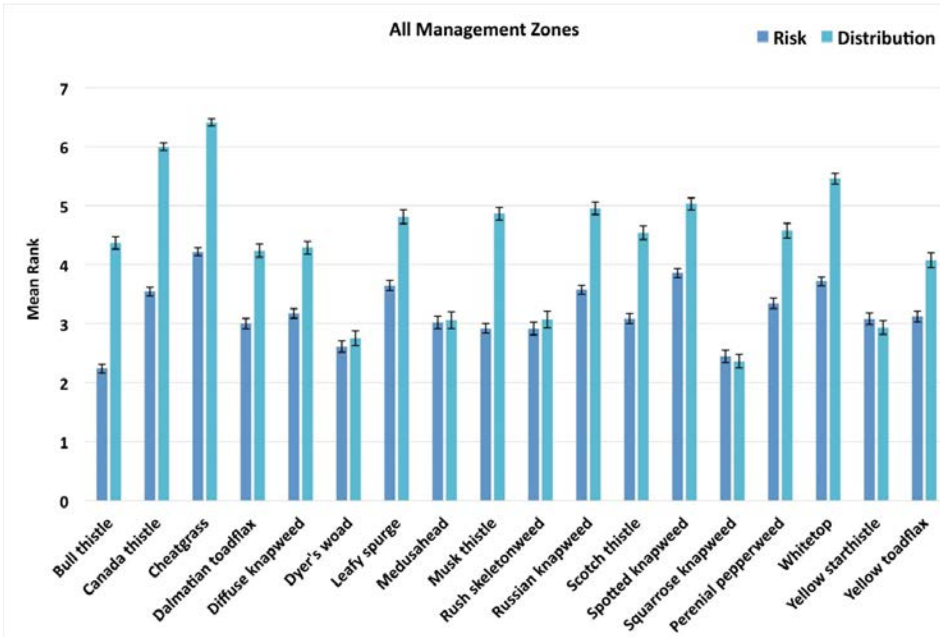

Figure X-2. Relative risk (dark blue bars; 1 = low risk to 5 = high risk) and estimated abundance (light blue bars; 1, absent; 2, rare and low concern; 3, absent and high concern; 4, rare and high concern; 5, a few small infestations; 6, many small or few large infestations; 7, many large infestations) of priority plants. Observations were estimated by responding managers based on the scale and site conditions of their management unit. Error bars are ± SD; n = 274 ± 16.4 (SD) (from Ielmini *et al*. 2015, p. 73).

Compounded effects

The compounding effects will be discussed in greater detail in the Compounded Effects chapter. In brief, the following impacts are likely to interact with the threat described in this chapter.

- Fire
- Infrastructure
- Free-roaming equids
- Climate Change
- Grazing

Invasives are likely to be readily dispersed along roads (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) and trail corridors and establishment is favored by anthropogenic disturbance and human landuse activities and associated infrastructure (Banks and Baker 2011, p. 384). In Wyoming, the abundance and distribution of invasive plants increased with infrastructure, including linear features such as roads (highways, major and minor unpaved thoroughfares, spurs and driveways, and two-tracks), pipelines, transmission lines, and site-specific features, such as active and reclaimed well pads (Manier *et al*. 2011, p. 10). Human developments, such as buildings, may also provide sites for cheatgrass colonization (Banks and Baker, p. 384). These anthropogenic features can facilitate establishment of invasive plants in adjacent sagebrush communities and elsewhere across the landscape, negatively affecting sage-grouse through habitat loss and ecosystem conversion (see discussion in Infrastructure chapter). The increased amount of landuse activities also will have a significant impact on the soils, biological soil crusts, and vegetation of these systems and their ability to recover from the cascading effects created by invasives, fire, and climate change (Belnap *et al*. 2006, p. 73). Progressive losses of resilience and resistance can result in the crossing of abiotic and/or biotic thresholds (Beisner *et al*. 2003, pp. 376–382) and may lead to a catastrophic shift in community structure (Scheffer *et al*. 2009, pp. 53–59; Reisner *et al*. 2013, p. 1047).

Functional habitat loss is occurring because of long-term loss of sagebrush cover and conversion to nonnative annual grasses (primarily cheatgrass), mainly due to an increase in fire occurrence, intensity, and severity (Miller *et al*. 2011, p. 183). The positive feedback process between cheatgrass and fires facilitates future fires, sagebrush loss, and cheatgrass dominance, resulting in entire landscapes being converted to nonnative annual grasslands (Miller *et al*. 2011, p. 183). Interactions among disturbances and stressors may have cumulative effects (Chambers *et al*. 2014a, pp. 365–368). Invasive annual grasses and noxious perennials continue to expand their range, facilitated by ground disturbances, caused by more frequent and more severe wildfires, overgrazing of native perennial plants by domestic livestock and free-roaming equids, 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., cheatgrass) are replaced by new invasive plants (Crawford *et al*. 2004, p. 9; Miller *et al*. 2011, p. 160). Long-term changes in climate that facilitate invasion and establishment by invasive annual grasses further exacerbate the fire regime and accelerate the loss of sagebrush habitats (D'Antonio and Vitousek 1992, pp. 63–87). The effects of disturbance will likely be amplified by greater susceptibility of habitats to burn as well as decreased likelihood for recovery of sagebrush-steppe communities (Miller *et al*. 2011, p. 183).

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 (see discussion in Climate Change chapter). The establishment of invasive annual grasses will then contribute to increased fire frequency in those areas, further compounding habitat loss and fragmentation. The fire-invasives feedback loop may be promoted by warmer, wetter winters and a subsequent increase in establishment and growth of invasive winter annuals. These cycles may be exacerbated by rising atmospheric carbon dioxide concentrations, nitrogen deposition, and increases in human activities that result in soil surface disturbance and invasion corridors (Chambers *et al*. 2014a, pp. 367–368). Cheatgrass already competes successfully against native perennial grasses because of early maturation, short root systems to collect water in soils, greater seed production, and the ability to respond quickly to resources released during disturbance. Thus, the ability of cheatgrass to compete in sagebrush ecosystems created by enhanced carbon dioxide or changes in the length of the growing season, temperature, or the frequency of wet winters will likely facilitate the establishment of invasive annual grasses and intensify the fire cycle and cheatgrass dominance (D'Antonio and Vitousek 1992, pp. 74–75; Ziska *et al*. 2005, pp. 1330–1331).

Projected Future impacts

Timescale for projecting this threat

The changes in sagebrush ecosystem dynamics due to invasive annual species and longer, hotter, and drier fire seasons due to a warming climate make it unlikely that these threats can be ameliorated completely (Abatzoglou and Kolden 2011, p. 476). We anticipate invasive plants and associated fires will be on the landscape for the next 100 years or longer.

Likelihood of future impacts

Increased fire frequency, facilitated by the spread of invasives (particularly nonnative annual grasses) will continue indefinitely unless an effective means for controlling invasives are found. To date, no broad scale cheatgrass eradication method has been developed. Rehabilitation and restoration techniques are largely unproven or experimental (Pyke 2011, p. 543). Effective restoration of sagebrush-steppe ecosystems will require many years to have a substantial impact in slowing or stabilizing this loss (Miller *et al*. 2011, p. 184). Therefore, given the history of invasive plants on the landscape, our continued inability to control such species, and the expansive infestation of invasive plants across the species' range currently, we anticipate invasives and associated fires will be on the landscape for the next 100 years or longer.

Anticipated changes from present

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 cheatgrass across much of the sage-grouse's range under current and future (2100) climate conditions. A strong indicator for future cheatgrass locations is the proximity to current locations (Bradley and Mustard 2006, p.1146) as well as summer, annual, and spring precipitation, and winter temperature (Bradley 2009, p. 196). Bradley *et al*. (2009, p. 1517) predicted that in the future some areas will become unfavorable for cheatgrass while others will become favorable. Specifically, Bradley *et al.* (2009, p. 1515) predicted that climatically suitable cheatgrass 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 cheatgrass habitat in these States, well within the range of sage-grouse (see Figure 4b in Bradley *et al*. 2009, p. 1517). Subsequent modelling documenting the probability of cheatgrass occurrence in the Great Basin (MZs III, IV, and V) suggests that the most serious risk of cheatgrass invasion lies in the Snake River Plains (Manier *et al*. 2013, p. 88). Observed and predicted warming trends may also lead to an increased susceptibility of cheatgrass invasion at higher elevation rangelands in the eastern portion of the species' range (e.g., Wyoming), particularly after a fire event (Mealor *et al*. 2012, p. 433).

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

Like cheatgrass, the distribution of other invasives will likely shift with climate change. Bradley *et al*. (2009, p. 1518) predict that the range of spotted knapweed 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). The range of yellow star-thistle is also predicted to expand eastward (Bradley *et al*. 2009, p. 1514) and that the invasion risk of leafy spurge will likely decrease in several States, including parts of Colorado and Idaho (Bradley *et al*. 2009, pp. 1516–1518).

Threat amelioration

Active Conservation

Through the Conservation Efforts Database (CED), the Service collected information relating to conservation actions that were completed, in progress, or planned. Based on a summary report of that information created on XXXXXX, the following table indicates the number of actions and approximate areas for threat amelioration. These numbers are self-reported; the Service will further review and certify these actions if they are pivotal to any determination.

The Service addresses regulatory actions in a separate chapter.

Table 6-1: List of Conservation Efforts (ameliorating threat described in this chapter) by management zone

Management Zone	Type of Conservation Effort	Sum of Acres or Miles	Number of Actions	Notes
1				
2				
3				

Management Zone	Type of Conservation Effort	Sum of Acres or Miles	Number of Actions	Notes
4				
5				
6				
7				

Threat Amelioration Summary

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

Comment [DMD52]: Need to support this statement with information from the CED and revise as necessary.

Treatment success also depends on factors which are not controllable, such as precipitation received at the treatment site (Pyke 2011, pp. 544–545). For example, only 3.3 to 33.6 percent of recent vegetation treatments conducted by the BLM in nonnative 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 re-establishment of native shrub and grass species and green-stripping 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.

Comment [DMD53]: This will be updated with information provided by the BLM via pers. comm. and in response to the datacall/CED.

A variety of regulatory mechanisms and nonregulatory measures to control invasive plants exist. However, no single Federal law or combination of policies provides clear authority or coordination among Federal agencies to address invasive species (Corn and Johnson 2013, p. 1) and the extent to which these mechanisms effectively ameliorate the current rate of invasive expansion is unclear. From a regulatory standpoint, only invasive plant species listed on Federal or State “noxious weed” lists are required to be managed. For example, only Oregon, California, Colorado, Utah, and Nevada list medusahead as a noxious regulated weed (Center for Invasive Species Management 2015), but other States with the range of sage-grouse are at risk of invasion by medusahead (e.g., Washington, Idaho). Cheatgrass is not listed as a Federal noxious weed and is largely unregulated by the States (Ielmini *et al*. 2015, p. 15). Colorado is the only western State that lists cheatgrass as a noxious weed (Center for Invasive Species Management 2015). These laws may provide some protection for sage-grouse habitats, although large-scale control of invasive plants is not occurring, and rehabilitation and restoration techniques are mostly unproved and experimental (Pyke 2011, p. 543).

The average rates of spread of invasive plants are difficult to determine because very little information is available describing the accurate abundance of invasive plant distributions in the western U.S. However, it is widely accepted that the spread of invasive plants is exceeding treatment rates conducted by most county, State, and Federal weed management programs (Ielmini *et al*. 2015, p. 25). If noxious weeds are spreading at a rate of 931 ha (2,300 ac) per day on BLM-administered lands (BLM 1996, p. 1), this amounts to 339,815 ha (839,500 ac) per year, representing an increase of about 8 to 20 percent annually (Federal Interagency Committee for the Management of Noxious and Exotic Weeds 1997, p. v). However, this estimate includes both suitable and nonsuitable habitat for sage-grouse and it is unclear whether this estimate is limited to noxious weeds or if it includes other invasives (e.g., cheatgrass). Regardless, we can compare this estimate to the area of all invasives (excluding conifers) treated by the BLM between October 2005 and September 2007, which totaled 259,897 ha (642,216 ac), i.e., approximately 86,632 ha (214,072 ac) treated annually.

The number of acres treated annually (86,632 ha; 214,072 ac) is not keeping pace with the rate of spread (339,815 ha; 839,500 ac), especially when considering the inability to treat the threat. We acknowledge that the rate of spread on BLM-administered lands also includes areas that are not sage-grouse habitat. However, the rate of spread may not have included cheatgrass 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,

Comment [DMD54]: This will be updated with information provided by the BLM via pers. comm. and in response to the datacall/CED. Additional information will be gathered from the Rapid Ecoregions Assessments and Draft Vegetative EIS expected to be released April 2015. The DEIS should include and update of acres treated and inventoried.

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 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.

Federal agencies duties and responsibilities for addressing invasive species are currently directed under Executive Order 13112. This Executive Order, when coupled with other Federal authorities, laws, regulations, and policies, requires Federal agencies to establish, coordinate, and implement better invasive species management programs across the U.S. However, individual Federal agency policies on invasive species management vary widely. In addition to broadly defining the duties of Federal agencies, the Executive Order established a National Invasive Species Council (NISC) to coordinate the Federal response, a non-Federal Invasive Species Advisory Committee operating under the Federal Advisory Committee Act, and the development of a National Invasive Species Management Plan (initially released in 2001 and updated in 2008) to guide Federal agency activities. However, the management plans have not driven Federal agency priorities nor have they provided a mechanism for increasing Federal funding for invasive species research or management. As a result, Federal invasive species research and management programs remain largely uncoordinated, and highly variable in structure, capacity, and functionality (Ielmini *et al*. 2015, p. 12). To date, NISC has not met since 2008, and an update to the national plan (which expired in 2012) has not yet been completed. Federal funding for the management activities necessary to implement policy and effectively counter the establishment and spread of invasives is lacking, particularly the western U.S., causing many Federal research and management programs to be curtailed or significantly reduced in both scale and scope. In some cases, the budgetary discretion given to agencies allows the diversion of dedicated invasive species funds for other uses, often creating additional pressures on invasive plant management program capacity (Ielmini *et al*. 2015, p. 13).

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

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

In the absence of Federally-led coordination, important regional efforts have emerged. In 2014, the Western Association of Fish and Wildlife Agencies (WAFWA) Wildfire and Invasive Species Initiative Working Group began the development of a status report (Ielmini *et al*. 2015, entire) on invasive species management practices and recommendation to restore sage-grouse and its habitats. The WAFWA Working Group, through the Great Basin Landscape Conservation Cooperative, contracted with Center for Invasive Species Management (CISM; Montana State University, Bozeman, MT) to develop and administer an on-line assessment, and to gather and analyze data on the specific characteristics and functions of invasive plant management programs within the current and historic range of sage-grouse buffered by 50 km (see Miller *et al*. 2011, p. 145). The on-line assessment provided information used to document the status and function of local, State and Federal invasive plant management programs, encompassing 11 western states, with additional information and data provided by western weed management experts. Using this information, the WAFWA report (Ielmini *et al*. 2015, entire) described the infrastructure, activities, and challenges of the western weed management community and offered recommendations to improve sage-grouse conservation.

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

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

The Western Weed Coordinating Committee (WWCC) serves in a leadership role to help coordinate local, State, and Federal invasive plant management activities, and facilitate communication and collaboration strategically across the West. State, Federal, and provincial invasive plat management agencies are the principle members of the WWCC. Other public and private invasive plant management organizations can be valuable partners for sage-grouse conservation and sagebrush-steppe restoration, particularly in regard to on-the-ground management activities within Cooperative Weed Management Areas (CWMAs). CWMAs provide a voluntary approach to control invasive species across the range of sage-grouse. CWMAs are partnerships between Federal, State, and local agencies, tribes, individuals, and interested groups to manage both species designated by State agencies as noxious weeds, and invasive plants in a county or multi-county geographical area. As of 2015, Nevada, Utah, Colorado, Washington, Idaho, Montana, Wyoming, and North Dakota had between 95 and 100 percent of their States covered by CWMAs or county weed districts (Table X-4; Goodwin 2015, pers. comm.).Oregon had between 65 and 85 percent coverage, while South Dakota had between 85 and 90 percent coverage (Table X-4; Goodwin 2015, pers. comm.). CWMAs and county weed organizations are powerful tools to combat increasing invasive plant populations and degradation of sagebrush habitat. These cross-jurisdictional entities provide a collaborative approach to invasive plant management, coordinating control, and consolidating resources and workloads. However, because CWMAs are voluntary partnerships we cannot be assured that they will be implemented nor can we predict their effectiveness. In addition, the high coverage listed in Table X-4 does not suggest high coverage of effectively implemented management. It is difficult to determine effectiveness across programs because each program has unique ecological settings and social contexts. Local differences make these factors prone to large variability, which include circumstances such as vegetation type, geographic area, the nature and extent of the invasives problem, resources available for treatment, workforce, collaboration, relationships, as well as concerns of the public and policy tools (Goodwin 2015, pers. comm.).

Table X-4. Proportion of States covered by CWMAs and county weed organizations within the range of greater sage-grouse.

State	2005 Coverage (%)1	2015 Coverage (%)
Oregon	75–89	65–852
Nevada	75–89	95–100
Utah	75–89	95–100
Colorado	75–89	95–100
Washington	90–100	95–100
Idaho	90–100	100
Montana	90–100	95–100
Wyoming	90–100	95–100
North Dakota	50–74	95
South Dakota	<25	85–90

1 Center for Invasive Plant Management (2008).

2 To date CISM has not received verification of coverage from Oregon/

Assessment of Potential Threat

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

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Chapter 7: Conifer Encroachment

Introduction

Conifer encroachment has direct and indirect negative effects on sage-grouse throughout their range. Conifers occur as native vegetation in the western United States. Over the past 150 years, rates of encroachment into sage-grouse habitat has increased exponentially due to a variety of inter-related factors. Conifer encroachment results in direct loss of habitat over time; habitat fragmentation; alteration of vegetation communities; changes in fire regimes; lek abandonment, and other effects. Since 2010, concentrated conifer control and restoration projects have occurred in portions of the sage-grouse range with some success.

Threat description

Pinyon-juniper woodlands are a native habitat type dominated by pinyon pine and various juniper species that can encroach upon, infill, and eventually replace sagebrush habitat. Pinyon-juniper woodlands are often associated with sagebrush communities and currently occupy at least XX million ha (XX million ac) of the Intermountain West within the sage-grouse's range (Crawford et al. 2004, p. 8; Miller et al. 2008, p. 1). These two woodland types are often referred to collectively as pinyon-juniper or collectively as conifers; however, some portions of the sage-grouse's range are only impacted by juniper encroachment.

Comment [EJ55]: Need updated numbers from USGS; these are from 2010.

Conifer encroachment is a large-scale threat in parts of MZ III, IV, and V, affecting millions of acres of habitat, but is present at least locally in all management zones (FWS COT report table 2,pp. 23 - 36). It is estimated that as much as 90% of conifer encroachment is the western US is occurring sagebrush habitats (Davies et al 2011, p? ; Miller et al 2011, p?). Western juniper (*Juniperus occidentalis*) has exhibited geometric growth rates and expanded its range by as much as 600% in the last 150 years (Romme et al 2009, p ?). There is large variability in stand characteristics as they relate to successional phases after stand establishement (Miller et al 2005, p?). Pinyon-juniper expansion into sagebrush habitats, with subsequent replacement of sagebrush communities, has been well documented (Miller et al. 2000, p. 575; Connelly et a.l 2004, p. 7-5; Crawford et al. 2004, p. 2; Miller et al. 2008, p. 1). When juniper increases in mountain big sagebrush communities (*A. tridentate* *vaseyana*), 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* (cheatgrass), 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.

Current impacts

Pinyon-juniper extent has increased 10-fold in the Intermountain West since European settlement causing the loss of many native perennial bunchgrass and sagebrush-bunchgrass communities (Miller and Tausch 2001, pp. 15-16). This expansion has been attributed to the reduced role of fire, the introduction of domestic livestock grazing, particularly during the latter 1800s and early 1900s; however, these factors may not entirely explain the expansion of western juniper (Soule and Knapp 1999, p. ?).Conifer encroachment may be facilitated by increases in global carbon dioxide concentrations (CO2), climate change, and natural recovery from past disturbance (Miller and Rose 1999, pp. 555-556; Miller and Tausch 2001, p. 15; Baker, 2011 p. ?; see also discussion under Fire) but the influence of CO2 has not been supporded by some research (Archer et al 1995, p. ?).

Photos of the same monitoring site between 1969 and 2005. Photos from Miller et al 2008 above and BLM-Prineville 2005 below

Miller at al. (2005) characterized three stages of woodland succession: Phase I, where trees are present but shrubs and herbs remain the dominant vegetation that influence ecological processes (such as hydrologic, nutrient and energy cycles); Phase II where threes are codominant with shurbs and herbs, and all three vegetation layers influence ecological processes on the site; and Phase III where trees are the dominant vegetation layer on the site, with significantly reduced shrubs and herbs.

Table (XX) modified from Miller et al 2005 (table 4 page 29) Stand Characteristics

Characteristics	Phase I (early)	Phase II (mid)	Phase III (late)
Tree canopy	Open, actively	Actively expanding	Expansion nearly

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Currently, conifer encroachment is largely an infill issue, where Phase I sites are becoming Phase II sites, and Phase II sites are maturing into Phase III sites. Most sites vulnerable to invasion became occupied by trees in the late 1800s and early 1900s as a result of changing management on the landscape, primarily wildfire control (Miller et al. 2005, Miller et al. 2008). Approximately 80 percent of sites invaded by conifers are still in Phase I and Phase II, where some native shrubs and bunchgrasses are present (Miller et al. 2008).

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 woodland in the sagebrush-steppe and Great Basin sagebrush vegetation types were previously dominated by sagebrush vegetation prior to the late 1800s (Miller et al. 2014, 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.

Results of impact (vital rate/population level effects (direct, indirect)

Greater sage-grouse are negatively impacted by the expansion of pinyon pine and/or juniper in their habitats, even if the underlying sagebrush (*Artemisia* spp.) habitats remain (Freese et al 2009, p. ?). Sage-grouse avoid these areas of expansion (Casazza et al. 2010, p. ?), and as the pinyon and/or juniper increases in abundance and size, the underlying habitat quality for sage-grouse diminishes (COT REPORT p. 47). Pinyon-juniper encroachment into occupied sage-grouse habitat reduces, and likely eventually eliminates, sage-grous occupancy in these areas. At higher elevations, confier and juniper woodlands are encroaching into sagebrush shrublands (Tausch et al. 1982, p?; Miller et al 2011, p ?), again resulting in lower habitat suitability for sage-grouse. Almost all leks were in areas containing little confier or grassland cover in the surrounding landscape(Knick et al 2013 p. 10)

Doherty et al (2008, p. 187) reported a strong avoidance of conifers by female greater sage-grouse in the winter. Also, 2-year telemetry study in central Oregon by Freese (2009, pp. 84-85, 89-90) found that sage-grouse used areas with less than 5 percent juniper cover.

Results in Baruch-Mordo et al. 2013 suggest that sage-grouse incur population-level impacts at a very low level of encroachment as no leks remained active when conifer canopy cover exceeded 4%. This pattern corresponds with other findings of a negative relationship, or avoidance, of confier habitat affecting all sage-grouse life stages (ie. nesting, brood-rearing, and wintering; Doherty et al 2008; Atamian et al. 2010; Doherty et al. 2010a; Casazza et al. 2011). In Oregon, Baruch-Mordo et al. (2013, p.239) evaluated conifer cover within 1 km of active and inactive leks and found that "…no leks remained active at conifer cover of >4%". Knick et al. 2013 (p ?) found that active leks were absent from regions with greater than/equal to 40% conifer and averaged less than 1% conifer forest within 5 km, compared to an average of 13% for the study area and 3.4% for historice grouse locations. Also in Oregon, Freese (2009, p.84) evaluated GRSG habitat use based on areas with <5% juniper cover and areas with >5% juniper cover and found "Preferred cover types during the breeding season were low sagebrush/mountain big sagebrush with less than 5% juniper cover and low sagebrush with less than 5% juniper cover". For sage-grouse in the Bi-state Population Casazza et al. 2011, p.163 found "strong evidence indicates that brood-rearing sage grouse avoided areas of pinyon-juniper encroachment at larger spatial scales."

Location and extent

Conifer encroachment is an ongoing, year-round issue, affecting sage-grouse use of habitat throughout the year. Conifer encroachment has direct and indirect effects on lek attendance, nest success, increased predation and brood survival throughtout the year.

Annual encroachment rates that were reported in five studies raned 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).

Table 1-2: List of impacts by management zone.

Management Zone	Timing of Impacts (Season)	Immediacy of Impacts	Severity of Impacts	Extent of Impacts	Resource or Life stage impacted	Notes
Example	Spring (or all the time, etc.)	Happening right now (or planned)	Direct mortality (or habitat destruction, etc.)	Impacting X% of occupied range by MZ(see Kevin's models)	Lekking adults, broods	This is an example…
1						
2						
3						
4						
5						

PLACEHOLDER FOR MAP

Compounded effects

The compounding effects will be discussed in greater detail in the Compounded Effects chapter. In brief, the following impacts are likely to interact with the threat described in this chapter.

- Fire/invasive grasses
- Climate change/increasing CO_2 levels
- Livestock grazing

Projected Future impacts

Timescale for Projecting this Threat

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).

Likelihood of future impacts

Mgmt Zone	Acres at risk of Conf Encrch	% of Current Range
1	954,187	1.97%
2	2,503,530	6.75%
3	3,054,275	10.60%
4	2,838,762	7.43%
5	2,044,351	10.60%
6	13,628	0.49%
7	169,287	14.34%
Total:	11,578,020	6.59%

Figure XX: acres at risk of conifer encroachment, and percent of current range, by management zone. USFWS 2015 (data from Jim Lindstrom pers comm 3/18/15).

Miller et al. 2008 estimated that without intervention, 75% of encroachment in the western portion of the sag-egrousr ange may transition into Phase III within the next 30-50 years.

Regardless of the cause of conifer woodland encroachment, the rate of expansion is increasing and is resulting in the loss and fragmentation of sage brush habitats (FWS 2010). Baker (2011, p. ? and Miller et al (2014, p. 37) offer a suite of causes, acting in concert with fire exclusion that may better explain the dramatic expansion of conifer wodlands 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 fluctions favorable to tree regeneration, enhanced tree growth due to increased water use efficiency associated with carbon dioide fertilization, and recovery from past disturbance (both natural and anthropogenic).

As woodland expansion occurs, fuel loads increase, elevateing the risk of fires. For example, Chambers (2008) reportated that fuel loads were 8 times higher in woodlands than in native sagebrush-steppe ecosystems.

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.

Anticipated changes from present

NRCS is projecting 8 million acres conserved through SGI by 2018, but not all of this is conifer control.

What are state plan commitments?

Need to compare results of modelling with the results from CED, and very carefully crosswalk this with the commitment of $$ from NRCS. See placeholder introduction language in threat amelioration summary below.

Threat amelioration

Active Conservation

PLACEHOLDER

Introduction/background from the COT Report: The Conservation Objective: Remove pinyon-juniper from areas of sagebrush that are most likely to support sage-grouse (post removal) at a rate that is at least equal to the rate of pinyon-juniper incursion (COT REPORT 47) Treatments to remove pinyon-juniper trees in phase 1 (trees present but shrubs and hebs are the dominant vegetation that influence ecological processes) and phase 2 (trees are co-dominant with shrubs and herbs and all three vegetation layers influence ecological processes; Miller et al 2008) state of incursion should match the rate of incusion (minimally 200,000 acres per year, Stiver et al 2006). Removal should be prioritized by seasonal habitats, based on the habitat that is locally limiting populations. Removal techniques should not include prescribed fire in low elevation, xeric sagebrush communities.

Pinyon and/or juniper removal activities should focus initially on areas within PACs, but all opportunities to remove this threat should be considered if resources are available. Where sate sage-grouse management plans provide an effective strategy for pinyon-juniper, those strategies should be implemented. In all other situations the following conservation options should be considered.

1. Prioritize the use of mechanical treatments for removing pinyon and/or juniper. These techniques allow for more selective removal of invading plants, and more importantly allows understory habitats to remain intact.

2. Use caution when planning use of prescribed fire in high elecation mountain big sage sites toprevent fire escape and any subsequent establishment of invasive annual grasses or other weeds.

3. Reduce juniper cover in sage-grouse habitats to less than 5% (Freese 2009, Cassaza et al 2010), but preferably eliminate entirely.

4. Employ all necessary management actions to maintain the benefit of pinyon and/or juniper removal for sage-grouse habitat, including long-term monitoring (greater than 30 years) with appropriate management responses should the resultant habitat quality decline.

SGI has cut invasive conifer from 405,241 acres, of which 84% of removal is focused in four Great Basin populations (Northern Great Basin, Box Elder, Central Oregon, and Western Great Basin) and nearly half of the reclaimed acresare in Oregon, where conifer removal during SGI has increased by 1,411 percent and alleviated 68 percent of the threat on private lands inside PACs (NRCS SGI report 2015 page 7)

"Removing encroaching conifer reduces fuel load by half and can decrease the negative impacts resulting from catastrophic wildfire (Chambers et al 2008) in NRCS-SGI report 2/2015, page 17(COT REPORT 47-48)

Commons et al. (1999, p. 238) fount 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. Pinyon-juniper treatments, particularly when done in the early stages of encroachment when sagebrush and forb understory is still intact, have potential to provide an immediate benefit to sage-grouse. However, studies have not yet documented a correlation between pinyon-juniper treatments and increased sage-grouse productivity.

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Through the Conservation Efforts Database (CED), the Service collected information relating to conservation actions that were completed, in progress, or planned. Based on a summary report of that information created on XXXXXX, the following table indicate the number of actions and approximate areas for threat amelioration. These numbers are self-reported; the Service will further review and certify these actions if they are pivotal to any determination.

Comment [KNorman56]: Kate's attempt…

PLACEHOLDER FOR CED THREAT AMELIORATION REPORT

The Service addresses regulatory actions in a separate chapter????

Comment [KNorman57]: Do we want to make this easier on folks? Does that undermine the "take away"?

Table 1-3: List of Conservation Efforts (ameliorating threat described in this chapter) by management zone

Management Zone	Type of Conservation Effort	Sum of Acres or Miles	Number of Actions	Notes
1				
2				
3				
4				
5				

6	
7	

Threat Amelioration Summary

Baruch-Mordo et al 2013 calculated the average cost of conifer removal as approximately US$250/ha based on J. Maestas personal observation), but noted that this is a relatively conservative estimate compared to McClain's (2012) estimate to remove early encroachment stands (US$75/ha) and given that costs vary by tree density, terrain, and degree of post-treatment slash reduction. Using these assumptions, Baruch-Mordo et al 2013 estimated the total costs to treat all phase 1 and phase 2 conifer stands within 5k, of all leks in Oregon was $87.5 million.

Assessment of Potential Threat

asdfasdf

Comment [KNorman58]: This should be a VERY brief restatement of the introduction. 1 paragraph. Remind reader of the overall message.

Conifer expansion is a significant threat to sage-grouse throughout the range of the species. The rate of conifer expansion into sage-grouse habitat is increasing despite significant efforts and concentrated local successes to address this threat. Due to the interconnected nature of conifer expansion with other compounding effects, it is unlikely that the recommendations from the COT report (to address conifer encroachment at least at the rate of expansion) will be met.

Citations

Will insert as working through draft

Chapter 8: Agricultural Conversion

Introduction

Greater sage-grouse (*Centrocercus urophasianus*; hereafter sage-grouse) are sagebrush (Artemisia spp.) obligates—dependent on large areas of contiguous sagebrush, especially for nesting, early brood-rearing, and wintering habitats (Girard 1937, p. 7; Connelly *et al*. 2004, p. 4-15). However, for more than 150 years humans modified, fragmented, and destroyed sagebrush rangelands (Knick *et al*. 2011, p. 207). Consequently, sage-grouse currently occupy approximately 56 percent of their historical potential habitat (Schroeder *et al*. 2004, p. 369). Overall abundance has decreased by as much as 93 percent from presumed historical levels (Braun 2006, p. 3).

Agricultural conversion of sagebrush is one of the primary causes of habitat loss and fragmentation for sage-grouse (Baker *et al*. 1976, p. 165; Braun 1998, p. 143; Schroeder *et al*. 2004, p. 363; Aldridge *et al*. 2008, p. 983; Schroeder and Vander Haegen 2011, p. 519; Wisdom *et al*. 2011, p. 462). Agricultural conversion is particularly notable in the following Sage-grouse Management Zones (MZ): Columbia Basin (MZ 6), Great Plains (MZ 1), and Snake River Plain (MZ 4) (Connelly *et al*. 2004, p. 5-55; Knick *et al*. 2011, p. 209). Approximately 11 percent of the species' historical range was converted to agricultural lands (Connelly *et al*. 2004, p. 1-4; Knick *et al*. 2011, pp. 205 and 208). Topography, soils, and climate historically limited agricultural development on the remaining sagebrush rangelands; however, recent economic advantages (e.g., crops for biofuels) and technological improvements (e.g., extended irrigation coverage and cultivation) now permit development on steeper terrain and further from floodplains (Knick *et al*. 2011, p. 208).

THREAT DESCRIPTION

Agricultural conversion changes sagebrush rangelands to tilled agricultural crops or re-seeded exotic grass pastures, resulting in habitat loss and fragmentation for sage-grouse (U.S. Fish and Wildlife Service 2013, p. 48). Agricultural conversion is especially likely for sagebrush habitat with deep, fertile soils and higher precipitation rates (Connelly *et al*. 2004, p. 1-1; Davies *et al*. 2011, p. 2575). Indirect effects from agricultural conversion may include increased exposure to predation, West Nile virus (WNv), pesticides, fences, and invasive plants (Connelly *et al*. 2004, p. 7-23; Braun 2006, p. 11; Walker 2008, p. 184; U.S. Fish and Wildlife Service 2013, p. 42). Sage-grouse are more likely to be extirpated from areas containing greater than 25 percent cropland and less than 25 percent sagebrush (Aldridge *et al*. 2008, p. 983).

The 2010 12-month finding for the sage-grouse concluded that agricultural conversion is contributing to the present and threatened destruction, modification, and curtailment of sage-grouse habitat and range. Impacts are not uniform across the range, but are substantial in many areas (75 FR 13910, March 23, 2010). Throughout the historical range of the sage-grouse, agriculture is the largest single category of landcover in areas not currently mapped in sagebrush, but likely to have contained sagebrush historically (Connelly *et al*. 2004, p. 5-8; Miller *et al*. 2011, p. 156). Agriculture is the dominant land cover within the historical range of the sage-grouse in Washington (42 percent) and Idaho (19 percent) (Miller *et al*. 2011, p. 156). A total of more than 230,000 km² (88,780 mi²)—approximately 11 percent of the sage-grouse's historical range—was converted to agricultural lands (Knick *et al*. 2011, p. 208). Lands previously converted to agriculture continue to impact sage-grouse through habitat loss and fragmentation. Furthermore, additional conversion of sagebrush to agricultural land continues (Range-wide Interagency Sage-Grouse Conservation Team 2012, p. 7). Topography, soils, and climate historically limited agricultural conversion on approximately 90 percent of lands dominated by sagebrush; however, recent economic advantages (e.g., crops for biofuels) and technological improvements (e.g., extended irrigation coverage and cultivation) now permit conversion on steeper terrain and further from floodplains (Knick *et al*. 2011, p. 208). Irrigation canals cover an additional 991 km² (383 mi²); approximately 0.1 percent of the land area within the current range of the species (Knick *et al*. 2011, p. 209). In addition, the creation of reservoirs for irrigation, hydroelectric power, flood control, and other purposes has likely inundated some riparian habitat used during brood-rearing (Braun 1998, p. 144) and may attract predators.

CURRENT IMPACTS

Mechanism

Agricultural conversion eliminates sagebrush habitat through the removal of sagebrush and the subsequent cultivation of various crops. Sage-grouse depend on sagebrush habitats, especially for nesting, early brood-rearing, and wintering habitats (Girard 1937, p. 7). Sage-grouse avoid cultivated cropland when selecting nesting and brood-rearing habitat (Aldridge and Boyce 2007, pp. 508 and 523). In winter, sage-grouse require sagebrush for both cover and food (Connelly *et al*. 2004, p. 7-44; Doherty 2008, p. 22). Sage-grouse are more likely to be extirpated from areas containing greater than 25 percent cropland and less than 25 percent sagebrush (Aldridge *et al*. 2008, p. 983).

Agricultural conversion also fragments remaining sagebrush habitat. Habitat fragmentation due to agricultural conversion occurs throughout the species' range, wherever there is an abundance of cultivated land associated with remnant sagebrush rangeland (Connelly *et al*. 2004, p. 7-23; Davies *et al*. 2011, p. 2575; Range-wide Interagency Sage-grouse Conservation Team 2012, p. 7; Knick *et al*. 2013, p. 11; U.S. Fish and Wildlife Service 2013, p. 48). For example, agricultural conversion over the past 30–100 years along the Milk River in northern Montana is likely the largest barrier to sage-grouse migration in the Northern Montana population (Great Plains MZ 1) and a significant contributor to population decline (Bush *et al*. 2011, p. 537). This population is unique because some individuals undertake the longest migratory event observed for the species—more than 120 km (75 mi) one way—from south-central Saskatchewan and northern Montana during spring and summer to south of the Milk River in Montana for wintering habitat (Tack *et al*. 2012, pp. 65–66, Smith 2013, p. 12). Migratory corridors and winter habitat may be at risk if conversion to agricultural lands continues along the Milk River (Tack *et al*. 2012, p. 67).

Results of Impact

Sage-grouse require large intact areas of sagebrush. The percentage of land in agriculture is almost three-fold higher in extirpated sage-grouse range than in occupied habitat (Wisdom *et al*. 2011, p. 462). In the western portion of the species' historical range (California, Idaho, Nevada, Oregon, Utah, and Washington), less than 2 percent of all leks have more than 25 percent agriculture within a 5 km (3 mi) radius, and 93 percent of all leks have less than 10 percent agriculture within a 5 km (3 mi) radius (Knick *et al*. 2013, p. 6). We expect that agricultural conversion results in similar effects elsewhere in the species' range. Agricultural conversion of sagebrush is especially notable in habitat with deep, fertile soils and higher precipitation rates (Connelly *et al*. 2004, p. 1-1). This loss eliminates the most productive sagebrush rangelands as habitat for the sage-grouse and marginalizes the species onto less productive sagebrush habitat (Manier *et al*. 2013, p. 1). For example, in the Columbia Basin (MZ 6), approximately 75 percent of sagebrush rangelands occurring on deep, loamy soils are converted to agriculture, but only 15 percent are converted on shallow soils (Connelly *et al*. 2004, p. 7-23).

Several studies assess the impacts to sage-grouse from agricultural conversion:

In Idaho, decline in the number of males per lek from 1975–1992 was strongly correlated with a 74 percent increase in the amount of land converted to agriculture (Leonard *et al*. 2000, p. 268);

In Wyoming, the proportion of sagebrush habitat (positive effect) and the proportion of tilled agriculture (negative effect) within 6.4 km (4 mi) was correlated with lek persistence (Walker *et al*. 2007, p. 2650);

In North Dakota, the percentage of cultivated land within 4 km (2.5 mi) of active leks was lower than around inactive leks, and the proportion of cultivated land was greater within a region of historically occupied, but currently not occupied habitat, compared to a region where the species still occurred (Smith *et al*. 2005, p. 314);

In Wyoming, Montana, and Colorado, eliminating 16 percent or more of lands dominated by sagebrush through plowing or spraying herbicide correlated with a 50–100 percent reduction in the number of male sage-grouse occupying leks (Swenson *et al*. 1987, p. 129);

In Montana, conversion of 30 percent of winter habitat to agriculture in a 200 km² (74 mi²) area resulted in a 73 percent decline in the number of male sage-grouse occupying leks (Swenson *et al*. 1987, p. 130);

In Washington, sage-grouse have been reduced to two populations, primarily due to the conversion of sagebrush rangeland to cropland (Schroeder and Vander Haegen 2006, pp. 7–8;

In Montana, North Dakota, South Dakota, and Canada, the probability of active lek occurrence decreased with increasing proportions of agricultural tillage. Large leks were 4.5 times less likely to occur than small leks when agricultural tillage fragmented 21% of landscapes within 1 km (0.6 mi) of leks (Tack 2009, p. iii);

In Canada, nesting sage-grouse and broods avoided areas close to cultivated cropland (Aldridge and Boyce 2007, p. 508); and

Rangewide, few leks occurred in areas where the proportion of agricultural land exceeded 50 percent (Johnson *et al*. 2011, p. 407);

In summary, lek-count declines may begin when the proportion of sagebrush converted to agriculture is 1.5–2.5 percent of the landscape; substantial declines in lek counts may occur when this proportion exceeds 16 percent; and sage-grouse populations may be extirpated when the proportion exceeds 25–27 percent (Manier *et al*. 2013, p. 30).

Sage-grouse may use human-modified habitats such as irrigated croplands, pasture, and Conservation Reserve Program (CRP) lands, particularly during the late brood-rearing period when native plants have matured and dried, but agricultural lands remain green (Connelly *et al*. 2004, pp. 4-1 and 4-10; Knick *et al*. 2011, p. 211). However, the value of these modified habitats depends on the type of vegetation and the juxtaposition of the modified habitat in relation to adjacent sagebrush habitat (Connelly *et al*. 2004, p. 4-18). The use of irrigated cropland and pasture may not be beneficial to sage-grouse if it increases exposure to pesticides (Blus *et al*. 1989, pp. 1141–1142), WNv (Walker 2008, p. 184), or predation (Connelly *et al*. 2004, p. 7-23), or increases mortality caused by collision with fences (Braun 1998, p. 145; Braun 2006, p. 11).

Timing

The destruction, modification, and fragmentation of sagebrush habitat from agricultural conversion are long-term or permanent effects rather than periodic or seasonal. Sage-grouse use sagebrush habitats year-round.

Therefore, the impact to sage-grouse from agricultural conversion occurs throughout the year and persists from one year to the next (Figure X-1).

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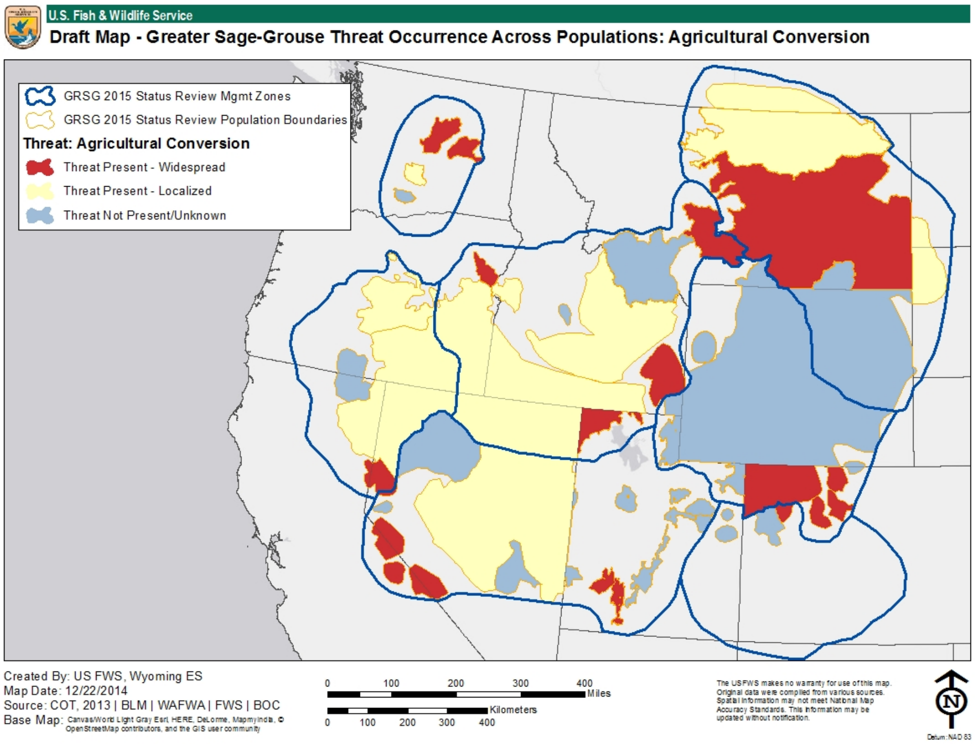
Figure X-1. Annual life cycle of sage-grouse (timing of impacts from agricultural conversion in relation to this life cycle is indicated by the red bar)

In addition to long-term or permanent effects caused by the loss and fragmentation of sagebrush habitat, agricultural conversion can result in the immediate removal of existing nests, eggs, and broods, if sagebrush is removed or mowing activities occur during the spring nesting or summer brood-rearing seasons.

Location and Extent

The extent of agricultural conversion is broad in scope, but the intensity of impacts varies between populations. The U.S. Fish and Wildlife Service (Service) drafted a collaborative report on conservation objectives for the sage-grouse with representatives from 10 states within the current range of the species (U.S. Fish and Wildlife Service 2013, p. ii). This effort is referred to as the Conservation Objectives Team (COT) Report. The following map illustrates the COT report's conclusions regarding the current threat to sage-grouse from agricultural conversion. The Bi-State populations (MZ 8) are included on maps for representation, but impacts to the Bi-State Distinct Population Segment are not addressed in this analysis.

Figure X-2. Impacts to sage-grouse from agricultural conversion [this map will be swapped out for a new map when available]



Agricultural lands are typically associated with private or tribal ownership (Stiver *et al*. 2006, Appendix C-2, pp. 11–13). The primary agricultural regions within historical sagebrush habitat occur in the Columbia Basin (MZ 6) (32 percent of total area) and the Great Plains (MZ 1) (19 percent of total area) (Knick *et al*. 2011, p. 209). Portions of the Snake River Plain (MZ 4) (25 percent of Idaho; 10 percent throughout the MZ) are also heavily affected by agricultural conversion (Connelly *et al*. 2004, p. 5-55; Knick *et al*. 2011, p. 209). The remaining management zones (Wyoming Basin, Southern Great Basin, Northern Great Basin, and Colorado Plateau; MZs 2, 3, 5, and 7 respectively) have less than 5 percent of the land in agriculture (Knick *et al*. 2011, p. 209). In addition to the direct loss of sagebrush habitat due to agricultural conversion, agriculture influences approximately 49 percent of remaining sagebrush habitat and 84 percent of priority habitats throughout the species' range by fragmenting remaining habitat and facilitating the movement of predators (Connelly *et al.* 2004, pp. 1-1 and 7-23; Manier *et al*. 2013, p. 30).

The following table summarizes recent conclusions regarding impacts to sage-grouse from agricultural conversion (Knick *et al*. 2011, p. 209; Manier *et al*. 2013, p. 158; U.S. Fish and Wildlife Service 2013, pp. 16–29). In the column describing extent of management zone impacted, we distinguish between direct impacts caused by habitat loss and the potential extent of indirect effects caused by an associated increase in avian predation.

Table 8-1: Impacts to sage-grouse

Management Zone	Timing (Season)	Immediacy	Severity[2]	Current Extent of MZ[3]	Resource/ Life stage	Notes
Great Plains (MZ 1)	Year-round	Imminent	Moderate	19%/91%	Sagebrush habitat/all sage-grouse life stages	Local impacts in 2/4 populations; widespread impacts in 1/4
Wyoming Basin (MZ 2)	Year-round	Imminent	Minor	4%/70%	Sagebrush habitat/all sage-grouse life stages	Widespread impacts in 4/9 populations
Southern Great Basin (MZ 3)	Year-round	Imminent	Minor	2%/62%	Sagebrush habitat/all sage-grouse life stages	Local impacts in 1/12 populations; widespread impacts in 2/12
					Sagebrush	Local impacts

[2] Impacts from agricultural conversion are documented at the population level as described in the Notes column.

[3] First percentage is the direct footprint; the second percentage addresses potential indirect effects based on a 6.9 km (4.3 mi) foraging distance for avian predators

Management Zone	Timing (Season)	Immediacy	Severity2	Current Extent of MZ3	Resource/ Life stage	Notes
Snake River Plain (MZ 4)	Year-round	Imminent	Moderate	10%/84%	habitat/all sage-grouse life stages	in 3/9 populations; widespread impacts in 4/9
Northern Great Basin (MZ 5)	Year-round	Imminent	Minor	4%/65%	Sagebrush habitat/all sage-grouse life stages	Local impacts in 2/4 populations; widespread impacts in 1/4
Columbia Basin (MZ 6)	Year-round	Imminent	Moderate	32%/90%	Sagebrush habitat/all sage-grouse life stages	Local impacts in 1/4 populations; widespread impacts in 2/4
Colorado Plateau (MZ 7)	Year-round	Imminent	Minor	5%/81%	Sagebrush habitat/all sage-grouse life stages	Widespread impacts in 1/2 populations
Bi-State (MZ 8)						Not evaluated

Compounded Effects

Sage-grouse population persistence is influenced by a combination of factors acting in synergy (Leu and Hanser 2011, p. 21). The factors listed below are discussed in more detail in their respective chapters. The compounding effects of these factors are discussed in greater detail in the Compounded Effects Chapter. In brief, the following factors are likely to interact with agricultural conversion.

Predation – Animals such as corvids (Corvus spp.), domestic cats (Felis catus), red fox (Vulpes vulpes), and cowbirds (Molothrus ater) are predators of sage-grouse or sage-grouse nests (Connelly *et al*. 2004, p. 7-23). The abundance of these predators may be increased by agricultural conversion, which can improve predator access and consequently reduce nest success (Connelly *et al*. 2004, p. 7-23). Sage-grouse may be increasingly subject to levels of predation that would not normally occur in the contiguous sagebrush habitat that was present historically.

West Nile virus – Sage-grouse are highly susceptible to infection from WNv (Naugle *et al*. 2005, p. 621; Clark *et al*. 2006, p. 18). Transmission of WNv may be exacerbated by man-made water sources such as irrigation canals that support mosquitoes, which transmit WNv to birds (Walker 2008, p. 184). WNv is likely a locally significant mortality factor.

Pesticides – Chemicals applied to crops can be toxic to sage-grouse foraging in cultivated fields (Blus *et al*. 1989, pp. 1141–1142; Connelly *et al*. 2004, p. 7-23). In southern Idaho, sage-grouse attracted to croplands sprayed with organophosphorus insecticides were later found intoxicated or dead (Blus *et al*. 1989). Insecticides potentially affect sage-grouse over broad regions, but no rangewide estimates of mortality are available.

Fences – Fences may be constructed to separate tilled land from rangeland. Fencing can fragment habitat and cause mortality due to collisions (Braun 1998, p. 145; Braun 2006, p. 11).

Invasive Species—agricultural conversion can result in the deliberate or accidental introduction of exotic plants that degrade sagebrush habitat (U.S. Fish and Wildlife Service 2013, p. 42).

PROJECTED FUTURE IMPACTS

Timescale for projecting impacts from agricultural conversion

Determination of the likelihood that impacts to at-risk species will continue in the future is a fact-based analysis that is specific to the species and the potential threat. Projections should only extend as far into the future as predictions are reliable. Habitat loss and fragmentation due to agricultural conversion that already occurred will continue indefinitely. Additional habitat loss and fragmentation due to future agricultural conversion is likely for some populations and will also continue indefinitely (see following section). Consequently, we anticipate that agricultural conversion will contribute to the present and threatened destruction (i.e., direct habitat loss), modification (i.e., compounded effects from predation, WNv, pesticides, fences, and invasive species), and curtailment (i.e., fragmentation) of sage-grouse habitat and range for the foreseeable future.

Likelihood of Future Impacts

Sagebrush habitat that has already been converted to agriculture will continue to impact sage-grouse in the future through long-term or permanent habitat loss and fragmentation. Additional sagebrush habitat loss and fragmentation from future agricultural conversion also is likely (Knick *et al*. 2013, p. 11). As previously mentioned, habitat characteristics such as topography, soils, and climate that historically limited agricultural development on approximately 90 percent of lands dominated by sagebrush no longer present such a barrier to development due to recent economic changes and technological improvements (Knick *et al*. 2011, p. 208). If agricultural activities are ongoing on the landscape and there is an abundance of private lands, the likelihood of further conversion is increased.

The following populations are at risk from additional agricultural conversion in the future:

Dakotas (Great Plains; MZ 1)—widespread threat;

Northern Montana (Great Plains; MZ 1)—localized threat along Milk River in Valley County;

Yellowstone Watershed (Great Plains; MZ 1)—widespread ongoing conversion;

Belt Mountains (Snake River Plain; MZ 4)—widespread potential threat;

Meeker-White River Colorado (Colorado Plateau; MZ 7)—widespread threat; and

Crab Creek (Columbia Basin; MZ6)—at risk of losing acres formerly enrolled in farm programs (U.S. Fish and Wildlife Service 2013, pp. 63–91).

[Discuss Results of Agricultural Conversion Model]

Anticipated Changes from Present

More of the sage-grouse range will be impacted by agricultural conversion in the future due to the ongoing removal and fragmentation of sagebrush within the range of the species. However, we expect that the rate of conversion from sagebrush to agriculture will slow because the most productive lands have largely been converted (Baker *et al*. 1976, p. 167). This conclusion is supported by statewide inventories showing changes in total cropland for every State from 1982–2010 (U.S. Department of Agriculture 2013, p. 4). For each State within the current range of the sage-grouse, with the exception of South Dakota, total cropland statewide on non-federal lands decreased during this time period. Some conversion of lands currently enrolled in the CRP back into cropland is likely; however, the extent of re-conversion is not known. Agriculture has the broadest spatial extent of impacts to the western landscape from human actions, covering approximately 10 percent of the western United States, exceeding urban areas and roads, the second and third most extensive anthropogenic features (Leu *et al*. 2008, pp. 1126 and 1130).

THREAT AMELIORATION

Federal and State programs that encourage landowners to conserve or restore sagebrush habitat can benefit sage-grouse. The following programs most commonly benefit the species.

Active Conservation

The CRP was authorized in 1985. It is a voluntary program administered by the Farm Service Agency that allows private landowners to receive annual payments in exchange for establishing permanent vegetation on idle or erodible lands that were previously used for growing crops. The purpose of the CRP is to control soil erosion, improve water retention, and provide wildlife habitat. Enrolled lands are set aside for 10–15 years and cannot be grazed except under emergency drought conditions. The enrollment of CRP lands can be detrimental to sage-grouse when sagebrush rangelands are converted to marginal croplands then subsequently converted to grasslands (U.S. Fish and Wildlife Service 2013, p. 48). CRP lands can also benefit the species, as described in the following section. However, the duration of enrollment may limit long-term benefits, unless the land remains retired from cultivation.

The Environmental Quality Incentives Program is a voluntary program administered by the Natural Resources Conservation Service (NRCS). It provides financial and technical assistance to agricultural producers through 10 year contracts that plan and implement conservation practices. The NRCS is using this program to fund their Sage-grouse Initiative (SGI) and assist producers in improving habitat for sage-grouse. Some of the conservation practices in the SGI address farming practices such as conservation crop rotation, critical area planting on erodible soils, and pasture/hayland planting of forage species compatible with sage-grouse (U.S. Fish and Wildlife 2010, pp. 20–21).

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

The Farm Bill of 2014 may directly affect future conversion of sagebrush rangelands to tilled crops in portions of MZ 1 (Montana, North Dakota, and South Dakota). The Bill includes a policy provision known as "Sodsaver." This provision reduces the Federal crop insurance subsidy available to landowners on any lands they convert to cropland (NRCS 2015, p. 14). This reduces the incentive to convert native rangelands to tilled crops. We address regulatory mechanisms directed at sage-grouse conservation in detail in other chapters.

Other voluntary Federal programs administered by the Service also can provide habitat for sage-grouse. Candidate Conservation Agreements (CCAs) between the Service and Federal or private landowners can be used to conserve and restore wildlife habitat. Candidate Conservation Agreements with Assurances (CCAAs) provide assurances to private landowners that if agreed-upon conservation measures are undertaken by the landowner, no further requirements will be made of the landowner if, in the future, the species is listed under the Endangered Species Act. The CCAs and CCAAs developed for sage-grouse often focus on ranching/grazing management practices; however, they can also include farm operations as a covered activity (e.g., CCAA for West Central Planning Area of Idaho, proposed CCAA for five Soil and Water Conservation Districts in Oregon). State programs such as State Acres for Wildlife Enhancement (SAFE) may also support sagebrush rangelands if sagebrush conservation is encouraged.

Through the Conservation Efforts Database (CED), we collected information relating to conservation actions for the sage-grouse that are completed, in progress, or planned. The following table lists conservation efforts described in the CED, or provided by Service Field Offices, that address impacts from agricultural conversion. Please note that the amount of lands conserved may not be additive for all stressors. For example, conservation easements can protect from both agricultural conversion and exurban development. However, the same lands are being protected.

Table 8-2: List of conservation efforts addressing agricultural conversion

Management Zone	Type of Conservation Effort	Lands Conserved	Number of Actions	Citation
Great Plains (MZ 1)	Conservation Easements	26,682 ha/65,881 ac	multiple	NRCS (2015)
Wyoming Basin (MZ 2)	Conservation Easements	95,260 ha/235,210 ac	multiple	NRCS (2015)
Southern Great Basin (MZ 3)	Conservation Easements	4,532 ha/11,191 ac	multiple	NRCS (2015)
Snake River Plain (MZ 4)	Conservation Easements	39,758 ha/98,167 ac	multiple	NRCS (2015)

Management Zone	Type of Conservation Effort	Lands Conserved	Number of Actions	Citation
Northern Great Basin (MZ 5)	Conservation Easements	11,693 ha/28,871 ac	multiple	NRCS (2015)
Columbia Basin (MZ 6)	Conservation Easements	1,769 ha/4,369 ac	multiple	NRCS (2015)
	CRP lands	109,480 ha/270,322 ac	multiple	Stinson (2014)
Colorado Plateau (MZ 7)	Conservation Easements	3,318 ha/8,193 ac	multiple	NRCS (2015)
Bi-State (MZ 8)				Not evaluated

Increased enrollment in the CRP has benefited sage-grouse, especially in the Columbia Basin (MZ 6) and Great Plains (MZ 1) (Knick *et al*. 2011, p. 208). Depending on the type of vegetation established and proximity to sagebrush, CRP lands can provide nesting, brood-rearing, and wintering habitat for sage-grouse (Schroeder and Vander Haegen 2006, p. 32; Schroeder and Vander Haegen 2011, pp. 524–528). The CRP is currently the largest effort to restore sage-grouse habitat in the Columbia River Basin, with approximately 109,480 ha (270,322 ac) of former agricultural lands enrolled in CRP in occupied habitat (Stinson 2014, p. 16). The proportion of sage-grouse nests in CRP lands in Washington State increased from 31 percent in 1992–1994 to 50 percent in 1995–1997 (Schroeder and Vander Haegen 2006, p. 4). This increase appeared to be associated with maturation of CRP lands, characterized by increased height and cover of perennial grasses and invasion by sagebrush. Lands may be beneficial to sage-grouse as soon as five years after enrollment (Stinson 2014, p. 9). Nesting success in CRP lands (41 percent) was comparable to nesting success in native sagebrush (35 percent) (Schroeder and Vander Haegen 2011, p. 525). The sage-grouse population in north-central Washington, an area with abundant CRP lands, was the only population in Washington that demonstrated an average rate of increase (Schroeder and Vander Haegen 2006, p. 6; Schroeder and Vander Haegen 2011, p. 528).

After enrollment in CRP expires, landowners may re-enroll lands or convert the land to some other use. Federal funding and economics related to crop prices can affect enrollment, and the long-term effectiveness of the CRP is uncertain. Local sage-grouse working groups in Idaho expressed concerns regarding the loss of CRP lands (Moore 2014, p. 5). . However, in Washington, lands have frequently remained enrolled since the late 1980s—long enough to allow for reestablishment of sagebrush and use by sage-grouse for nesting habitat (Schroeder and Vander Haegen 2011, p. 524). Other areas with abundant CRP lands (northern Utah, southeast Idaho, western Colorado, and eastern Montana) have not been similarly examined (Schroeder and Vander Haegen 2011, p. 529).

The following map shows the location of known conservation programs throughout the sage-grouse range.

[INSERT MAP WHEN AVAILABLE]

Summary

Existing agricultural lands should be managed to avoid or minimize adverse impacts to sage-grouse. Conversion of additional sagebrush habitat to agriculture should be avoided. Enrollment in voluntary conservation programs can protect or restore sage-grouse habitat. Some sage-grouse habitat is currently protected through enrollment in the CRP or other voluntary Federal or State programs, particularly in the Columbia Basin (MZ 6) and Great Plains (MZ 1).

ASSESSMENT OF POTENTIAL THREAT

The 2010 12-month finding for the sage-grouse (75 FR 13910, March 23, 2010) concluded that agricultural conversion is contributing to the present and threatened destruction, modification and curtailment of sage-grouse habitat and range. Most sage-grouse populations have steadily declined in recent decades (Connelly *et al.* 2004, p. 6-1; Garton *et al.* 2011, pp. 305–365; Manier *et al.* 2013, pp. 11 and 16; U.S. Fish and Wildlife Service 2013, pp. 63–91). Population declines are attributed to several factors, including agricultural conversion. The impacts to sage-grouse from agricultural conversion are not uniform throughout the species' range (Miller and Eddleman 2000, p. 1). The most widespread impacts from agricultural conversion will likely occur in the following populations:

Great Plains (MZ 1)—Dakotas and Yellowstone Watershed populations,

Wyoming Basin (MZ 2)—Eagle-South Routt, Middle Park, North Park, and Northwestern Colorado populations,

Southern Great Basin (MZ 3)—Panguitch and Bald Hills populations,

Snake River Plains (MZ 4)—Baker, East-Central, Belt Mountains, and Box Elder populations,

Northern Great Basin (MZ 5)—Warm Springs Valley population,

Columbia Basin (MZ 6)—Moses Coulee and Crab Creek populations, and

Colorado Plateau (MZ 7)—Meeker-White River population.

Some of the aforementioned populations are considered at high risk of extirpation (Dakotas, Eagle-South Routt, Belt Mountains, and Meeker-White River) (U.S. Fish and Wildlife Service 2013, pp. 63–91).

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Chapter 9: Oil and Gas

Introduction

asdfasdf

Comment [KNorman59]: The Elevator Speech (please write this last)
- What is the take home message (this is very bad across the range, this may be bad locally, this really isn't a big deal for all but a few populations)
- What has changed since 2010? What's new or different in a nutshell?

Threat description

During the last half-century, global demand for energy increased by more than 50 percent and according to the National Petroleum Council (2007, p. 46) a similar increase is anticipated to occur by 2030. The demand for energy in the United States is projected to increase by 0.5-1.3 percent annually (National Petroleum Council

2007, p. 46). Despite a growing recognition of negative global impacts to the environment from carbon dioxide emissions, fossil fuels remain the largest source of energy worldwide (Naugle *et al*. 2011, p. 55).

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). Oil and gas development has occurred in the past, with historical well locations concentrated in sage-grouse Management Zones (MZs) I, II, III, and VII (portions of Wyoming, eastern Montana, western Colorado, and eastern Utah; IHS Incorporated 2006).

Interest in developing oil and gas resources in North America has been cyclic based on demand, market conditions, and technological advances (Braun *et al*. 2002, p. 2; Applegate and Owens 2014, p. 287). For example, 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 such as the Energy Policy and Conservation Act (EPCA) of 1974 (National Petroleum Council 2007, pp. 5-7). EPCA (42 United States Code (U.S.C.) 6201 et seq.) includes mandates to effect an increase in energy development and 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 Federal land management agencies to designate energy transport corridors on Federal land in 11 western States for oil, gas and hydrogen pipelines and electricity transmission and distribution facilities (42 U.S.C. 15926).

Current impacts

Mechanism

Energy development impacts sage-grouse and sagebrush habitats through direct habitat loss from well pads, construction activities, seismic surveys, and associated infrastructure (roads, powerlines), and pipeline

Comment [LW 60]: First time it's mentioned… do we need to call is 'ntaural gas' (hereafter; gas)… and then refer to specifics (CBNG, CBM, etc.) when/where appropriate…?

Get what I'm saying?

Comment [LW 61]: Another term we'll have to determine a consistent way of referring to…

Comment [LW 62]: This includes western UT, southern great basin… so we need to adjust references to state locations below?

corridors; indirectly from noise, gaseous emissions, changes in water availability and quality, decreased habitat quality through increased exposure to invasive grasses, predators, and disease, and increased human activity and presence (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 2011, p. 267-271).

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). A recent technological shift from vertical to horizontal and directional drilling allows multiple wells to be placed on one pad, reducing the level of surface disturbance (Applegate and Owens 2014, p. 288).

Results of impact

A large and growing body of scientific literature documents overwhelmingly negative and often severe impacts from energy development activities (primarily oil, gas, coal-bed methane, and the extensive infrastructure associated with each) on sage-grouse populations (See Table X-1). Research has been focused primarily in eastern portions of the sage-grouse range (Powder River Basin (NE WY), Pinedale Anticline project (SW WY), Manyberries Oil Field (Canada), Cedar Creek Anticline (MT,ND,SD)) that are experiencing ongoing, rapid and widespread energy development (Naugle *et al.* 2011, p. 59).

Comment [LW 63]: Do we need 'corridors' here? Or just say 'pipelines' and roll up in the preceeding parathetical statement

Comment [LW 64]: 'surface' water…? My mind's going to WNv… so just a thought.

Comment [DP65]: I deleted because the sentence was really long and this is all captured in the preceding list.

Comment [DP66]: any information on how this could affect sagr? or sabr?

Comment [LW 67]: So we've referred to 'gas', coal-bed natural gas, and coal-bed methane below.
Again, related to my previous comment. If the specific type is appropriate then we should clarify. Could create confusion.

Comment [DP68]: how so? Can we provide an example? (including the reduction in the appurtenant facilities if appropriate

THIS TABLE NEEDS SIGNIFICANT WORK, WILL BE MORE CONCISE, HIGHLIGHTING CONCLUSIONS ON DISTANCE OF IMPACTS, TIME LAGS, AND BIOLOGICAL RESPONSE

Table 9-1: Recent research on the effects of energy development on sage-grouse.

Pub Yr	Location	Comparison	Covariate Investigated	Spatial Scale(s) Investigated	Sage-Grouse Biological Response	Source	Time lag
2014	Wyoming	Lek count comparison	Well pad density	point density of well-pads within 0.5, 1, 2, 5, and 10 km areas surrounding leks	1991-2011, oil and gas well-pad density increased 3.6-fold across the state. was associated with a 24% decline in the number of male sage-grouse. found a 1-to-4 year time lag between development density and lek decline.4- to-5 year lag occurs between the time that oil and gas development reaches a particular density to when population-level sage-grouse responses are observed	Gregory and Beck 2014	4-5 years
2014	Wyoming	Sage-grouse locations	oil and gas structures	0.27-km, 0.54-km, 1.00-km, and 3.00-km buffers	Sage-grouse avoid oil and gas structures.	Dinkins *et al.* 2014	
	Wyoming					Copeland *et al.* 2013	
2013	NE Wyoming, E Montana, W Dakotas (most of MZ1)	Lek count comparison	Well pad densities and West Nile virus occurrence	Well density within 1.0 km, 3.2 km, 5 km, 10 km, and 15 km and 20 km of leks	Decline in lek size with increasing well density. Decline from West Nile virus was worsened by high levels of oil and gas development.	Taylor *et al*. 2013	
2012	Wyoming	Sage-grouse	Distance to	Multiple buffers	Females avoided nesting and brood-rearing	Kirol 2012	

Pub Yr	Location	Comparison	Covariate Investigated	Spatial Scale(s) Investigated	Sage-Grouse Biological Response	Source	Time lag
		female nesting and brood-rearing (early and late) occurrence	well pads; proportion of buffer disturbed by gas development activities	to 1.26 km (5 km2) of seasonally selected sites	in areas with increased numbers of visible wells within a 1-km2 area; females avoided sites when the proportion of a 5-km2 area disturbed by gas development exceeded 8%		
2012	Wyoming	Sage-grouse chicks survival	Proportion of buffer disturbed by gas development activities	Multiple buffers to 1.26 km (5 km2) of seasonally selected sites	Chick survival decreased when the proportion of a 1-km2 area disturbed by gas development exceeded 4%		
2012	Bighorn Basin, north-central Wyoming	Lek activity comparison	Well pad densities	5 scales (1.0, 3.2, 4.0, 5.0, and 6.4 km buffer of leks)	0% probability of lek occurrence when well pad densities exceeded 6.5 pads/mi2 (section)	Hess and Beck 2012	
				1, 3.2, 5, 10, 15 and 20 km		Taylor *et al* 2012	
2011	Eastern range of species	Lek count comparison	Well pad densities	3.2-km buffer of leks	Well pad densities exceeding 1 pad/mi2 (section) negatively influence number of sage-grouse on leks	Naugle *et al*. 2011	
2011	Eastern range of species	Lek count comparison	Distance to well pads	N/A (study area)	Impacts to the number of males on leks were most severe when infrastructure occurred near leks; impacts remained discernible out to distances of 6.2 to 6.4 km		
	Wyoming	Lek count comparison	Well pad densities	3.2 km buffer around leks	probablity of lek persistance and abundance of males on leks declined with an increase in well density. Time lags were identified	Doherty *et al*. 2010	4 years

Pub Yr	Location	Comparison	Covariate Investigated	Spatial Scale(s) Investigated	Sage-Grouse Biological Response	Source	Time lag
2010	Wyoming	Lek count comparison	Well pad densities	8.5-km buffer of leks	Impacts to the number of sage-grouse on leks found at well pad densities >0.4 to 0.8 well pads/km2 (0.15 to 0.3 pads/section). Time lags up to 10 years were indicated.	Harju *et al*. 2010	2-10years
2010	Wyoming	Lek count comparison	Distance to well pads (pad presence (1) vs. absence (0) within buffers of leks)	Multiple buffers to 4.8 km of leks	Well pads within smaller buffers (<1.6–2 km) around leks associated with 35–76% fewer sage-grouse on leks compared to leks with no well pads within these buffers		
2010	Wyoming	Sage-grouse female nesting occurrence	Distance to well pads	N/A (study area)	Yearling females avoided nesting within 950 m of well pads. Yearling males had reduced survival and recruitment.	Holloran *et al*. 2010	
2010	Alberta, Canada	Sage-grouse winter occurrence	Distance to well pads	N/A (study area)	Sage-grouse avoided habitats within 1.9 km of infrastructure during winter	Carpenter *et al*. 2010	
2009	Montana and western North and South Dakota, USA, and southeast Alberta and southwest Saskatchewan, Canada	Comparison of occurrence of large (>25 males) vs. small leks vs. inactive leks	Well pad densities	12.3-km buffer of leks	Large leks did not occur in areas where well pad densities exceeded 2.5 pad/mi2 (section)	Tack 2009	
2009	Management Zone I (Great Plains: includes	Lek count comparison	Build out scenarios based on		Predict 7-19 percent population decline based on anticipated oil and gas developement.	Copeland *et al*. 2009	

Pub Yr	Location	Comparison	Covariate Investigated	Spatial Scale(s) Investigated	Sage-Grouse Biological Response	Source	Time lag
	portions of MT, WY, ND, SD, SA, and AB) and II (Wyoming Basin: includes portions of ID, WY, UT, MT, and CO)		BLM planning documents				
2008	Powder River Basin, NE Wyoming and SE Montana	Sage-grouse winter locations to landscape features (vegetation, topographic, and energy development)			Sage-grouse avoided development (wells within a 4 km2 area) in otherwise suitable habitat.	Doherty *et al.* 2008	4 years
2007	Alberta, Canada	Nest and brood occurance.	Well pad densities	1 km2 buffer around nest and brood locations	Chick survival decreased with increasing numbers of visible wells within 1 km of brood-rearing locations. Nest success was independent of well density.	Aldridge and Boyce 2007	
2007, 2008	Powder River Basin, NE Wyoming and SE Montana	Lek count comparison	Well pad locations	3.2 km buffer around leks	Reduces lek attendance and persitance and lag effect. lek-countindices in CBNG fields declined by 82%, at a rate of 35%per year (x¯ rate of increase in CBNG¼0.65, 95% CI: 0.34– 1.25) whereas indices outside CBNG declined by 12%, at a rate of 3% per year.Among leks active in 1997 or later, fewer leks remained active by 2004–2005 in CBNG	Walker *et al.* 2007	3-4 years

Pub Yr	Location	Comparison	Covariate Investigated	Spatial Scale(s) Investigated	Sage-Grouse Biological Response	Source	Time lag
					fields (38%) than outside CBNG fields (84%; Table 1).12 became inactive after or in thesame year that development occurred (Fig. 4). The averagetime between CBNG development and lek disappearancefor these leks was 4.1 6 0.9 years (x¯ 6 SE).analysis indicates that maintaining extensive stands of sagebrush habitat over large areas (6.4 km or more) around leks is required for sage-grouse breeding populations to persist.		
2005	Upper Green River Basin, W Wyoming	Lek count comparison. Female nest and brood location.	Distance to development, well and road densities, and traffic activity levels and timing.	5km buffer around known leks	Decline in male lek attendance and recruitment of juvenile males. Decreased female and male survival. Avoidance of nesting and brooding females. Demonstrated lag period between development and sage-grouse response. Breeding population decline within 3-5km of developement	Holloran 2005	
2006	Upper Green River Basin, W Wyoming	nest locations, survival, lek recruitment of yearling males and females	drilling rigs, producing wells, and main haul roads	within 10 km of study area,5 km of drilling rigs, 3 km of producing wells, or 3 km of main haul roads	Avoidance, reduced recruitment, reduced chick survival	Kaiser 2006	
2003	Near Pinedale, SW Wyoming	Female nest initiation and nest success	Distance to development	6 leks classifies as disturbed or undistirbed	Nest initiation: disturbed leks = 65%; undisturbed leks = 89%. Success was 50% at both disturbed and undisturbed	Lyon and Anderson 2004	

Comment [DP69]: For those studies that did not document a time lag information should be noted in the time lag column. For example, no time lag discussed, or something similar/appropriate.

Pub Yr	Location	Comparison	Covariate Investigated	Spatial Scale(s) Investigated	Sage-Grouse Biological Response	Source	Time lag
				based on development within 3km			

An example of one such area extensively researched is the Powder River Basin in northeastern Wyoming and southeastern Montana (MZ 1) that has experienced significant shallow coal bed natural gas development. 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. Between 1997 and 2007, approximately 35,000 producing wells were in place on Federal, State, and private holdings in the Powder River Basin area (Naugle *et al*. 2011, p. 492). In 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). 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. In the Powder River Basin area, population trends projected an almost 90 percent decline by 2037 (Garton *et al*. 2011, p. 310). This projection is consistent with the Walker *et al*. (2007a, 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, resulting in declining population trends. In 2013, this area of Wyoming had the lowest average peak male lek attendance in the state, averaging 9 males per active lek versus the statewide average of 17 males (Northeast Wyoming Sage-grouse Working Group, 2014, p. 4).

Comment [DP70]: we should follow up on this to see what has happened here.

Comment [DP71]: so there is a mixing of units here that at first confused me. lek persistence , population trend and males/active lek. They don't compare equitably – hence the suggested edits.

Does the local working group document also report the number of active leks? If si I would include that here. If the number of leks is declining that would be key information to report here (along with the peak male attendance) .

The population declines and extirpations (loss of leks) associated with energy development result from decreased lek attendance and behavioral avoidance (Holloran 2005, pp. 38-39, 50; Kaiser 2006, p. 23; Walker *et al*. 2007a, p. 2648; Harju *et al*. 2010, p. 443; Taylor *et al*. 2013, p. e71256), lower nest initiation (Lyon 2000, p. 109; Lyon and Anderson 2003, p. 5), poor nest success (Aldridge and Boyce 2007, p. 517; Webb *et al*. 2012, p. 9), decreased survival in all sex and age classes (Holloran 2005, p. 54; Kaiser 2006, p. 34; Aldridge and Boyce 2007, p. 517; Holloran *et al*., 2010, p. 70; Kirol 2012, p. 15;), and avoidance of energy infrastructure in important wintering habitat (Doherty *et al*. 2008, pp. 192-193; Carpenter *et al*. 2010, p. 1811; Dzialak *et al*. 2012, p. 12; Dzialak *et al*. 2013, p. 16; Smith *et al*. 2014, p. 15). Populations are negatively affected by energy development activities, especially those that degrade important sagebrush habitat, even when mitigative measures

Comment [DP72]: ? is extirpation the loss of one lek or several? I think I would clarify (if appropriate) to something like:

"The population declines and extirpations (as indicated by the loss of all active leks)….

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).

The biological response of sage-grouse populations to development may not be immediate. A growing number of studies have identified time lags between the onset of energy development activity and population-level impacts (i.e. declines in numbers of sage-grouse on leks, population extirpation) (Holloran 2005; Walker *et al* 2007a, p. 2651; Doherty 2008, p. 78; Doherty *et al* 2010, p. e10339; Harju *et al*. 2010, pp. 441-445; Gregory and Beck 2014, p. e97132). Population level impacts may not become apparent for up to 10 years following onset of development (3-4 years, Walker *et al* 2007a, p. 2651; 4 years, Doherty 2008, p. 78; 4 years, Doherty *et al* 2010, p. e10339; 2-10 years, Harju *et al*. 2010, pp. 441-445; 4-5 years, Gregory and Beck 2014, p. e97132). The lag time is likely the result of a combination of factors including the pace and extent of development, the high site fidelity but reduced survival of adults, and lowered recruitment and behavioral avoidance exhibited by yearling sage-grouse (Harju *et al*. 2010, p. 443; Holloran *et al* 2010, p. 70; Taylor *et al*. 2012, p. 8; Gregory and Beck 2014, p. e97132). Identification of time lags is vitally important to understanding the impacts of energy development on sage-grouse persistence across the range; impacts from recent (within the past 4 years) development have likely not been fully realized.

Direct habitat loss, degradation, and resulting fragmentation of remaining habitat 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). Energy development contributes to direct habitat loss and degradation 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 (See Table x-2 below).

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 Sage-grouse Conservation Area (estimated pre-settlement sage-grouse

Comment [DP73]: good idea to include the time spans by source!

Comment [DP74]: we need to define recent so I pulled this from the range presented above.

Comment [LW 75]: Just some food for thought. Likely project proponents, operators, and some agencies might/may argue that these are not necessarily losses, but rather temporary degradations. The literature would support otherwise given the lack of success in reclaimation and restoration… but it is something we should keep in mind.

Comment [DP76]: are these from the SAB? If so they need a year and page number

Comment [DP77]: citation? We also may want to combine with above describing this to minimize repetition.

Comment [DP78]: but if there is direct habitat loss from thumping it could be more extensive than the size of the field right? Without any literature quantifying losses due to thumping this would be very hard to tease out, but we might want to mention that habitat will minimally be degraded by thumping

Comment [LW 79]: Do we want/need to explain this term earlier? We use it to explain the area of interest, but it's not our term and could confuse the reader. May help put the percentages in context…? Or tie back to our spatial layers…?

distribution; SGCA) (Knick *et al*. 2011, p. 240). However, the estimated ecological footprint (the extended effect of the infrastructure or activity beyond its physical footprint and determined by a physical or behavioral response of the sage-grouse) is more than 13.8 million ha (34.2 million ac) or 6.7 percent of the SGCA (Knick *et al*. 2011, p. 240) based on applying a zone of influence to estimate potential avoidance, increased mortality risk, and lowered fecundity in the vicinity of development (Lyon and Anderson 2003, p. 459; Walker *et al*. 2007a, p. 2651; Holloran *et al*. 2010, p. 70). Based on their method, Knick *et al*. (2011, p. 240) 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*. 2011, p. 240). Copeland *et al*. (2009, p. 6) modeled a scenario where a minimum of 2.3 million additional ha (5.7 million ac) would be directly impacted by oil and gas development by the year 2030 based on 20-year reasonable foreseeable development projections from the BLM's resource management plans (RMPs). The corresponding ecological footprint is likely much larger. This projected increase in oil and gas energy development within the sage-grouse range would reduce the population by 7 from today's numbers (Copeland *et al*. 2009, p. 4). This projection does not reflect the effects of the increased development of renewable energy sources or conservation actions to reduce the physical and ecological footprint of development..

Comment [LW 80]: Including or excluding the zone of influence?

Comment [DP81]: did I get this right?

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

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

Comment [DP82]: I added this because I thought this paragraph was going to focus on roads again. Hopefully the parentheses resolves this.

infrastructure footprint is relatively small (typically 6¬8 ha per 2.6 km2 (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.

Comment [DP83]: I don't understand this sentence. What is the project area? What is the area of influence used and why?

Comment [DP84]: Its not intuitive that a loss of sagebrush is the result of cumulative impacts of energy development and other human activities. I suggest re-working.

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). More recent research found that leks experimentally exposed to noise had an average 51 percent decline in male lek attendance and a similar decline in female attendance (48 percent) (Blickley *et al* 2012, p. 467). Leks were exposed to either intermittent traffic road noise or relatively continuous drilling noise typical at a developed site. The magnitude of decline differed by noise type; leks exposed to road noise, declined by 73 percent while leks exposed to drilling noise decreased by 29 percent. The impact of the noise on leks was immediate and sustained, and continued over the 3 consecutive breeding seasons monitored during the experiment indicating that sage-grouse did not become sensitized to this disturbance. Chronic noise (from either source) also increased stress hormone levels and masked the male vocalizations that females use to locate leks and assess potential mates (Blickley *et al* 2012, p.

Comment [DP85]: citation

5; Blickley and Patricelli 2012, pp. 30¬–32; Kock *et al*. 2015, pp. 353-357).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.

Comment [DP86]: move this to the discussion on thumping

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.

Comment [DP87]: while the info in this paragraph is correct it needs further development to get at the magnitude of the impact (as well as citations)

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, proximity to natural gas discharge reservoirs negatively influenced nest success in the Powder River Basin in Wyoming (Kirol *et al*. 2015, p. 104). Kirol *et al*. (2015) hypothesize the decreased nest success might be due to increased nest predation by species like the striped skunk (Mephitis mephitis) and common raccoon (Procyon lotor) that are more commonly associated with water and riparian areas. The increased surface-water on the landscape may also 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 Disease and Predation). Produced water also could result in direct habitat loss through prolonged flooding of sagebrush areas, or if the discharged water is

Comment [DP88]: but this is also influenced by the quality of the discharge water.

Comment [DP89]: update citation.

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). Recently samples collected near (5-110 m) oil and gas production sites in Wyoming showed high concentrations of volatile compounds including benzene, formaldehyde, and hydrogen sulfide (Macey *et al*. 2014, p. 8). Concentrations exceeded health-based risk standards. No information is available regarding the effects to sage-grouse of gaseous emissions produced by oil and gas development.

Comment [DP90]: Another item to consider is the loss of vegetation from dust covering plants. Franz Inglefinger did a MS at UW on this relative to sagebrush dickey birds. It might be useful her.

Comment [DP91]: you should talk to Kim D. I think she is either testing or has found elevated trace elements in raptors in the Pinedale area that are the result of poor air quality. Perhaps her data are not rip yet.

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)

PLAN TO GREATLY EXPAND DISCUSSION ON DISTANCE OF EFFECTS, AND INCLUDE EXAMPLES OF OUTLIERS i.e., HEAVILY DEVELOPED AREAS THAT DID NOT HAVE EXTREME DECLINES etc…

The extent of indirect impacts (the area of influence beyond the direct footprint of a project) range widely for energy projects and their associated infrastructure (See Table X-1). While the areas of influence reported in the scientific literature are widely variable, they are significant in magnitude; negative impacts have been documented many miles from the area of actual direct habitat loss (range 3.2km (2mi) to 20km (12.4mi)). Impacts are more severe when development is in close proximity to the lek (i.e., within nesting habitat), however, negative impacts can remain discernable for much greater distances. Impacts to sage-grouse in Wyoming were not detected at low levels of development (~1 well per section [259 ha or 640 ac]) (Doherty *et al*. 2010, p. e10339). Above this level, however, lek losses were 2 to 5 times greater inside than outside of developed areas. Leks that remained active in developed areas experienced a 32-77 percent decline.

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. 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

Comment [acn92]:

Comment [acn93]:

Comment [DP94]: citations?

Comment [DP95]: citation

Comment [DP96]: we will probably want to revisit this statement once we have the allocative layers/decisions from the BLM. This will likely have to be re-phrased in the past tense and we will have to present the new information.

We also need to consider development off BLM surface. Even if the ylease the subsurface the surface restrictiosn are determined by the surface land management agency. So this as written is an overstatement.

Comment [DP97]: and also the majority of non-renewable energy development

Comment [DP98]: given the age of this reference I don't think this is something we can use as an accurate assessment of current condition. Hopefully this is here as a place marker until we get the model and/or the GIS layer?

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).

Comment [DP99]: see above comment. We will need to update this section with new information. We also need to consider the impacts of energy development on non-BLM surface.

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).

Comment [DP100]: update as new information becomes available.

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 on federal lands in the sage-grouse range vary from 1 well per 32 ha (80ac) to 1 well per 16 ha (40 ac) (Naugle *et al*., 2011, pp. 497). Holloran (2005, pp. 38-39, 50) reported that male sage-grouse attendance at leks decreased over 23 percent in gas fields where well density was 5 or more within 3 km (1.9 mi). Sage-grouse are less likely to occupy areas with wells at a 32 ha (80 ac) spacing than a 400 ha (988 ac) spacing (Doherty *et al*. 2008, p. 193).

Comment [DP101]: we should add examples of exemptions – something like due to tight sand formations, other resource sonsiderations such as archaeological sites, etc.

Comment [DP102]: H asn't Jonah gone to 10 acrea spacing? We should check.

Comment [DP103]: Holloran also reported that there was a negative response when well density exceed the 1/699 acres – that would be a good citation to add given the content above. It's the same reference (his dissertation).

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).

Comment [DP104]: need to bring in Kirol et al. 2015 in this discussion. Its not specific to reclamation but does talk about how minimization measures, including miniziming footprints, can improve conditions for sagr (but not to the level of undisturbed habitats).

Comment [DP105]: Need to identify its not an immediate response – it can take years for reclamation to provide sagr habitat. That leads to all kinds of concerns with a change in land use – if its not been available for years sagr may not come back even if fully reclaimed – at least not right away.

Timing

The destruction, modification, and fragmentation of sagebrush habitat from energy development are long-term or permanent effects rather than periodic or seasonal. Effects to all sex and age classes have been documented. Sage-grouse use sagebrush habitats year-round. Therefore, the impact to sage-grouse from energy development occurs throughout the year and persists from one year to the next.

Figure X-1. Annual life cycle of sage-grouse. Impacts from energy development are indicated by the red bar.

Location and extent

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 (MZ II) as defined by EPCA (DOI *et al*. 2008, p. 3¬11) is highest in sagebrush-dominated landscapes (Knick *et al*. 2003, pp. 613, 615)

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 2011, p. 383).

Comment [DP106]: We need to add the Bakken and the fact that all sagr habitat in ND is now leased. Kevin shelley in our ND office can probably help with a citation on this.

Comment [DP107]: update citation

Comment [DP108]: we should try to update this if possible – hopefully is in the data call received from the states?

Between 1997 and 2007, approximately 35,000 producing wells were in place on Federal, State, and private holdings in the Powder River Basin area (Naugle *et al*. 2011, p. 492). In 2008, the BLM in Montana completed a supplement to the 2003 Environmental Impact Statement (EIS) and Record of Decision (ROD) to allow for 5,800–16,500 new coal bed 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*. 2011, p. 492). 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. 493).

Comment [DP109]: update citation

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).

Comment [DP110]: citations?

Comment [DP111]: didn't they also predict extirpation of some local leks and populations?

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 (2011, p. 263) as experiencing high-intensity human activity that is consistent with lek loss and population decline (Wisdom *et al*. 2011, p. 467). 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. e7400).

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*. (2011, p. 467) 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 (Table x-1), is expected over time to reduce

Comment [DP112]: were they ever developed? We should probably update this section with actual development information if available.

Comment [DP113]: citation

Comment [DP114]: didn't Knick and Hanser also come to this conclusion? If so we should cite them as well.

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. 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).

Comment [DP115]: we need to update with current levels of development.

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.

Comment [DP116]: update with what has actually been developed.

Comment [DP117]: We need to include information on NPL (Natural Pressurized Lance) development which will be additional to Pinedale and Jonah.

Knick *et al.* (2011, pp. 237-236) reviewed BLM documents for the Greater Green River Basin area, which includes the Pinedale and Jonah projects, and reported that 6,916 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*. 2011, p. 240). 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).

Comment [DP118]: update information.

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*. 2011, pp. 208, 212; Leu and Hanser 2011, p. 270). 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*. 2011, p. 299; COT 2013, pp. 17-18, 27-28) although population data are limited for most of this area (Garton *et al*. 2011, p. 316, 363).

Based on applying a 3 km (1.9 mi) buffer to construction areas, Knick *et al*. (2011, p. 240) 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

Comment [DP119]: update information

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).

Table X-2. Impacts by Management Zone

Management Zone	Timing of Impacts (Season)	Immediacy of Impacts	Severity of Impacts	Energy footprint as a percent of Occupied Range	Resource or Life stage impacted	Notes
1	Year round	Imminent	Population-level decline	1.87	All seasonal habitats and life stages	
2	Year round	Imminent	Population-level decline	2.32	All seasonal habitats and life stages	
3	Year round	Imminent	Local impacts	0.22	All seasonal habitats and life stages	
4	Year round	Non-Imminent	Local impacts	0.12	All seasonal habitats and life stages	
5	Year round	Non-imminent	Local impacts	0.16	All seasonal habitats and life stages	
6	Year round	Non-imminent	Local impacts	0.13	All seasonal habitats and	

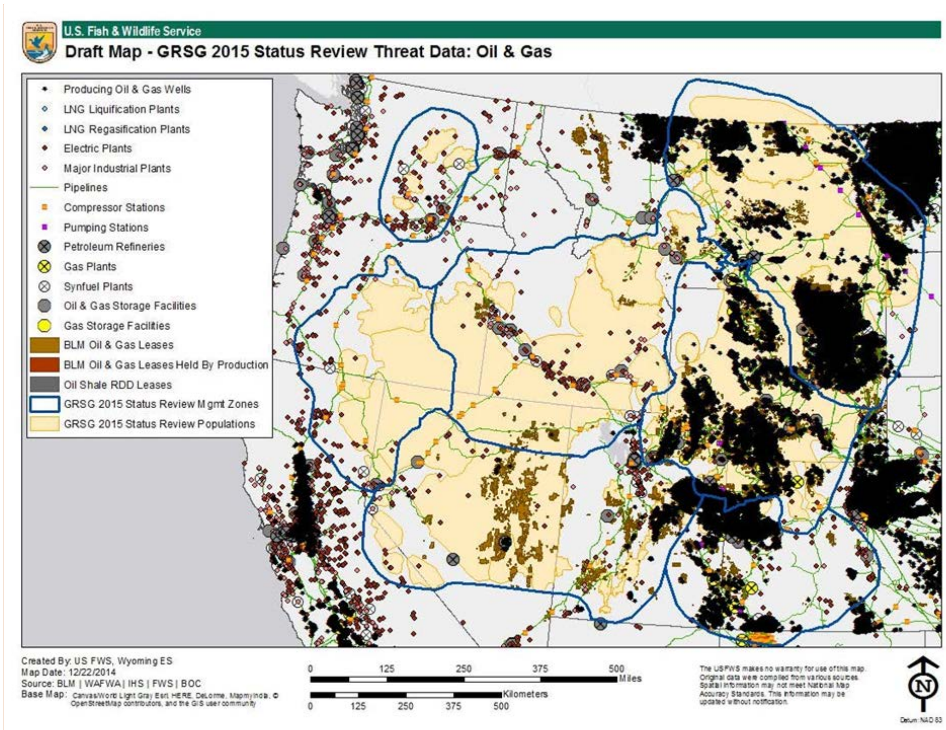
Comment [DP120]: update information. For this entire section we need to show what has changed since 2010

Comment [DP121]: I suggest consistency in terminology. If we use immediacy in the title it should also be used in the description.

Comment [DP123]: suggest deleting column as it is empty.

Comment [DP122]: will need to be updated

					life stages
7	Year round	Immenent	Population-level decline	3.36	All seasonal habitats and life stages



Comment [DP124]: very scary map

Figure X-2. Placeholder draft map of all energy

Compounded effects

The compounding effects will be discussed in greater detail in the Compounded Effects chapter. In brief, the following impacts are likely to interact with the threat described in this chapter.

- Predation

- Disease
- Infrastructure
- Hunting

Projected Future impacts

Timescale for Projecting this Threat

The effects of oil and gas development 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. asfasfd

Likelihood of future impacts

asfasdfas

Anticipated changes from present

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

The decline in use of conventional fossil fuels for power generation in the future is expected to be supplemented with biomass, unconventional oil and gas, and renewable sources—all of which are existing or

Comment [DP125]: can we provide a one or two sentence summary here?

Comment [DP126]: Does Naugle address this in his energy development book? (the time frame and looking forward).

Comment [KNorman127]: How far into the future can we reasonably predict this threat

Comment [acn128]: Clearly articulated, fact-based rationale for timeframe.

Comment [DP129]: You may want to crosswalk this with the climate change chapter for information on how policy, etc. are affecting the rate of energy development. I think it was addressed there….

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. 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.

Comment [DP130]: is this within the range of sagr? If so is there a source of updated information?

Threat amelioration

Comment [KNorman131]: The CED reports will include a summary of conservation actions designed to ameliorate each threat.

Based on January In-Person meeting, this list may include ALL self-certified actions. Service personnel may need to further review these actions in future.

Comment [DP132]: For WY, and maybe MT, we need t oassess how the core area strategies are affecting impacts for sagr, especially those projecting forward. That is estimates from "earlier" literature (pre-2008) may no longer be accurate for WY simply because of the limits placed on development due to implementation of the EO.

Active Conservation

Through the Conservation Efforts Database (CED), the Service collected information relating to conservation actions that were completed, in progress, or planned. Based on a summary report of that information created on XXXXXX, the following table indicate the number of actions and approximate areas for threat amelioration. These numbers are self-reported; the Service will further review and certify these actions if they are pivotal to any determination.

Comment [KNorman133]: Kate's attempt…

The Service addresses regulatory actions in a separate chapter????

Comment [KNorman134]: Do we want to make this easier on folks? Does that undermine the "take away"?

Table 9-2: List of Conservation Efforts (ameliorating threat described in this chapter) by management zone

Management Zone	Type of Conservation Effort	Sum of Acres or Miles	Number of Actions	Notes
1				
2				
3				

Management Zone	Type of Conservation Effort	Sum of Acres or Miles	Number of Actions	Notes
4				
5				
6				
7				

Threat Amelioration Summary

Asdfasdf

Assessment of Potential Threat

We concluded the following in our 2010 Finding, "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)."

Comment [DP135]: we probably need to beef this up a bit…..

CITATIONS

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Chapter 10: Mining

Introduction

Comment [RJB136]: For final reviewer – I have tried to make this as complete as possible prior to sending it to you. Needed still: 1) Still need the data tables and maps from GIS. These have been stalled for quite a while. Will need to ensure any text references to acres derived from this updated data is updated too. 2) A highlighted text reference to % of total MZ acres covered by CED projects will have to be updated when the new GIS data is obtained. 3) One reference – we have all be unable to locate a hard copy for the administrative record (highlighted in Citations). 4) A final formatting.

Overall mining impacts are occurring primarily at local and regional scales. Direct impacts are based on the location of the minerals. Indirect impacts, such as noise, dust, and habitat fragmentation by appurtenant roads, fences and powerlines, are expected to be more widespread. As such, range-wide, mining can be considered a significant incremental source of impacts, adding to and interacting with other impacts such as infrastructure development, predation, and energy development.

Covered in this chapter is mining as it relates to mineral materials; this chapter does not discuss oil and gas, or geothermal mining. Those subjects are covered in Energy Development chapter of this report.

Threat description

Mining activities have occurred within the range of greater sage-grouse (*Centrocercus urophasianus*; hereafter sage-grouse) since the mid–1800s (Legends of the West 2014, p.1, Nevada Mining Association 2015), and continue today (American Mining Association 2014).

There are at least 50 minerals mined throughout the range of the sage-grouse (Minerals Education Coalition 2015, National Mining Association 2014a). Mining is generally divided into three categories based upon the type of mineral extracted; each type with its own regulations. These categories are locatable minerals, leasable minerals, and salable minerals (see below under Threat Amelioration for more details). Table 1-1 lists the minerals and elements which are, or have been, mined within the range of the sage-grouse. The extent of mining for any individual mineral varies widely, and ranges from a single mine per state (e.g., lithium) (USGS 2013c, p.94) to many (e.g., coal). Additionally, individual mines vary tremendously in size (see Figures 1-1 and 1-2), challenging one to develop a representation of what a "typical mine" is.

Table 10-1: Minerals and Elements Mined in Sage-Grouse Range

MINERALS		
Andesite (BP)*	Crushed Stone	Phosphate Rock
Antimony (BP)*	Diatomite	Platinum (BP)*
Arsenic (BP)*	Diorite	Potash
Asbestos	Dolomite (limestone)	Pumice
Aurichalicite	Feldspar	Quartzite

MINERALS		
Barium	Galena (BP)*	Salt
Basalt (stone)	Gold	Sand & Gravel
Bentonite	Gypsum	Sandstone
Beryllium	Iron	Selenium
Calcite (limestone)	Lead	Shale
Clays	Limestone	Silver
Coal	Lithium	Sodium Carbonate (Soda Ash)
Cobalt	Mercury (historical)	Sulfur
Conglomerate (borates)	Molybdenum	Talc
Conglomerate (sand & Gravel)	Nickel (BP)*	Uranium
Copper	Perite	Zeolites
Creedite	Phosphate Rock	
*** BP = by-product contained in other minerals; Sources: Minerals Education Coalition, USGS (various)**		

Surface and subsurface mining for mineral resources result in direct loss of sagebrush habitats. The direct impact from surface mining is typically greater than it is from subsurface mining. Habitat loss from both types of mining can be exacerbated by the storage of overburden (soil removed to reach subsurface resources) in otherwise undisturbed habitat. If the construction of mining infrastructure is necessary, additional direct loss of habitat could result from structures, staging areas, roads, railroad tracks, and powerlines; these impacts are discussed in the Infrastructure Chapter. Blasting, to remove overburden or the target mineral, produces noise and ground shock which could potentially result in lek or nest abandonment (Moore and Mills 1977, p.137). Sage-grouse and nests could be directly affected by trampling or vehicle collisions. Sage-grouse will likely be impacted indirectly from an increase in human presence, land use practices, ground shock, dust, reduced air quality, and changes in vegetation and topography (Moore and Mills 1977, entire; Brown and Clayton 2004, p. 2).

Historical mining in the West used both hand and mechanical tools; the advent of new methods in the late 19th century facilitated the expansion of mining activities, and undoubtedly introduced additional effects such as vehicle noise and collisions. Currently, surface and subsurface mining activities 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 many states. For instance in 1997, the value of nonfuel mineral production in Nevada was $3 billion dollars, for Utah it was $1.76 billion dollars, for Wyoming it was $996 million dollars, and for Colorado it was $536 million dollars (USGS 2015b).

However, minerals are not distributed evenly across sage-grouse range. For instance, in 2012, Wyoming (MZs I and III) was the largest coal producer in the nation representing almost 40 percent of coal production (EIA 2014a, Table 2). The top ten producing mines in the country are located in Wyoming's Powder River Basin (MZ I) (Wyoming Mining Association 2008, p. 2), yet six major coal mines are located in eastern Montana (Montana Coal Council 2015) and there are none in Nevada, Idaho or Oregon (EIA 2014a). Wyoming also ranks first in uranium production in 2013 (EIA 2014b, d, Table 9). But Nevada (MZs III, IV, and V) is the nation's leader in gold production, and combined with other mining commodities, production totaled $11.2 billion dollars in 2012 (Mineweb 2014, entire). Mining thus tends to be somewhat localized or regional, and depending upon the location of the minerals; the effects of the mines to sage-grouse will vary based on the localized utilization of the habitat by the birds.

Taking Uranium as an example, mining and milling has occurred in Wyoming, Utah, Colorado, and Nevada. 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 2009, p. 73) and stimulate the demand for uranium. Electricity supplied by nuclear plants is expected to increase 2 to 55 percent by 2030; the increase is dependent on variables such as construction costs and regulatory mandates (EIA 2009, p. 52), which are difficult to predict. 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).

Another example is Bentonite, a locatable mineral. Mining has been conducted on over 85 km^2 (32.8 mi^2) 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 km^2 (839 mi^2) 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), and current reclamation activities do not always consider sage-grouse habitat needs. The BLM foresees up to 89 additional km^2 (34.4 mi^2) 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).

Thus, the nature and extent of the mining impacts to sage-grouse depend significantly upon such variables as the actual location of the minerals, the current or expected market value of the commodity, and the overlap of the mines' spatial component to sage-grouse populations. As such, drawing accurate estimates regarding the range-wide effects of future mining is tenuous.

Current impacts

Mechanisms

Sage-grouse are dependent on large areas of contiguous sagebrush (Patterson1952, p. 48; Connelly et al. 2004, p. 4-1) and large scale characteristics within surrounding landscapes influence sage-grouse habitat selection. 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).

The mechanisms by which mining potentially produces impacts to sage-grouse are varied, but generally consist of: 1) direct impacts to sage-grouse or its habitat by physically destroying or usurping available habitat, or killing the birds outright by collision or crushing (Aldridge and Boyce 2007, p. 522; Connelly et al. 2000, pp. 228-229); or 2) indirect impacts including increased predation (Connelly et al. 2000, entire), degradation of habitat (Wisdom et al. 2011, entire), or fragmentation of the habitat and interference with seasonal migration (Knick and Hanser 2011, entire).

Direct impacts include the direct loss or degradation of habitat by a project's footprint or the direct loss of individuals or nests by collision and crushing (Aldridge and Boyce 2007, p. 522; Connelly et al. 2000, pp. 228-229). In addition to the actual removal of habitat by the mine itself, direct habitat loss could result from associated facilities such as buildings, tanks or ponds. Other direct impacts can include a mine's associated access roads, railroads, powerlines, and staging areas. Habitat can also be lost by the storage of a mine's overburden soil (soil removed to reach subsurface resources).

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; Blickley and Patricelli 2012, entire, Blickley et al. 2012, entire). Amstrup and Phillips (1977) 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).

An increase in human presence by mine workers during construction and as part of ongoing operations, increases the risk of collision with vehicles resulting in direct mortality.

An increase in human presence 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 (Earth Island Journal 2013, entire; 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 larger population-level impacts. Degradation of riparian areas could result in a loss of brood habitat.

The specific type(s) of impact will vary with the mining technique and the size of the operation. All types of mines occur within the range of sage-grouse and include tunnel (subsurface) mines, open pit mines, placer mines and surface sediment mines. These range in size from large open pits mines of major mining companies (Figure 1-1), often for gold, copper or coal, to smaller single operator mines (Figure 1-2).

Figure 10-1: A Large Copper Mine in Utah, 1999

Habitat loss at open pit mines includes the pit itself, as well as the surrounding areas by the construction of appurtenant structures (e.g., housing, offices, processing buildings, equipment staging areas, tanks and ponds, roads, railroads, overburden tailings, and powerlines). Impacts typically increase with the size of the mine. Open pit mines can support significant vehicle traffic volume. Generally, negative effects to sage-grouse from roads can include direct collisions, potential chemical effects, the demographic and genetic subdividing of populations, and especially avoidance (Forman and Alexander 1998, entire).

Figure 1-2: An Example of an Individual Placer Minor Working at Stream, 1940

In another example, Braun (1986) showed the upgrade of haul roads associated with coal mining activity in Colorado resulted in increased traffic levels and was correlated with declines in the number of displaying males on leks situated within 2 km (1.3 mi) of the road. Further, rates of declines in sage-grouse male lek attendance increased as traffic volumes on roads near leks increased, and vehicle activity during the early morning strutting period had a greater influence on male lek attendance compared to roads with no vehicle activity during the strutting period in southwestern Wyoming (Holloran 2005, p. 40). Thus, impact of roads on sage-grouse appears to vary by road type, activity level, and timing of traffic events, along with the associated noise and dust, and the potential for direct mortality by collisions. For large subsurface mines (tunnels), with the exception of the actual mine footprint, the other associated impacts are mostly the same (see the Infrastructure chapter for more information on road).

Indirect impacts are those associated with mining activities which do not directly remove sage-grouse habitat, and are most often associated with some kind of direct impact. 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).

Mining may include development of roads, fences, and other infrastructure that are described in separate chapters in this document.

Results of impact

There is little peer-reviewed literature on the direct impacts of general mining to sage-grouse or its habitat. There is a substantial amount of information for coal mining and oil and gas development. For mining of other minerals, we are extrapolating from this literature (e.g. oil and gas mining). We recognize that, although sometimes similar (e.g., traffic noise, infrastructure, etc.), this may not be entirely representative of the direct and indirect impacts for various mining techniques, but we are attempting to use the best available information to describe the current and future impact of mining on sage-grouse.

Direct impacts from mining result in a lowering of the populations by direct mortality or a decrease in population fitness or size by limiting the available habitat. Other direct impacts results can include a reduction in lek attendance due to noise (Blickly and Patricelli 2012, entire, 2013, entire, Blickley et al. 2012, entire). Indirect impacts can result in a reduction of populations by providing increased opportunities for predators to detect individuals or nests. The presence of tall structures providing nesting and perching sites for avian predators (Baruch-Mordo et al. 2013, entire; Connelly et al. 2000, entire; Connelly et al. 2011a, p. 65), the potential for providing breeding areas for mosquitos in new settling ponds that could carry West Nile virus (Walker and Naugle 2011, p. 141), or a potential reduction in fitness by interference with seasonal movement patterns (Connelly et al. 2011b, pp. 82-83; Knick and Hanser 2011, entire), are all potential indirect impacts.

A few scientific studies specifically examine the effects of coal mining on sage-grouse. In a study in North Park, Colorado, overall sage-grouse population numbers were not reduced by the development of coal mines, but there was a reduction in the number of males attending leks within 2 km (1.3 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). 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 assumed to not limit local populations around 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 cited in* USFWS 2010, p. 13949).

As described above, mining directly removes habitat, may interfere with auditory cues important to mate selection, and can result in a decrease of males and yearling recruitment at leks in proximity to mining activity. USGS (2013a, p. 159) propose that the influence of oil and gas, and coal mining can be felt up to 19 km (11.8 mi) from the actual footprint of the facility, and up to 2.5 km (1.6 mi) from locatable and saleable mining sites. 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 Oil and Gas chapter. The studies were conducted on a local scale that provides limited insight into impacts at a larger landscape perspective.

Timing

The modification, fragmentation, and elimination of sagebrush habitat associated with mining are long-term effects rather than periodic or seasonal. Sage-grouse use sagebrush habitats year-round. Therefore, the impacts to sage-grouse from mining occur throughout the year, persist from one year to the next, and have the potential to affect all life stages and seasonal habitats.

Additional impacts of daily operations including blasting noise and vibrations, vehicle disturbance, and human presence, will vary with each facility. These daily activities can indirectly affect nearby populations year-round. Additionally, since reclamation and restoration of sagebrush habitat remains difficult, direct impacts can result in longer term impacts regardless of the timing. Thus, generalizations or conclusions about the timing of mining operations impacts to sage-grouse needs to be determined at the local population level first, and then integrated with larger landscape or multi-population scales to determine potential effects on nearby populations.

Location and extent

Minerals are not distributed evenly across the sage-grouse landscape. For instance, coal, oil, and gas mining are more prevalent in Wyoming and Montana (MZs I and II), while gold and other hard rock mining is more common in Nevada and Utah (MZs III, IV and VII). Coal is primarily found in the Rocky Mountain States (see Figure 1-5), while lithium has been mined exclusively in Nevada (although a more recent discovery has been made in southwestern Wyoming (Mining.com 2014). Precious metals, while being mined to some degree in all 11 states across the sage-grouse range, is primarily carried on in Nevada and Colorado (USGS 2013b). As a result, depending upon the type of mineral, the associated mining activities tend to be somewhat localized or regional, and thus their impacts likewise tend to be similarly localized. Figure 1-3 shows an example of the localization of mining “trends” in northern Nevada (Nevada Bureau of Mines and Geology 2003).

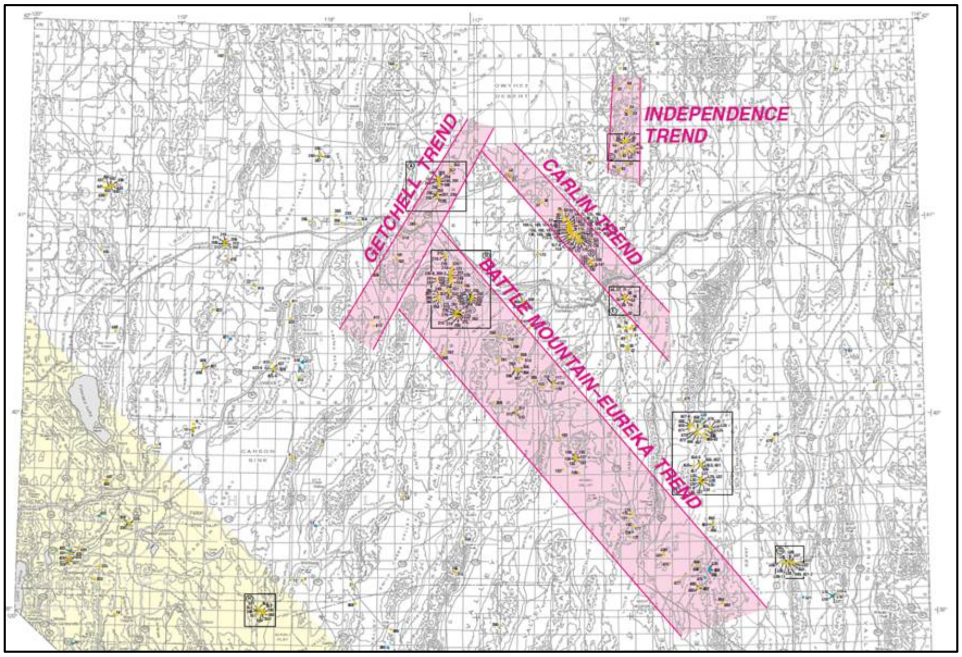


Figure 1-3: Mineral Trends in northern Nevada, showing localization of mineral resources.

The Conservation Objectives Team report (COT 2013, pp. 16–29) indicates that mining is considered a widespread and significant threat to sage-grouse in six of the seven Western Association of Fish and Wildlife Agencies (WAFWA) Management Zones (Stiver et al. 2006, entire), and 18 of the 39 populations. An additional seven populations are indicated as having some threat from mining activities, but at a potentially low level.

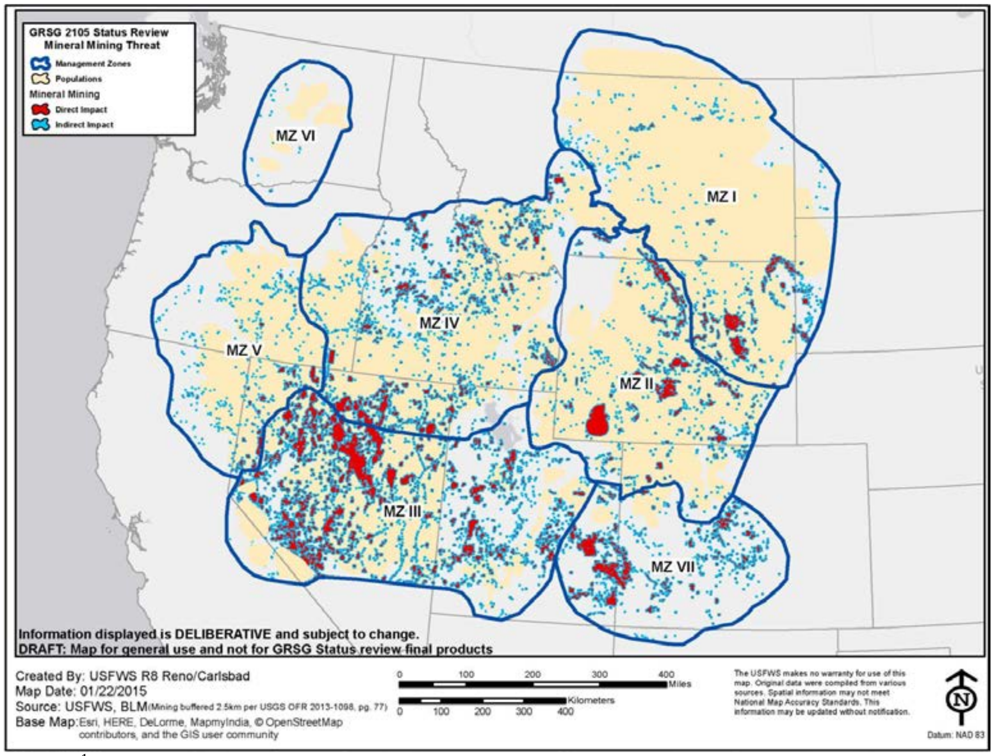


Figure 0-4: Location of Mining Activities[1] in Sage-Grouse Management Zones[2]

[2] Actual sizes of impact areas are exaggerated to enhance visualization of smaller sites.

(NOTE: The following tabular data and graphic above are preliminary, and are currently being revised by the GIS team)

Table 1-2: Summary of Present Day Mining (all types excluding geothermal, oil & gas, and coal)

Management Zone	Total Acres	Acres Directly Impacted	%
I	86,778,743	803,156	0.93
II	60,277,823	1,955,239	3.24
III	78,519,688	5,840,233	7.44
IV	79,976,963	2,268,147	2.84
V	40,175,611	313,979	0.78
VI	15,992,753	966	0.01
VII	38,693,518	1,486,477	3.84
Overall:	400,415,099	12,668,197	3.16

Coal production continues to represent a significant mining activity, primarily in Wyoming and Montana (Braun 1998. p. 5, USGS 2013a, p. 74; Figure 1-5.). Coal mining also occurs in Colorado, Utah, and North Dakota, but to a lesser degree.

Table 10-2: Summary of Present Day Coal Mining

Management Zone	Total Acres	Acres Directly Impacted	%
I	86778743	246201	0.28
II	60277823	71799	0.12
III	78519688	3108	0
IV	79976963	0	0
V	40175611	0	0
VI	15992753	0	0
VII	38693518	2593	0.01
Overall:	4E+08	323701	0.08

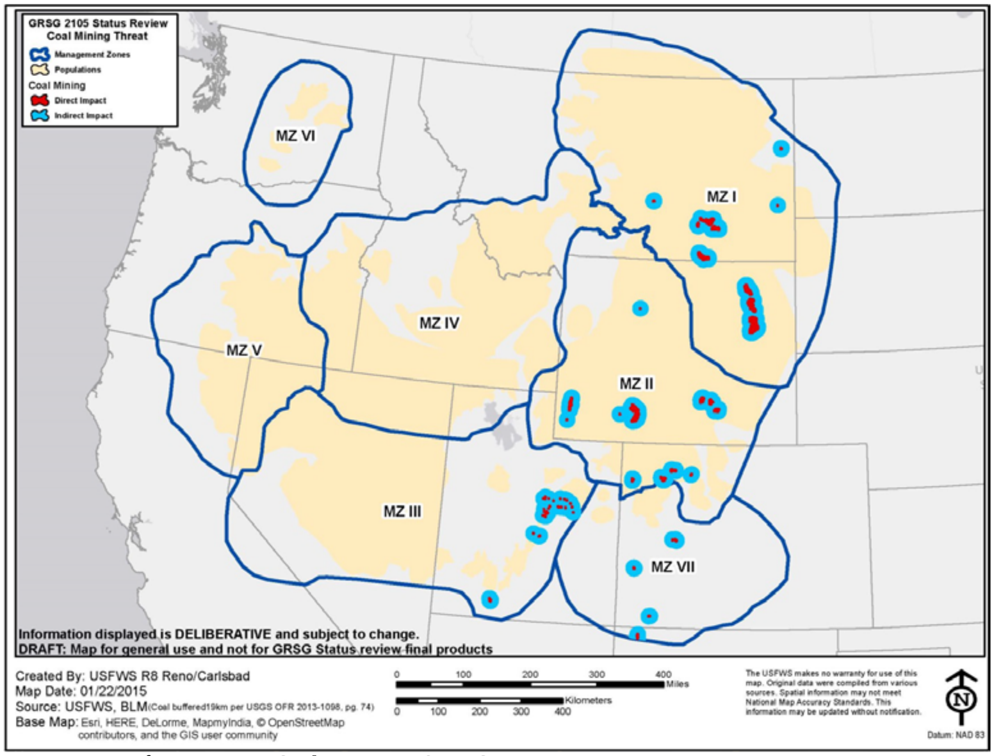


Figure 1-5: Location of Present Day Coal Mining in Sage-Grouse Management Zones

1. Actual sizes of impact areas are exaggerated to enhance visualization of smaller sites; includes permit application data.

(NOTE: The foregoing tabular data and map are preliminary, and are currently being revised by the GIS team)

Tables 1-3 and 1-4 indicate that currently non-coal mining activities are primarily impacting Management Zones II, III, IV, and VII. Coal mining is exclusively impacting Management Zones I, II, III, and VII.

Compounded effects

The compounding effects will be discussed in greater detail in the Compounded Effects chapter. In brief, the following impacts are likely to interact with the threat described in this chapter.

- Ex-urban development
- Fences
- Contaminants/Pesticides
- Infrastructure
- Fire
- Disease
- Predation
- Energy Development (renewable and non-renewable)

Projected Future impacts

Timescale for Projecting this Threat

It is anticipated that mining activities within the range of the sage-grouse will continue indefinitely.

Likelihood of future impacts

Market prices for any specific mineral commodity can vary greatly. As such, generally speaking, the extent of mining activities has a tendency to fluctuate along with the return on the investment. This makes trying to accurately determine the future impacts of these activities somewhat difficult. We anticipate that impacts will continue on the same trajectory we have witnessed in the recent past.

Anticipated changes from present

Although the need for any specific mineral can vary from year to year, and barring major economic downturns, the *overall* extent of mining activity in the United States has remained fairly consistent over the past five years (National Mining Association 2014b; Figure 1-7). An analysis of mining production for 23 commonly mined minerals (including coal) from the years 2008 to 2013 shows a mean production ranging from 14.1 billion metric tons (2009) to 16.9 billion metric tons (2008) with a combined average across all years of about 15.9 billion metric tons.

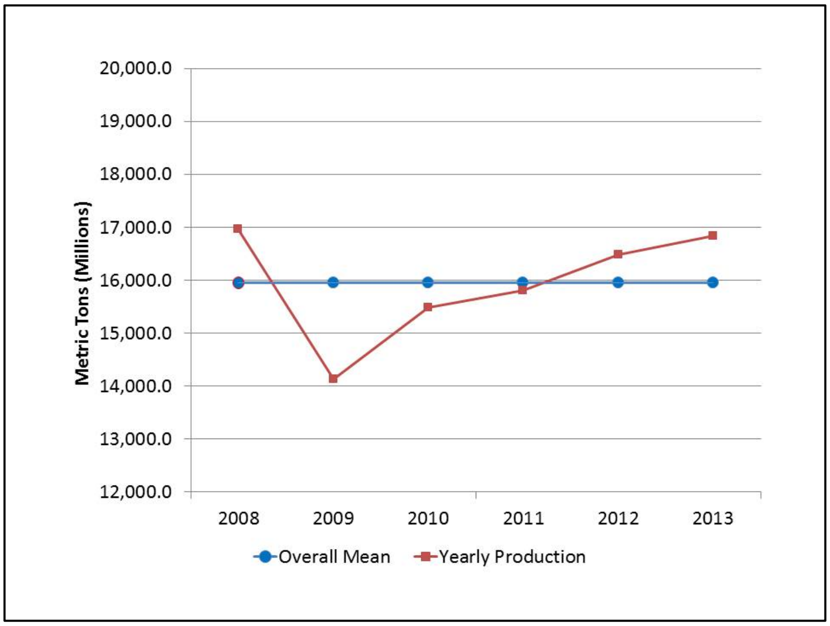
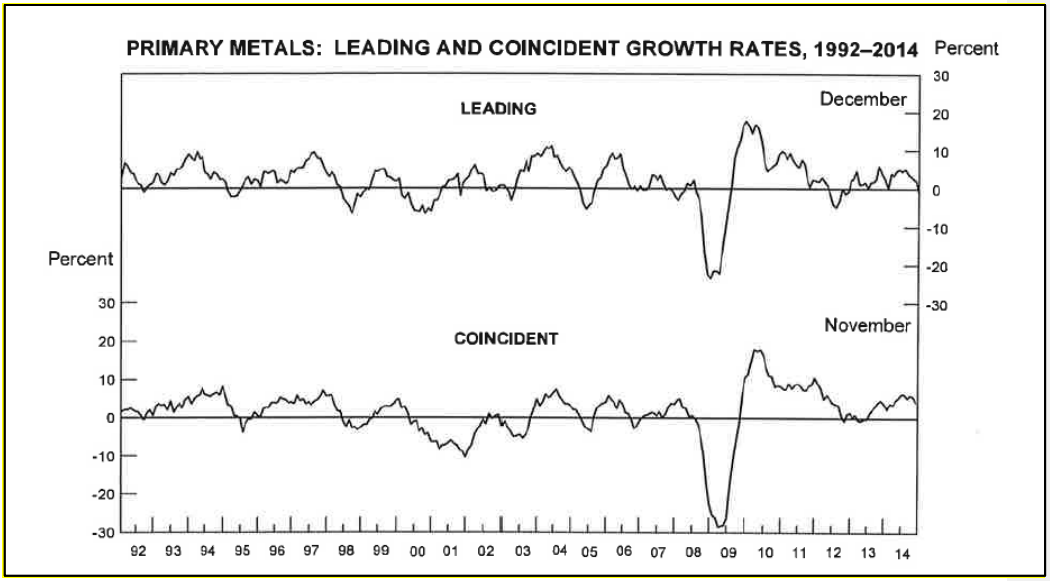


Figure 0-6: Overall Production for Twenty-three Commonly Mined Minerals in the United States from 2008-2013 (N = 25; based on a sample of 23 commonly mined minerals; sand & gravel, and stone were subdivided).

The results indicate a major drop in mineral production from 2008 to 2009, coinciding with the worst part of the recent recession, but then steadily increasing each year from 2009 to 2013 (Figure 1-7). Because of the dramatic drop from 2008 to 2009, and the steady recovery since that time, it is difficult to assess whether the exhibited yearly increase is due to a generalized recovery from the low of 2008, or represents an ongoing pattern of increase which would have occurred regardless of the recession. Overall mining has recovered to a level similar to that of 2008, but extrapolation of this recovery trend cannot be fully evaluated.



However, an examination of mineral product growth rate indices (USGS 2015a, p. 4), which are economic indicators of near term market prices, supports the assumption that mineral production has continued to return to pre-recession levels, and appears to be once again more or less stable (Figure 1-7 and Figure 1-8). These indices show major changes in current industry activity (USGS 2015a).

Figure 0-7: Mineral Product Growth Rates for Primary Metals

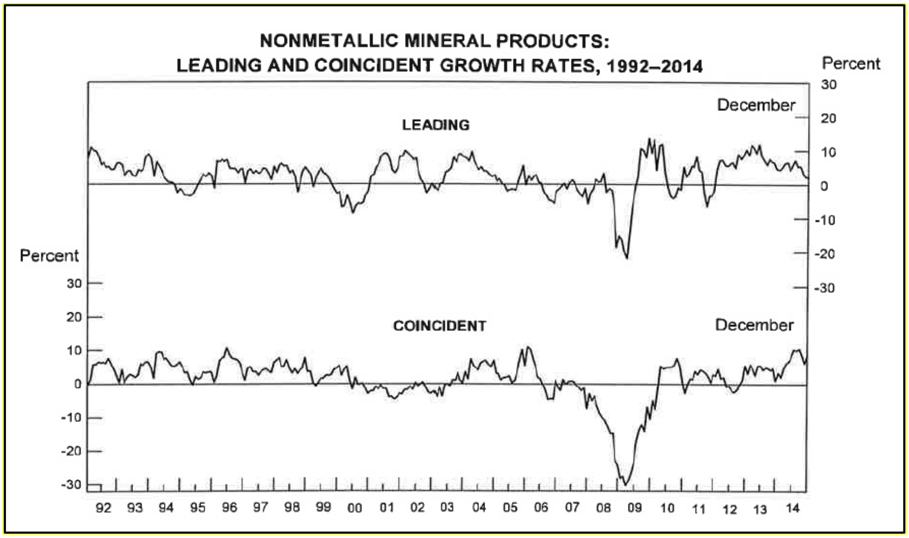


Figure 0-8: Mineral Product Growth Rates for Non-Metallic Minerals

Overall coal production in the United States has generally declined over the past nine years (Figure 1-9). After reaching a high production level of 1.17 billion metric tons in 2008, it has consistently declined to a value of 9.96 million metric tons in 2014 (EIA 2015a, Table 6.1). In sage-grouse range, production in each of the five states mining coal has similarly dropped (Figure 1-9; EIA 2015b-2015g). This pattern seems to indicate that coal production will continue to decline, or remain stable, for the foreseeable future.

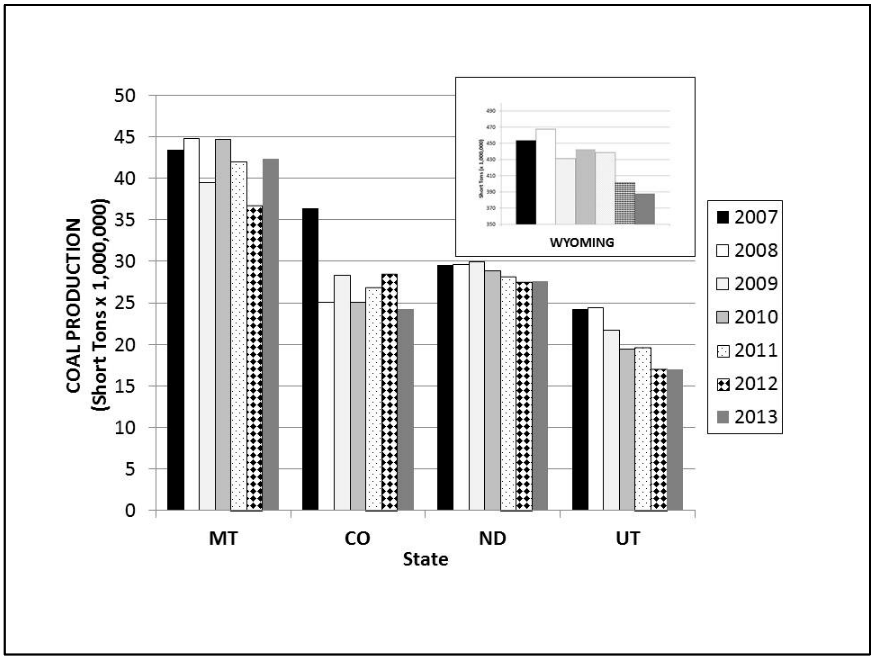


Figure 1-9. Coal Production in Sage-Grouse Range by State from 2007 to 2013.

Taking into account the inherent uncertainty of the future need for specific minerals, the uncertainty of future mineral prices, and the unknown potential for new technology to allow more efficient mining operations, we are challenged to forecast annual demand for individual mineral resources or overall mining growth. However, based on the recent level of mining activities, and the recovery from recession-based downturns in the mineral sector, we anticipate mining will continue at about the same level as shown in Figures 1-7 and 1-8; varying within and between years some, but generally fluctuating around the observed mean.

Threat amelioration

In the United States, mining activity is authorized under an array of statutes primarily administered or leased by the Bureau of Land Management (BLM), both on federally-managed lands as well as other lands where mineral rights have been reserved to the U.S. (i.e., split-estate lands). Coal is administered by the Office of

Surface Mining Reclamation and Enforcement (OSM), which in turn may delegate their authority to the states. Statutory authority for mining originated with The General Mining Law of 1872, as amended (30 USC 22-54 and 43 CFR 3809); subsequent statutes have provided additional standards and processes for Federal administrative oversight for specific classes of mineral deposits. In 1976, the Federal Land Policy and Management Act (FLPMA), as amended (43 USC 1701–1784) authorized the promulgation of regulations for the administration of applicable mining statutes, in order to ensure that mining operators and claimants prevent the unnecessary or undue degradation of public lands, by adherence to performance standards, reclamation of disturbed areas, and complying with all applicable Federal and state laws related to environmental protection and the protection of cultural resources.

The BLM published implementing regulations for the various mining statutes in 1981. The BLM's statutory and regulatory authority thus depends upon the nature of the mineral deposit, which can be thought of in terms of three categories – leasable, salable or locatable. Leasable deposits refer to substances such as coal (43 CFR 3400), oil and gas (aka fluid minerals; 43 CFR 3100), and non-energy leasables such as potassium and potash (43 CFR 3500), administered under the Mineral Leasing Act of 1920 (30 USC 181 et seq.). Salable deposits include common-variety substances such as sand, gravel, pumice, stone, soil and clay; these are regulated under the Materials Act of 1947, as amended (30 USC 601 et seq. and 43 CFR 3600). Locatable refers to mostly metallic minerals (e.g., gold, silver, lead, uranium) and uncommon varieties of clays and building stone; these continue to be regulated under the General Mining Law of 1872, as amended (cited above, see also the regulations at 43 CFR 3809).

The General Mining Law of 1872 calls for all locatable mineral deposits in on Federal lands to be free and open to exploration and purchase. (BLM 2011, entire). Only areas that have been withdrawn to mineral entry by a special act of Congress, regulation, or public land order are truly closed to locatable mineral entry.

As mentioned above, mining activities fall into discrete management categories and are governed by different statutes. Locatable minerals and notice-level activities represent categories of mining which are mostly non-discretionary for land managers, and as such their ability to manage or limit locatable mining and notice level activities is highly limited.

However other types of mineral extractions (i.e., fluid minerals, non-energy leasable minerals, salable minerals) do allow resource agencies discretionary actions to prevent or otherwise manage their activities. Policies for the management of such discretionary (i.e., non-locatable, non-notice-level) mining, and the amelioration of mining threats, can include a wide variety of possible planning actions, ranging from outright closure of highly sensitive areas (i.e., “withdrawal”, “exclusion” or “closure”), to Avoidance with No Surface Occupancy (NSO; with or without exceptions, modifications, stipulations), to the imposition of Required Design Features (RDF) or Best Management Practices (BMP) designed to minimize impacts that will still occur. Management can also include the requirement of projects to follow the recommended Avoid-Minimize-Compensate scenario as described in the USFWS Mitigation Framework (USFWS 2014a, entire) or similar State mitigation plan.

Active Conservation

In April, 2014, the National Policy Team (NPT 2014) provided specific allocations for minerals for BLM and USFS to use in their land use plan amendments (Table 1-4).

Table 1-4: National Policy Team Suggested Mineral Land Use Allocations (NPT 2014)

Non-Energy Leasable Minerals	
Great Basin Region (NV, CA, OR, ID[1], UT)	Rocky Mountain Region (WY, MT, CO)
Priority Habitat: These areas will be “Closed” to new permits.	Same as Great Basin Region
Expansion of existing operations could be considered if the disturbance is within the cap and subject to compensatory mitigation.	Wyoming only: these areas will be “Open,” but are subject to the disturbance cap and stipulations. Consider closing these areas.

General Habitat: These areas will be "Open" subject to stipulations that will protect sage grouse and its habitat. However, sub-regions may consider closing these areas.	Same as Great Basin Region
Mineral Materials (Salable Minerals)	
Great Basin Region (NV, CA, OR, ID1, UT)	Rocky Mountain Region (WY, MT, CO)
Priority Habitat: These areas will be "closed" to new mineral material sales. **These areas would be "open" to free use permits and the expansion of existing active pits, subject to the disturbance cap.** Existing active pits will be subject to the disturbance cap. Expansion of existing operations could be considered if the disturbance is within the cap and subject to compensatory mitigation. The disturbance cap and required design features would be applied to all free use permits.	Same as Great Basin Region
General Habitat: These areas will be "Open" subject to stipulations that will protect sage grouse and its habitat. However, sub-regions may consider closing these areas.	Same as Great Basin Region

1. For Idaho/SW Montana EIS, Medial Habitat would follow the same management regime as Priority Habitat

By eliminating or restricting new non-energy leasable and salable mineral easements over the life of the land use plan amendments (i.e., 20 years), potential mining impacts (excluding potential impacts from oil and gas, or geothermal mining) to sage-grouse habitats are essentially those that will be derived from non-discretionary locatable minerals. Currently, habitats of significant conservation value (i.e., strongholds or Sagebrush Focal Areas) have been proposed to the BLM and USFS by the Service for inclusion into their conservation plans as withdrawal areas for locatable mineral exploration and development (USFWS 2014b). If these areas are withdrawn, added significant conservation for the sage-grouse will be realized.

Through the Conservation Efforts Database (CED), the Service collected information relating to conservation actions that were completed, in progress, or planned. Based on a summary report of that information created on March 17, 2015, the following tables (Tables 1-5 and 1-6) lists the number of actions and approximate areas for threat amelioration associated with mining in single management zone projects and multiple management zone projects, respectively. These numbers are self-reported; the Service will further review and certify these actions if they are pivotal to any determination. Based on the CED data, in relation to mining, there are approximately 64 projects, covering 322,000 acres (0.08 percent of management zone acres) within the WAFWA Management Zones being addressed, or will be addressed, by one form of conservation or another.

Comment [RJB137]: Likely to change as new GIS acreages are forthcoming

Table 10-3: List of Conservation Efforts for Mining Found in Single management zoneas reported to the Conservation Efforts Database

SINGLE MANAGEMENT ZONE:	I		II		III		IV		V	VI	VII	
	No. / Status	Acres	No. / Status	Acres	No. / Status	Acres	No. / Status	Acres			No. / Status	Acres
Habitat Protection: Conservation Easement	1 - Completed	970	2 - Completed	22,515	Completed		Completed				Completed	
	In Progress		In Progress		In Progress		In Progress				In Progress	
	1- Planned	700	Planned		Planned		Planned				Planned	
Habitat Protection: Acquisitions	Completed		4 - Completed	4,988	3 - Completed	1,040	Completed				Completed	
	In Progress		In Progress		In Progress		In Progress				In Progress	
	Planned		Planned		Planned		Planned				Planned	
Non-regulatory Conservation Strategies	Completed		Completed		Completed		1 - Completed				Completed	
	3- In Progress		2 - In Progress		In Progress		In Progress				1 - In Progress	
	Planned		1 - Planned		Planned		Planned				Planned	
Regulatory Mechanisms; Plans; Policy	Completed		Completed		Completed		Completed				Completed	
	1 - In Progress		In Progress		In Progress		In Progress				In Progress	
	1 - Planned		1 - Planned		Planned		Planned				Planned	
Restoration: Infrastructure Removal and Modification (*Reported in linear miles)*	2 - Completed	*8.6 Miles*	Completed		Completed		Completed		No Reports for Zones 5 and 6		Completed	
	In Progress		In Progress		In Progress		In Progress				In Progress	
	Planned		Planned		Planned		Planned				Planned	
Restoration: Livestock & Rangeland Management	1 - Completed	5,487	Completed		Completed		Completed				Completed	
	1 - In Progress	3,352	In Progress		In Progress		In Progress				In Progress	
	Planned		Planned		Planned		Planned				Planned	
Restoration: Habitat Reclamation Efforts	5 - Completed	862	Completed		Completed		Completed				Completed	
	1 - In Progress	197	In Progress		In Progress		1 - In Progress	0.40			In Progress	
	2 - Planned	424	1 - Planned	30	Planned		Planned				Planned	
Restoration: Habitat Restoration	3 - Completed		1 - Completed	5	Completed		Completed				Completed	
	3 - In Progress		In Progress		In Progress		In Progress				In Progress	
	2 - Planned		Planned		Planned		Planned				Planned	
TOTALS:	27 Projects	11,992	12 Projects	27,538	3 Projects	1,040	2 Projects	0.40			1 Project	

Table 10-4: List of Conservation Efforts for Mining Found in Multiple Management Zones as reported to the Conservation Efforts Database

MULITPLE MANAGEMENT	I and II		II and III		II and IV		II and VII		IV and V		I, II and IV		II, III and IV		III, IV and V	
	No. / Status	Acres	No. / Status	Acres	No. / Status	Acres	No. / Status	Acres	No. / Status	Acres	No. / Status	Acres	No. / Status	Acres	No. / Status	Acres
Habitat Protection: Conservation Easement	Completed		Completed		Completed		Completed		Completed		Completed		Completed		Completed	
	In Progress		In Progress		In Progress		In Progress		In Progress		In Progress		In Progress		In Progress	
	Planned		Planned		Planned		Planned		Planned		Planned		Planned		Planned	
Habitat Protection: Acquisitions	Completed		Completed		Completed		Completed		Completed		**2 - Completed**	**281,000**	Completed		Completed	
	In Progress		In Progress		In Progress		In Progress		In Progress		In Progress		In Progress		In Progress	
	Planned		Planned		Planned		Planned		Planned		Planned		Planned		Planned	
Non-regulatory Conservation Strategies	Completed		Completed		**2 - Completed**		Completed		**5 - Completed**		Completed		Completed		Completed	
	In Progress		In Progress		In Progress		In Progress		In Progress		In Progress		In Progress		In Progress	
	1 - Planned		Planned		Planned		Planned		Planned		Planned		Planned		Planned	
Regulatory Mechanisms; Plans; Policy	Completed		Completed		Completed		Completed		**2 - Completed**		Completed		Completed		**2 - Completed**	
	In Progress		**1 - In Progress**		In Progress		In Progress		In Progress		**1 - In Progress**		**2 - In Progress**		In Progress	
	Planned		Planned		Planned		**1 - Planned**		Planned		Planned		Planned		Planned	
Restoration: Infrastructure Removal and Modification (*Reported in linear miles)*	Completed		Completed		Completed		Completed		Completed		Completed		Completed		Completed	
	In Progress		In Progress		In Progress		In Progress		In Progress		In Progress		In Progress		In Progress	
	Planned		Planned		Planned		Planned		Planned		Planned		Planned		Planned	
Restoration: Livestock & Rangeland Management	Completed		Completed		Completed		Completed		Completed		Completed		Completed		Completed	
	In Progress		In Progress		In Progress		In Progress		In Progress		In Progress		In Progress		In Progress	
	Planned		Planned		Planned		Planned		Planned		Planned		Planned		Planned	
Restoration: Habitat Reclamation Efforts	Completed		Completed		Completed		Completed		Completed		Completed		Completed		Completed	
	In Progress		In Progress		In Progress		In Progress		In Progress		In Progress		In Progress		In Progress	
	Planned		Planned		Planned		Planned		Planned		Planned		Planned		Planned	
Restoration: Habitat Restoration	Completed		Completed		Completed		Completed		Completed		Completed		Completed		Completed	
	In Progress		In Progress		In Progress		In Progress		In Progress		In Progress		In Progress		In Progress	
	Planned		Planned		Planned		Planned		Planned		Planned		Planned		Planned	
TOTALS:	**1 Project**		**1 Project**		**2 Projects**		**1 Project**		**7 Projects**		**3 Projects**	**281,000**	**2 Projects**		**2 Projects**	

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

Threat Amelioration Summary

Current mining laws provide some level of regulatory environmental protection, but generally lack sage-grouse specific foci. Current Federal regulations, primarily handled through the National Environmental Policy Act (NEPA), but also the OSM and some State regulations, require the avoidance and minimization of general environmental impacts (including sensitive species), and reclamation of sites once projects have been completed. In addition, some states have their own environmental quality laws (e.g. California Environmental Quality Act) affording additional protection of wildlife habitat throughout the state.

Restoration and rehabilitation of mine sites continues to be problematic. Sagebrush habitats are slow growing, not fire resistant, and subject to invasive species. However, BLM has limited the level of disturbance until a proportional amount of the land is reclaimed. For example, if 65 hectares (160 acres) is part of a locatable claim area available for mining, only 10 percent to 20 percent is active at any one time, rather than the entire claim. We anticipate that restoration techniques for sagebrush habitats will be further developed soon, but currently recovery of impacts from mining is slow, and often not fully successful.

Mining activities on Federal lands, and their target minerals, vary in location. Mining for locatable minerals and small (<5 acres) notice-level activities are mostly non-discretionary with respect to agency approvals. Generally, by incorporating the NPT sage-grouse allocation guidelines, BLM and US Forest Service (USFS) land use plan amendments will provide a significant level of amelioration for non-energy leasable minerals, and salable minerals. Additional conservation will be garnered if BLM and USFS adopt withdrawal of locatable mining from habitats of significant conservation value (i.e., Sagebrush Focal Areas).

Assessment of Potential Threat

It is difficult to accurately predict the future impacts of mining due to the market driven nature of the activity. For example, uranium production was lowest in 2003, climbed steadily to a high in 2008, dropped sharply in 2009 (EIA 2014c, p. 15), and has tended to increase only slightly per year since. Further, as new advances in mining technology are invented and implemented, new mining could be realized in areas which were previously thought unprofitable. Additionally, the future unknown need for minerals, not currently required to the extent to make their mining economically viable, could provide new markets and therefore new pressure on sage-grouse habitats. Thus, the extent and nature of the impacts from these unknown needs would be primarily determined by the location of the minerals within sage-grouse range, and the expected return on the mining investment fueling new exploration and development.

Current and proposed land use plan regulatory amendments by BLM and USFS, if incorporating NPT allocation guidelines at a minimum, combined with additional conservation efforts by the individual states, tend to minimize potential threats by mining to sage-grouse by prohibiting or otherwise restricting new discretionary mining in priority habitat, and limiting surface disturbance by mining in general habitat.

Mining in the range of the sage-grouse will continue indefinitely. Sage-grouse habitat and populations will continue to impacted by mining activities both directly and indirectly. However, the exact location and extent of future mining remains uncertain. Direct impacts tend to be local or regional in nature based on the location of the minerals, thus affecting populations or fairly local groups of populations. Indirect impacts, such as noise, dust, and habitat fragmentation by appurtenant roads, fences and powerlines, are expected to be more widespread, potentially affecting many populations. Based on the best available science, we conclude that mining is considered a significant incremental source of impacts, adding to and interacting with other impacts such as, for example, infrastructure development, predation, and energy development.

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Photo Credits

Figure 1. Public Domain photo. 1999. Kennecott_Utah_Copper_Mine_pc_Public_Domain.jpg. http://wg.convio.net

Figure 2. Gold Prospector Pouring Water Through his Rocker Box. 1940. Library of Congress Prints and Photographs Division, Washington, DC 20540. Author: Russell Lee.

Chapter 11: Renewable Energy

Introduction

Renewable Energy Development

Renewable energy development (wind, solar, and geothermal) is a significant risk to the greater sage-grouse (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). The primary concern are the direct effects of energy development on the long-term viability of 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 (coal, oil, and natural gas) in the eastern portion of the sage-grouse range is predicted to continue to increase over the next 25 years (EIA 2015, entire).

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 rangewide (Copeland *et al*. 2009, p. 4). Development of commercially viable renewable energy—wind, solar, geothermal is increasing across the range of the sage-grouse with focus in some areas already experiencing traditional (coal and oil) energy development (EIA 2009b, pp. 3-4; AWEA 2009a, entire), further fragmenting these habitats.

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. Wind energy resources are being investigated in south-central and southeastern Oregon where large areas of relatively unfragmented sagebrush dominated landscapes are important for maintaining long-term connectivity within the sage-grouse populations (Knick and Hanser, 2011, pp. 1-2.). The BLM and USFS are proposing to exclude wind development in priority habitats (PH) until such a time that there are no impacts to sage-grouse populations. Some of these plans are extending this protection to right-of-way (ROW) exclusion, which will cause no impacts due to wind and solar development, with the assumption that there will be no exceptions to these designations. Many of the plans have designated areas as avoidance for transmission lines, which may have ROW permits

Comment [SSLM138]: Jesse: Is this prediction still valid – citation is 7 years old.

Comment [SSLM139]: I couldn't find anything more up to date with any predictions like this. We can delete it, if you would rather.

granted at any time in the future. The exclusion designation provides protections for sage-grouse from wind turbines, however cross county transmission lines and roadways could still be constructed under an avoidance designation.

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). Development of commercially viable renewable energy within the range of sage-grouse –wind, solar, geothermal,–is rapidly increasing rangewide with a focus in some areas already experiencing significant traditional energy development (e.g., MZs I and II) (EIA 2015, Entire; DOE, 2014, Entire). 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 sage-grouse to persist in those areas in the future. The studies on the impacts of wind energy development on sage-grouse have shown impacts that are consistent with the service's 2010 finding (75 fr 13910, p. 13951). Sage-grouse are avoiding powerlines and roadways. Recent studies on the impacts of predators on sage-grouse has shown that ravens in particular are selecting habitats with anthropogenic features and increased edge effects (areas in close proximity to land cover edges) (Howe *et al*. 2014, p.44), and that female sage-grouse (yearlings and older females) avoid habitats with increased numbers of predators. As a result of nest failure, hens have lower nest site fidelity compared with hens with successful nests (Dinkins *et al*. 2014, p.638). Older females are not moving at the large distances as the yearlings, however they are overcoming site fidelity as a means of protecting themselves, their eggs, and their chicks. Behavioral avoidance, alteration of habitat quality, and changes in trophic interactions are showing important implications to greater sage-grouse population responses to wind energy development. Anthropogenic features such as roads, powerlines, fences and wind towers are linked to elevated mortality rates and shifts in life history strategies, for example avoidance (Winder *et al* 2014, p.11, Holloran 2005, p. 1; Pruett *et al*, 2008, p. 6). If habituation to disturbance does not occur, behavioral avoidance to wind development may result in a population level response resulting in and effective loss of habitat (Winder *et al* 2014, p.11). With the increasing pressures of energy use, renewable energy sources will be in more demand than ever putting more pressure on contiguous tracks of sage-grouse habitats. Even with the exclusion designation of wind and solar energy developments in priority habitats, transmission right-of-way authorizations have both exclusion and avoidance areas designated within all of the MZs. (Definitions of avoidance and exclusion can be found on p. 1-45). The intent of an avoidance designation is to primarily exclude projects, however permits may be granted for any reason under an avoidance designation.

Threat description

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). Wind energy power began in the 1850's in the United States with the start of the U.S. Wind Engine Company. With the passing of the Public Utility Regulatory Polices Act in 1978 wind energy production interest increases. However, it isn't until 1992 with the onset of the Energy Policy Act and then in 2008 when the U.S. Department of Energy published their 20 percent Wind Energy by 2030 initiative that wind energy production became the number-one source of renewable electricity (DOE, 2014, entire), making renewable energy development (e.g., wind, solar, geothermal) a relatively more recent activity in sage-grouse habitats rangewide. 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 9.2 quadrillion Btu in 2013. Currently, there are 1,204 turbines within the GRSG Mgmt Zones and 4,638 turbines within the GRSG Current Range (See Table X-1 Wind Turbines within GRSG 2015 Status Review Current Range) (USFWS, 2015, pers.comm). The foot print buffer for turbines is 62 meters around each turbine totaling 3, 514 acres in habitat removal due to turbine footprints (See Table X-3 Wind Turbine Footprints within GRSG 2015 Status Review Current Range), at this time we do not have a digitized footprint of all of the wind project boundaries to determine the actual acreage of disturbance for each project area. However, we do have information on the BLM permitted wind ROW acreages that give us an idea of the extent of the size of the developments, however, the acreages provided in MZ V, VI, and VII are not constructed since, there are no turbines associated with those MZs (See Table X-6 Wind BLM Right Of Way (ROW) within GRSG 2015 Status Review Current Range). The Met Tower data found on Table X-4 FAA MET Tower Footprints within GRSG 2015 Status Review Current Range, will also give us an idea of potential future locations of wind developments.

Wind

Wind energy resources are found throughout the range of the sage-grouse, and growth of wind power development is expected to continue. As you can see on map-GRSG Threat Wind Power Development there are wind turbines in every MZ (as depicted by the green diamonds), even in areas that do not have the extensive potential throughout the MZ, as in MZs I and II, wind development is occurring throughout the range of sage-grouse. The Department of Energy (DOE) predicts that wind may provide 20 percent of the nation's energy needs by the year 2030, and substantial growth of wind developments will be required. With the advent of federal tax credits for wind energy facilities, wind development has increased 20 percent in 2013(Esterly and Gelman, 2013, p. 3).

Areas of commercially viable wind generation have been identified by the NREL (2014) and Bureau of Land Management (BLM) (BLM, 2005, p.5-103). MZs III through VII each have approximately 1 to 14 percent of sagebrush habitats that are commercially developable for wind energy (See table X-9). Wind harvesting potentials are more concentrated and geographically extensive in sage-grouse MZs I and II; areas of highest commercial potential include 40 percent of the available sagebrush habitats in these MZs. Over 14 percent of the sagebrush lands in the sage-grouse range have high potential for wind power.

The Energy Policy Act (Public Law 109–58, August 8, 2005) establishes a goal for the Secretary of the Interior to approve 10,000 megawatts of electricity from non-hydropower renewable energy projects located on public lands. The State of Nevada, through the Renewable Portfolio Standard, has mandated that investor-owned utilities generate, acquire, or save 20 percent of their produced electricity from renewable systems by 2015. The State of California, has mandated that 33 percent of electrical power be derived from renewable energy sources by 2020.

The BLM manages more land areas of high wind resource potential than any other land management agency (BLM contains 21 percent of wind development, with 72 percent of wind development on private lands) and is 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). In 2005, the BLM completed the Wind Energy Final Programmatic EIS (PEIS) that provides an overarching guidance for wind project development on BLM-administered lands (BLM 2005a, entire). This EIS provided an avenue to accomplish the DOE's 20 percent Wind Energy by 2030 initiative assisting with the nation's energy demands and also, providing a form of energy production that does not contribute to climate change. 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*., 2011a, p. 244). The active lease areas cover thousands of acres (Knick *et al*., 2011a, p. 244) and the wind potential area covers tens of thousands of acres in occupied sage-grouse habitats (see table X-9), creating another means of habitat degradation and fragmentation.

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 under estimation of indirect effects. Based on what we know of oil and gas development (see the oil and gas chapter), the impact of structures (see chapter X infrastructure), 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 (Holloran 2005, p. 1; Pruett *et al*, 2008, p. 6, Patricelli *et al*., 2013, p.231). The BLM's determination of the quantity of lands potentially impacted by wind energy development could be 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 and 2012-044 (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 (MZ V). Currently, the BLM and USFS are proposing to exclude wind development in priority habitats (PH) until such a time wind energy technology advances to the point that there are no impacts to sage-grouse populations. Some of these plans are extending this protection to right-of-way (ROW) exclusion, which will cause no impacts due to wind and solar development, with the assumption that there will be no exceptions to these designations. Many of the plans have designated areas as avoidance for transmission lines, which may have ROW permits granted at any time in the future. The exclusion designation provides protections for sage-grouse with more guarantees, however under an avoidance designation may still construct transmission lines and roadways at any time.

Comment [SSLM140]: Yes these IMs are still current.

Comment [DP141]: ate these IM's still current?

A recent increase in wind energy development is most notable within the range of the south-central Wyoming subpopulation of sage-grouse in Management Zone (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*., 2011, p. 136). The BLM Final PEIS on Wind Energy Development underestimated the amount of development that would occur likely because the document was written before the 2008 DOE policy that wind will provide 20% of the nation's energy by 2030. In Wyoming, where wind development is advancing and predicted to increase by 10 fold or more (DOE 2008, p. 10), 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. Wyoming does not have a requirement for increased reliance on renewable energy sources and no specific wind siting authority. However, large commercial construction projects in the State are subject to approval by an Industrial Siting Council (ISC) of the State Department of Environmental Quality, with the Wyoming Game and Fish Department (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. Although Wyoming does not have a requirement for increased reliance on renewable energy sources most of the energy produced is being transported to state's where there is a requirement for increased reliance on renewable energy souces, such as Nevada. This is evident with proposals for cross country transmission lines projects, such as the transwest express and the gateway west and south (see chapter X infrastructure for more information).

In addition to Wyoming, southeastern Oregon was a focus area for potential commercial-scale wind development. The BLM is the major land manager in this part of the southeastern Oregon, with jurisdiction over 49,000 km2 (18,900 mi2) (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). If these monitoring sites are subsequently developed fragmentation of this relatively intact sagebrush landscape could have negative impacts on sage-grouse. To date these potential areas in OR have still not been developed, nor have developments occurred in MZ VI or VII (where there are also current locations of met towers). Turbines and ROW disturbance areas are found currently in MZ I, II, III, and IV (See Table X- Wind Turbines within GRSG 2015 Status Review Current Range, Table X- FAA MET Towers within GRSG 2015 Status Review Current Range**,** and Table X- Wind BLM Right Of Way (ROW) within GRSG 2015 Status Review Current Range).

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). 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. 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).

Mud Spring Wind Ranch has announced the start of construction on its four-phase 240 MW, 120-turbine project on private land in Carbon County, Montana. The first three phases are each comprised of 80 MW (40 turbines); the fourth phase consists of substation and transmission line construction. The lease size is approximately 24,832 acres. This project location occurs in a PAC (Priority Area for Conservation) as identified in the 2013 COT Report (Wyoming Basin population) and core sage-grouse habitat as mapped by Montana Fish, Wildlife and Parks and most recently (September 2014) in Montana Executive Order 10-2014.

Montana-Dakota Utilities constructed, owns and operates the 30-MW Diamond Willow wind farm in Fallon County near Baker, Montana. Constructed in three phases between approximately 2007 and 2010, this wind farm consists of 20 1.5 MW wind turbines. This project occurs in a PAC as later identified in the 2013 COT Report (Dakotas population) and core sage-grouse habitat as mapped by Montana Fish, Wildlife and Parks and most recently (September 2014) in Montana Executive Order 10-2014.

Table X-1 Wind Turbines within GRSG 2015 Status Review Current Range

Management Zone	Number of Wind Turbines
1	392
2	583
3	110
4	119
5	0
6	0

7	0
Total:	1,204

Source: (Service, 2015)

Table X-2 Wind Turbines by "On-Line" Year within GRSG 2015 Status Review Current Range

Mgmt Zone	1982	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
1												79	169	130		14		392
2	2	3	112	28	50		80		1			108	123	76				583
3													43	1			66	110
4									11			61		15	32			119
5																		0
6																		0
7																		0
Total:	2	3	112	28	50	0	80	0	12	0	0	248	335	222	32	14	66	1,204

Source: (Service, 2015)

Table X-3 Wind Turbine Footprints within GRSG 2015 Status Review Current Range

Management Zone	Turbine Footprint Acres	% of Current Range
1	1,167	0.00%
2	1,664	0.00%
3	328	0.00%
4	355	0.00%
5	0	0.00%
6	0	0.00%
7	0	0.00%

Total:	3,514	0.00%

Source: (Service, 2015)

Table X-4 FAA MET Towers within GRSG 2015 Status Review Current Range

Management Zone	Number of MET Towers
1	9
2	34
3	2
4	6
5	1
6	0
7	1
Total:	53

Source: (Service, 2015)

Table X-5 FAA MET Tower Footprints within GRSG 2015 Status Review Current Range

Management Zone	MET Tower Footprint Acres	% of Current Range
1	27	0.00%
2	101	0.00%
3	5	0.00%
4	18	0.00%
5	3	0.00%
6		
7	3	0.00%
Total:	157	0.00%

Source: (Service, 2015)

Table X-6 Wind BLM Right Of Way (ROW) within GRSG 2015 Status Review Current Range

Management Zone	BLM Wind ROW Acres	% of Current Range
1	2,414	0.00%
2	380,869	1.03%
3	510,126	1.77%
4	750,882	1.96%
5	996,182	5.17%
6	278	0.01%
7	28,293	2.40%
Total:	2,669,044	1.52%

Source: (Service, 2015)

Solar

In 2005 the BLM proposed to develop a new Solar Energy Program to further support utility scale solar energy development on BLM-administered lands in the six-state study area (Arizona, California, Colorado, Nevada, New Mexico, and Utah). The proposed Solar Energy Program would replace certain elements of BLM's existing solar energy policies with a comprehensive program that would allow the permitting of future solar energy development projects on public lands to proceed in a more efficient, standardized, and environmentally responsible manner. The proposed program would establish right-of-way (ROW) authorization policies and design features applicable to utility-scale solar energy development on BLM-administered lands. It would identify categories of lands to be excluded from utility-scale solar energy development and identify specific locations well suited for utility scale production of solar energy where the BLM would prioritize development (i.e., solar energy zones, or SEZs). The proposed action would also allow for responsible utility-scale solar development on lands outside of priority areas.

The scope of the analysis is limited to utility-scale solar energy facilities and required transmission connections from these facilities to the existing electricity transmission grid and other associated infrastructure such as roads . For the purposes of the Solar Programmatic Environmental Impact Statement (PEIS) and associated decision making, utility-scale solar energy development is defined as any project capable of generating

20 megawatts (MW) or more. As a result, BLM's new Solar Energy Program would apply only to projects of this scale; decisions on projects that are less than 20 MW would continue to be made in accordance with existing land use plan requirements, current applicable policy and procedures, and individual site-specific NEPA analyses. To meet the objectives of BLM's sage-grouse conservation policy, the Solar PEIS has excluded specifically identified sage-grouse habitat (currently occupied, brooding, and winter habitat) located on BLM public lands in Nevada and Utah. These exclusions will be subject to change based on the outcome of the BLM's sage-grouse planning efforts and resulting plan amendments (BLM, 2012, p.E-10). The BLM/USFS under the sage-grouse RMP amendment EISs are excluding or avoiding solar developments within sage-grouse priority habitats (see table X-5 Summary of BLM/USFS Draft RMP/EIS Wind/Solar Energy Actions), therefore these actions should be happening outside of sage-grouse priority habitats. Viable utility-scale solar technologies considered likely to be deployed over the next 20 years (i.e., until about 2030) and analyzed as part of the Solar PEIS include parabolic trough, power tower, dish engine systems, and photovoltaic (PV) systems (BLM, 2012, p.1-5).

Current solar developments are outside of sage-grouse priority habitats, this information will be updated as new data becomes available.

Table 11-1: Solar Plants within GRSG 2015 Status Review Current Range Source: (Service, 2015)

Management Zone	Number of Plants	MW
1		
2		
3	1	1
4		
5	1	4.95
6		
7		
Total:	2	5.95

Table 11-2: Solar Plant Footprints within GRSG 2015 Status Review Current Range Source: (Service, 2015) Solar Plant Footprint = 62 meter buffer of Solar Plant point data

Management Zone	Plant Footprint Acres	% of Current Range
1		
2		
3	3	0.00%
4		0.00%
5	3	
6		
7		
Total:	6	0.00%

Geothermal

The hottest geothermal resources and where commercial electrical generation would most likely occur, are generally within MZ III, IV, and V (EIA 2009e, entire). Nevada is predicted to experience the greatest increase in geothermal growth across the United States–doubling production from geothermal sources by 2025 (BLM and U.S. Forest Service (USFS) 2008b, p. 2-35).

The BLM has the authority to lease geothermal resources in 11 western States (eight of which are in sage-grouse MZs). 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). Some of the BLM/USFS under the sage-grouse RMP amendment EISs are closing sage-grouse priority habitats to geothermal development, however many are allowing development under the lease stipulations outlined for fluid mineral development (see table X-5 Summary of BLM/USFS Draft RMP/EIS Wind/Solar Energy Actions). 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 km2 (694 mi2) of active geothermal leases exist on public lands primarily in the Southern (MZ IV) and Northern Great Basin (MZ III) and 1,138 km2 (439 mi2) of leases are pending (Knick *et al.*, 2011, p. 245). See the location and extent section for a map of the current geothermal leasing areas.

Table 11-3: Geothermal Power Plants within GRSG 2015 Status Review Current Range Source: (Service, 2015)

Management Zone	Number of Power Plants
1	0
2	0
3	2
4	1
5	0
6	0
7	0
Total:	3

Table 11-4: Power Plant Footprints within GRSG 2015 Status Review Current Range Source: (Service, 2015) * Geothermal Power Plant Footprint = 62 meter buffer of Geothermal Power Plant point data

Management Zone	Power Plant Footprint Acres	Percent of Current Range
1	0	0.00%
2	0	0.00%
3	6	0.00%
4	3	0.00%
5	0	0.00%
6	0	0.00%
7	0	0.00%
Total:	9	0.00%

Current impacts

Mechanism

Wind

The average footprint of a turbine unit is relatively small from a landscape perspective, but large-scale developments 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) (Howe *et al* 2014, p.46), cumulatively contribute to habitat fragmentation, and increase noise levels due to wind facilities and roads in areas that were previously undeveloped (Holloran 2005, p. 11,p. Patricelli *et al*.2013, p.230). Wind generating facilities have increased in size and number, outpacing development of other renewable sources in the sage-grouse range. For more than a decade throughout the U.S., wind energy has been the fastest growing energy technology worldwide, achieving an annual growth rate of over 30% (BLM, 2014b). However, turbine construction within the sage-grouse range peaked in 2009 with 335 turbines constructed. Construction declined from that point until 2013, when turbine construction went from 12 in 2012 to 66 in 2013 (See Table X- Wind Turbines by "On-Line" Year within GRSG 2015 Status Review Current Range for more information for each MZ).

Renewable energy facilities typically require many of the same features for construction and operation as do nonrenewable energy resources (see chapter X oil and gas). 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. The footprint of powerlines is 200 m (100 m on either side of the powerline) (Mariner *et al*.,2013, p.44), depending on the size of the powerline the lines may be buried or overhead.

Recently there has been indication of wind turbines creating microclimates, this has been particularly evident in offshore turbine facililties, however research in Iowa to determine the effects of microclimate changes on croplands has found that wind turbine-generated changes in mean wind, pressure, and turbulence may influence fluxes of heat, moisture, and CO2 (Rajewski *et al*. 2013,p.655). Wakes of wind turbines are known to persist up to 15 rotor diameters downwind of a turbine differences in microclimate may extend well beyond the wind turbines' small footprint on the landscape. Three mechanisms that influence surface micrometeorological conditions in the near lee of turbines: 1) wind turbine wakes overhead that have not reached the surface but modify the wind profile, scales of turbulence, and the vertical mixing between the surface and the overlying boundary layer; 2) wind turbine wakes that are intersecting the surface, allowing wake turbulence to modify the surface microclimate; and 3) static pressure fields (high pressure upwind and low pressure downwind) around each turbine and line of turbines that generate perturbations in surface flow (e.g., localized over speeding) and fluxes within a few diameters of the turbine line (Rajewski *et al*. 2013,p.670). There is no current research indicating how these turbine generated microclimate changes will affect sagesteppe habitats, we know that something is happening, at this time we do not know what or to what extent.

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). 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 1-4 megawatt generating capacity (AWEA 2013, 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 desired level of wind-generated electricity by 2030.

Sage-grouse are selecting habitat in response to landscape attributes and anthropogic features, and are selecting locations further away from landscape attributes that could be used as perches or provide subsidized food resources for predators (Dinkins, *et al*. 2014, p. 638). In turn avian predators particularly ravens are selecting nest locations that are in close proximity to transmission lines, in close proximity to land cover edges, and are within areas that contained abundant edge formed by adjoining land cover types (Howe *et al*. 2014, p. 44). Sage-grouse are avoiding avian predators during all reproductive stages- nesting, early brood rearing, and late brood rearing- but at different magnitudes (Dinkins *et al* 2014, p. 639). Sage-grouse habitat use patterns could be explained by areas of relatively greater predation over time leading to low sage-grouse productivity (i.e. sage-grouse disappear from a localized area, resembling nonuse by sage-grouse) (Dinkins, *et al*. 2014, p. 638). As fragmentation reduces sagebrush cover, and raven populations increase, there may be a hyperpredation effect, sage-grouse risk of nest depredation is determined by the spatial distribution of breeding reavens throughout developed and undeveloped areas (Howe *et al*, 2014, p. 46).

Solar

Solar-generating systems have been used on a small scale to power individual buildings, small complexes, remote facilities, and signs. Commercial solar generation results in direct habitat loss (i.e., solar fields completely eliminate habitat), fragmentation, roads, powerlines, increased human presence, and disturbance during facility construction with likely similar effects to sage-grouse as reported with oil and gas development. Solar-powered electricity generation is increasing. Solar energy infrastructure is often ancillary to other development, and large-scale solar-generating systems have not yet contributed to any calculable direct habitat loss for sage-grouse; 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). 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, NREL, 2013,p. v). The amount of solar power installed in the U.S. has increased from 1.2 gigawatts (GW) in 2008 to an estimated 17.5 GW as of the end of the third quarter of 2014 (DOE, 2014b).

Geothermal

Geothermal energy production is similar to oil and gas development as it requires surface exploration, exploratory drilling, field development, and plant construction and operation. Each drill site could disturb approximately 1-5 acres, and the drill rig could be approximately 60 feet tall. 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). Direct habitat loss occurs from development of well pads, structures, roads, pipelines, and transmission lines. The development of geothermal energy requires intensive human activity during field development and operation. The number of personnel required during construction varies significantly, but at any one point there may be a few hundred laborers and professionals on-site with attendant vehicle traffic. The number of people required for routine operation of a power plant is typically three per shift; however, additional personnel (as many as 12 total, depending on plant size) may be on site during the day for maintenance and management (EIA 2009e, entire). Geothermal plants could be in remote areas necessitating housing construction, transportation, and utility infrastructure for employees and their families (Suter 1978, p. 12). Wells are drilled to access the thermal source and could take 7 days to 60 days of continuous drilling (BLM, 2007, p.2-4; BLM, 2011, p. 9, 15) depending on the depth of the well, and can potentially cause toxic gas releases depending on the geological formation (BLM, 2013k, p.427). The type and effect of these gases depends on the geological formation in which drilling occurs (Suter 1978, pp. 7-9). Water is necessary for drilling operations and later for condenser cooling at the generation plants, which are similar in size to coal- or gas-fired plants. Thus, local water depletions may be a concern for sage-grouse if they result in the loss of brood-rearing habitat. The BLM and USFS completed a programmatic EIS for geothermal leasing and operations across much of the western United States in 2008 (BLM and USFS 2008b, entire). Best management practices were included for minimizing the effects of geothermal development and operations on sage-grouse, but they are guidance only and general in nature (BLM and USFS 2008b, pp. 4.82–4.83).

Comment [SSLM142]: I had to leave some of these citations because I couldn't find documents that provided equivalent information.

Comment [DP143]: do we have more recent information on methodology?

Results of impact

Studies examining the impacts of renewable energy development on sage-grouse populations are limited. Renewable energy facilities typically require many of the same features for construction and operation as do nonrenewable energy resources. 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 (See chapter X: Oil and gas).

Wind

Most published reports of the effects of wind development on birds focus on the risks of collision with towers or turbine blades (Pruett *et al* 2009, p.013136). Sage-grouse could be killed by flying into turbin rotors or towers (Erickson *et al*. 2001, entire) although reported collision mortalities have been few; average tower heights, flight elevations of grouse, and diurnal migration habitats minimize the risk of collision. However, sage-grouse can be killed by flying into turbine rotors or towers (Erickson *et al*. 2001, entire). 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 known sage-grouse mortality at this facility during three years of monitoring. We have recent data on wind turbine collisions in wind developments in Wyoming. At the Glenrock Rolling Hills I facility there were two collision mortalities in 2009 and one collision mortality in 2010, at the High Plains McFadden Ridge facility there was 1 collision fatality in 2011, at the Seven Mile I facility there was one collision mortality in 2012, at the Cambell Hill facility there was one collision with a turbine and one collision with a wind turbine associated met tower in 2012, and at the Top of the World facility there was one collision fatality in 2012 (USFWS, 2015, pers.comm.). However, due to the sampling design for predicting mortality rates for this project area, only a subset of the turbines were monitored for collision mortalities. Approximately, 30 percent of the turbines were searched, and the searcher efficiency is approximately 60-70 percent. In addition, sage-grouse are more likely to be scavenged and removed from the search area before the search is conducted, it is unclear what level of mortality rates these fatalities represent (USFWS, 2015, pers.comm.). For sage-grouse, the highest collision probabilities appear to occur when structures are located in areas where sage-grouse typically fly between foraging and loafing habitats. If the locations of such areas are known,impacts can be reduced by avoiding them when siting wind energy facilities (Johnson and Holloran, 2010, p.9). Preliminary data from research in Wyoming has indicated that direct mortality from collision occurs and may be greater than previously anticipated (USFWS, 2015, pers. comm.).

The LaBeau (2014) study is the first and to date only study, to document the short-term effects of wind energy infrastructure on greater sage-grouse habitat selection, nest, brood, and female survival. Sage-grouse female survival did not appear to be related to distance to turbines, which is counter to research conducted in natural gas fields for sage grouse and prairie-chickens (LaBeau, 2014, p.528). This is likely related to high site fidelity inherent to sage-grouse (LaBeau, 2014, p.2). Sage-grouse nest and brood survival decreased in habitats in close proximity to wind turbines. Decreased nest and brood survival was likely the result of increased predation, which may have been a product of anthropogenic development and habitat fragmentation (LaBeau *et al* 2014, p.522). Sage-grouse are nesting in less risky habitats farther away from potential perches and in areas that have lower densities of small, medium, and large avian predators (Dinkins *et al* 2014, p. 629). Despite sage-grouse high site fidelity older sage-grouse hens with failed nests from the previous nesting season had lower nest site fidelity compared with hens with successful nests. As in previous findings in response to disturbance, yearling birds had relatively larger changes in their spatial locations than older birds whose spatial changes were at a smaller scale (Dinkins *et al* 2014, p.638). Sage-grouse habitat use patterns could be explained by areas of relatively greater predation over time leading to low sage-grouse productivity (Dinkins *et al* 2014, p. 638). Sage-grouse are using direct and indirect mechanisms to avoid predators in habitat selection, possibly partially lowering their exposure to predation and nest predation (Dinkin *et al* 2014, p. 629).

The avoidance of human-made structures such as powerlines and roads by sage-grouse and lesser and greater prairie-chickens is documented (Holloran 2005, p. 1; Pruett *et al*, 2008, p. 6). New powerlines and possibly other tall structures such as wind turbines may be avoided in previously suitable habitats and serve as barriers to movement (Pruett *et al* 2008, p.013138). If habituation to disturbance does not occur, population level response could contribute to behavioral avoidance to wind development resulting in habitat loss (Winder *et al* 2014, p.11). Sage-grouse female and nest survival has been linked to the distance from transmission lines (Gibson *et al* 2013, p.27). Sage-grouse selected habitat in response to landscape attributes and anthropogenic features. Sage-grouse select habitat locations farther away from landscape attributes that could be used as perches or provide subsized food sources for predators at all reproductive stages, power lines at brood locations, and major roads and riparian habitat at nest locations (Dinkins *et al* 2014, p.639). Habitat fragmentation could potentially negatively affect demographic rates due to increased risk of predation or energy use (Gibson *et al* 2013, p.2). Nests in fragmented habitats were 9 times more likely to be depredated as those in continuous habitats, and the majority of nests in fragmented habitats were depredated by corvids (Vander Haegan *et al*. 2002, Howe *et al*., 2014, p.45).

In addition, meso-carnivore mammals and corvids, primary sage-grouse nest predators, may be attracted to wind energy developments because of subsidized food resources from deaths of birds by turbines, combined with low levels of human activity, whereas predators that prey on adults (e.g., golden eagles (*Aquila chrysaetos*) may not (LaBeau *et al*. 2014p. 528). Ongoing land use changes suggest there will be further increases in raven abundance (see the predation chapter for more information) in these fragmented sagebrush steppe habitats (Howe *et al* 2014, p. 44). Human manipulation of habitat that promotes increased densities of avian predators may limit sage-grouse populations, because even habitat that has high quality cover and forage may become functionally unavailable to sage-grouse as avian predator densities increase (Dinkins *et al* 2014, p. 640).

Noise is produced by wind turbine mechanical operation (gear boxes, cooling fans) and airfoil interaction with the atmosphere. There has been recent research demonstrating the effects of noise from natural gas developments on sage grouse, there have been no published studies focused specifically on the effects of wind power noise and sage-grouse. However, other types of anthropogenic noise sources (e.g., infrastructure from oil, geothermal, and mining, as well as wind development, off-road vehicles, highway traffic, and urbanization) are similar in acoustic frequency, amplitude, and timing, and response by sage-grouse to these other noise sources may be similar (Patricelli *et al* 2013, p.231). 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). Recent noise research has shown noise from natural gas development negatively impacts sage-grouse abundance, stress levels, and behaviors (Patricelli *et al.*, 2013, p. 231). Noise from natural gas development primarily is produced by drilling rigs, compressors, generators, and traffic on access roads. All of these noise sources are loudest in frequencies (i.e. pitch) <2.0 kHz. Male sage-grouse produce signals in a similar frequency range between 0.2 and 2.0 kHz, the potential exists for industrial noise to mask sage-grouse communication, interfering with the ability of females to find and choose mates. Noise may also increase predation risk by masking the sounds of approaching predators and increasing stress levels by increasing the perception of predation risk. In other vertebrate species noise has been found to impact individuals directly, by causing startling behaviors, increasing the heart rate, or increasing annoyance (Patricelli *et al*. 2013, p.231). All of these factors may interfer with normal foraging, resting, and breeding behaviors and contribute to higher stress levels and reduced fitness (Patricelli *et al*. 2013, p.231).

Immediate and sustained declines in male attendance on noise leks where 29 percent of the decline was due to drilling noises and 73 percent of the decline was due to traffic noises, with similar declines in female lek attendance (Patricelli *et al*. 2013, p. 231). There was evidence of elevated corticosteroid levels associated with increased physiological stress suggesting that males that did not physically abandon the lek were physiologically impacted. In addition, males altered the timing of their vocalizations in response to noise, increased display rates during close courtship on leks with drilling noise, and waited for gaps of quiet on leks with vehicle noise (Patricelli *et al*. 2013, p. 231). Sage-grouse do not appear to habituate to anthropogenic noise over time. The declines in male attendance observed in this study was immediate and sustained throughout the 3-year study period. Elevated stress hormones were observed in both second and third years of noise playback indicating that sage-grouse do not adapt to increased noise levels over time (Patricelli *et al*. 2013, p. 231).

Timing

Figure X-1. Annual life cycle of sage-grouse. Impacts from renewable energy developments occur year round as indicted by red bar.

Direct impacts due to habitat removal for pad locations, roads, and transmission lines would likely* occur outside of the breeding, nesting and brood rearing time periods and before the winter concentration season begins (BLM, 2013a, p.296,247;BLM, 2013b, p. 48,49,51,67,161-66,188;BLM, 2013c, 2-99, 100, 105, 172,173,178; BLM 2013d, p.46-48; BLM 2013e, 2-40-59; BLM 2013f, p. 2-44.45; BLM, 2013g, p.; BLM, 2013h, p. 2-90, 2-89, 90,92,94,96,98,100; BLM, 2013i, p. 2-133,134,136,137,143; BLM, 2013j, p. 145,146,151); *noise*, and sage-grouse strikes due to wind, solar, and geothermal developments could occur year round once a development is constructed. Indirect effects such predation and habitat avoidance. The effects of habitat fragmentation resulting in habitat loss and modification is long term and would occur year round. Predation occurs mainly during the nesting and brood rearing seasons. Avoidance of the wind turbines, roads, and transmission lines likely occurs year round and would be influenced by seasonal habitat use and movements. The impacts of modification, fragmentation, and elimination of sagebrush habitat from development of renewable energy are long-term effects rather than periodic or seasonal. These impacts not only occur throughout the year, but are persistent from one year to te next, and have the potential to affect all life stages and seasonal habitats.

Comment [DP144]: In general I don't think that we have established that noise is a direct impact outside the lekking period. I think this needs to be discussed further amongst the biologists so that all folks are treating it the same way.

* Development of renewable energy could result in immediate removal of existing nests, eggs, and broods, if sagebrush is removed during the spring nesting or summer brood rearing season; exceptions, waivers, and modifications (BLM, 2013a, p.37, 38, 247; BLM, 2013 b, p. 393; BLM, 2013d, p.39; BLM, 2013f, p.2-38; BLM, 2013g, p.2-14; BLM, 2013 i, 2-132, 133; BLM, 2013j, 2-62; BLM, 2013k, p.34) may be requested to conduct activities during the breeding, nesting, brood-rearing and winter concentration season at any time. In addition, areas that are designated as avoidance areas may be granted ROW permits for wind and solar development, as well as, ROWs for transmission lines at any time.

Location and extent

Table 11-5: Area of sagebrush habitat with wind energy development potential by management zone (Data from Service 2014)

SAGE-GROUSE MZ	Area of Sagebrush with Developable Wind Potential		
	km2	mi2	Percent of MZ
I	141937	54802	40.42
II	56275	21728	23.07
III	3880	1,498	1.22
IV	12,703	4,905	3.92
V	6,365	2,457	3.91
VI	1,528	590	2.36
VII	19	7	0.01
Total	222,708	85,988	13.74

Wind

California and Nevada have more than 150 megawatts of developed wind capacity. An additional 828 to 1,080 megawatts are slated for development by 2014. California and Nevada have the potential to contribute nearly 1,080 megawatts of wind-generated energy. This amount of energy would provide enough energy for over 250,000 homes in California and Nevada.

There are 114,936 acres of wind energy ROWs in the planning area (see Table X-10, Acres of Wind Energy Rights-of-Way in GRSG Habitat); however, there is currently one active industrial-scale wind energy generation facilities in the planning area (BLM, 2013a, p. 104).

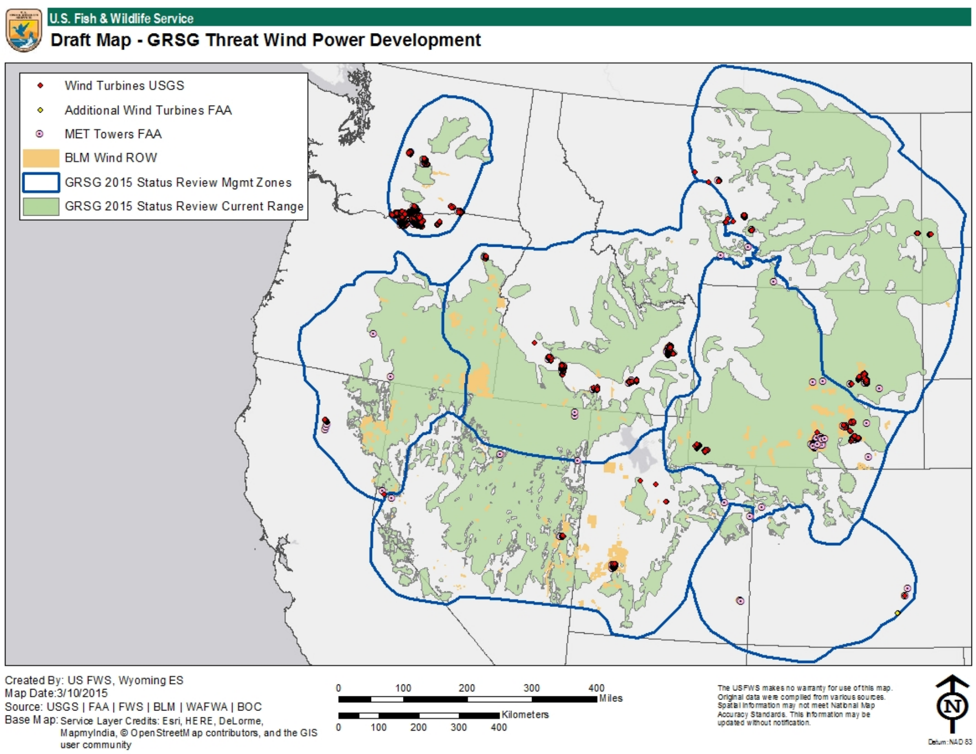
We are currently aware of four preliminary, planning-stage wind project proposals in the State of Montana may ultimately encroach to a minor extent on general habitat polygons; however, whether or not these proposals may be further refined, or even constructed, is unknown (USFWS, 2015 pers comm). We are not aware of additional wind projects specifically proposed in PACS. See Draft Map GRSG Threat Wind Power Development Map below, for the current locations of wind energy projects within GRSG habitats. The red dots represent currently constructed wind turbine locations.

Currently, the installed renewable energy capacity in Wyoming is 1,412 megawatts (MW) of wind energy, 0.05 MW of solar energy, and 0 MW of geothermal energy. A recent study, "Assessing the Potential for Renewable Energy on Public Lands," presented a nationwide overview of renewable resources on BLM–administered lands. In this study, Wyoming was determined to have a high potential for wind-energy development and a low potential for solar, and geothermal energy development. Wyoming's wind resource is ranked 8th in the nation (BLM, 2013j, p.3-52).

Table 11-6: Acres of Wind Energy ROWs in GRSG Habitat (Mariner et al. 2013, p.62)

Management Zone Entity	PPH SG Habitat (Acres)	
MZ I–GP	11,636,400	34,663,000
BLM	5,808,000	4,524,900
Forest Service	5,808,000	515,300
Tribal and Other Federal	219,700	2,427,700
Private	7,132,500	24,682,800
State	995,600	2,498,400
Other	1,900	13,900
MZ II and VII–WB & CP	17,476,000	19,200,200
BLM	9,021,200	9,012,500
Forest Service	162,000	452,500
Tribal and Other Federal	784,000	1,354,600
Private	6,233,900	7,394,800
State	1,244,800	979,800
Other	30,100	6,000
MZ III–SGB	10,028,500	3,970,100
MZ IV–SRP	21,930,600	10,958,500
BLM	13,710,700	4,928,200
Forest Service	1,613,800	1,113,500
Tribal and Other Federal	633,600	522,500
Private	4,890,200	3,516,742
State	1,019,373	846,200

Management Zone Entity	PPH SG Habitat (Acres)	
Other	62,900	31,400
MZ V–NGB	7,097,20	5,808,000



Solar

Wind and solar resource facilities are permitted with ROWs through the Lands and Realty Program. All solar energy projects 20 megawatts and greater are excluded in all RMPs within the Northwest District, as described in the Solar Energy Development Programmatic EIS Record of Decision, dated October 2012. Geothermal resources, as mentioned above, are considered fluid leasable minerals.

Although there are solar projects located in California and Nevada, there are no solar energy ROWs in the planning area (BLM, 2013a, p.105).

There are no existing renewable energy land use authorizations within the planning area within GRSG habitat (BLM, 2013b, p. 269).

Wind and solar resource facilities are permitted with ROWs, through the Lands and Realty Program. There are no active renewable energy ROW authorizations within the planning area (BLM, 2013g, p. 3-17).

There are currently no ROW acres for solar energy facilities in the planning area (BLM, 2013h, p.3-99).

The planning area has had no activity regarding solar energy projects, but this could change in the future (BLM, 2013k, p. 413).

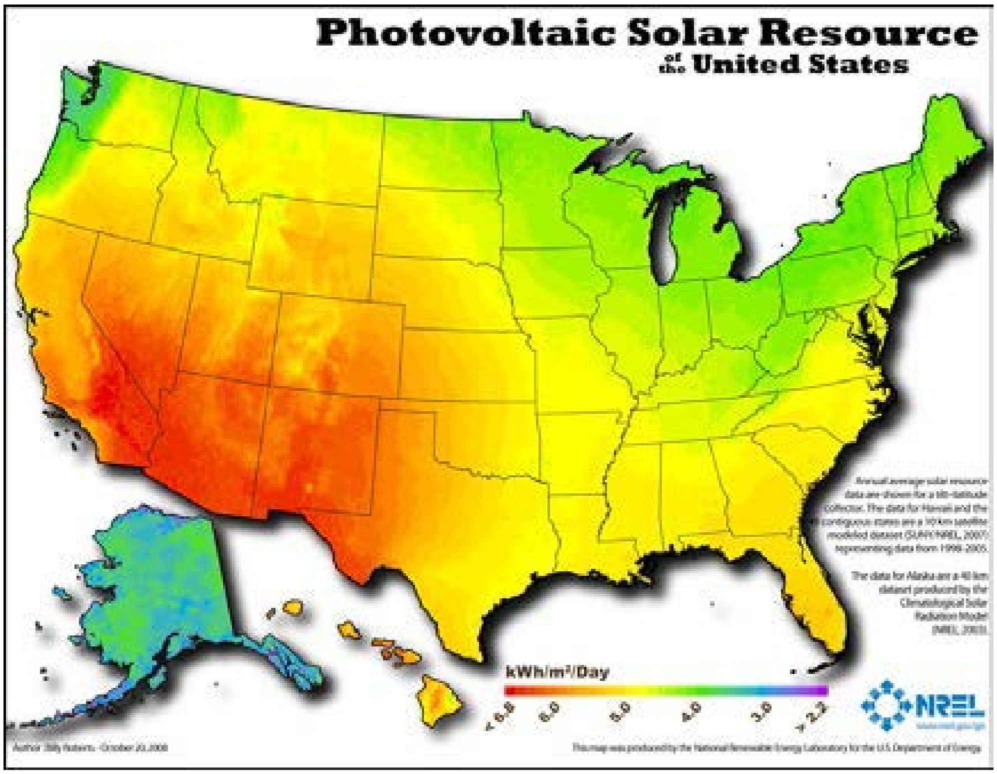
No commercial solar plants are operating in sage-grouse habitats at this time. The PEIS for Solar Energy Development (2012) identified specific locations well suited for utility-scale production of solar energy (i.e., SEZs) where the BLM proposes to prioritize development (and to apply any identified SEZ-specific design features), in six southwestern states (Arizona, California,Colorado, Nevada,New Mexico,and Utah). Solar Energy Zone are defined by the BLM as an area within which the BLM will prioritize and facilitate utility-scale production of solar energy and associated transmission infrastructure development. SEZs should be relatively large areas that provide highly suitable locations for utility-scale solar development: locations where solar development is economically and technically feasible, where there is good potential for connecting new electricity-generating plants to the transmission distribution system, and where there is generally low resource conflict (BLM, 2012, ES-7,8).

Table 11-7: Proposed SEZs and Approximate Acreage by State (BLM, 2012, p. ES-13)

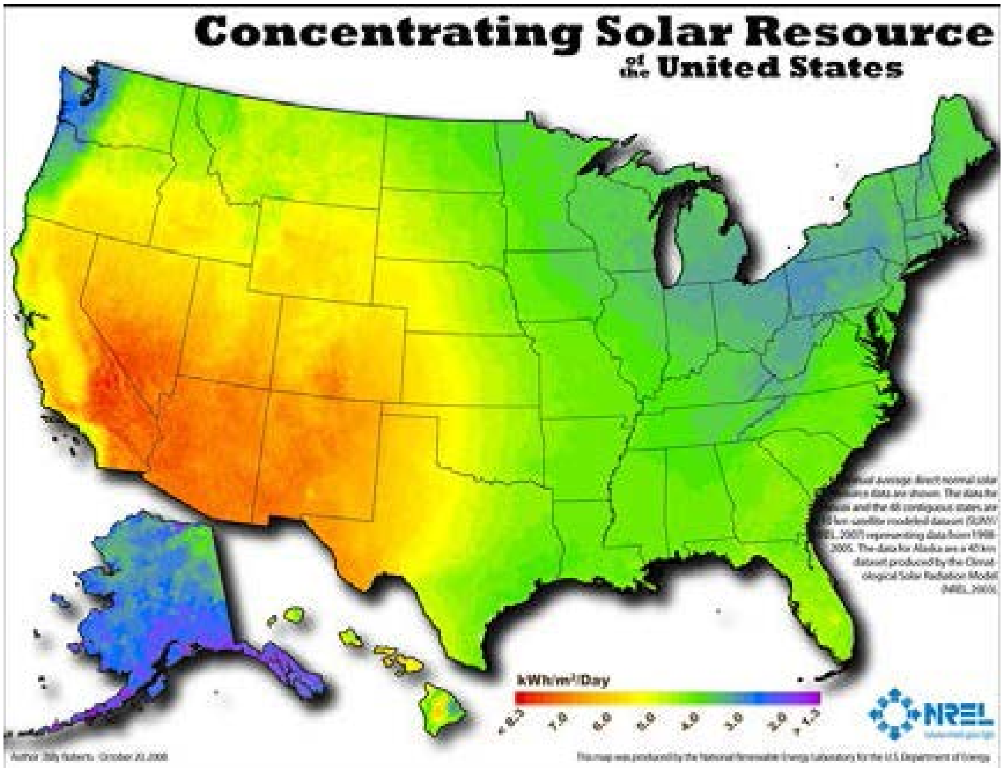
Proposed SEZ (BLM Office/Country)	Approximate Acreage
California	
Imperial East (El Centro/Imperial)	5717

Riverside East (Palm Springs-South Coast/Riverside)	147910
Total	153627
Colorado	
Antonia Southeast (La Jara/Conejos)	9712
De Tilla Gulch (Saguache/Saguache)	1064
Fourmile East (La Jara/Alamosa)	2650
Los Mogotes (La Jara/Conejos)	2650
Total	16308
Nevada	
Amargosa Valley (Southern Nevada/Nye)	8479
Dry Lake (Southern Nevada/Clark)	5717
Dry Lake Valley North (Ely/Lincoln)	25069
Gold Point (Battle Mountain/Esmeralda)	4596
Millers (Battle Mountain/Esmeralda)	16534
Total	60395
Utah	
Escalante Valley (Cedar City/Iron)	6533
Milford Flats South (Cedar City/Beaver)	6252
Wah Wah Valley (Cedar City/Beaver)	5873
Total	18658
Total	248988

There are over 799 major solar projects currently in the Solar Energy Industries Association database, representing over 43 GW of capacity. These projects have been constructed throughout the U.S. and occur on both private and public lands (SEIA,2014). Because of the proprietary nature of this digitized information, we only have spatial data on the projects on public lands which currently occur outside of priority habitats.



Source: NREL, 2010



Source: NREL, 2010

Geothermal

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.

Although geothermal potential exists in the planning area, there has been no interest in commercial development (BLM, 2013b, p. 294).

There are currently 25 federal leases in Idaho, covering approximately 60,000 acres. Leases are scattered across southern Idaho, but are primarily located near Raft River, Crane Creek, two geothermal leases located on the north side of Magic Reservoir, there are geothermal leases located west of Weiser, and Parma, Idaho. There are no active leases currently in the Dillon Field Office. Seventeen of Idaho's 25 geothermal leases are located in GRSG habitat, and all have existing stipulations protecting GRSG habitat during critical seasons (as well as having stipulations to protect crucial habitat for other species) (BLM, 2013c, p. 3-103):

Geothermal exploration and development activity on federal lands in Idaho has been sporadic, due largely to economic factors. Idaho now has one 10 megawatt geothermal power plant currently operating, as of 2007. It is located on private land at Raft River, south of Burley, Idaho. Nine federal leases surround the plant and extend up the southeast flank of Jim Sage Mountain. The BLM approved five geothermal drilling permits on a lease at Raft River in 2010, however no drilling has occurred to date. The drilling permits have several Conditions of Approval attached to protect wildlife. These include fencing reserve pits and safeguarding migratory birds from hazards associated with pits and treatment facilities, including but not limited to pit screening or netting, and placing protective cones over vent stacks. In addition, drilling is prohibited during the GRSG strutting and brood-rearing season (lease stipulation) (BLM, 2013c, p. 3-105).

There has been a marked increase in geothermal interest, including the recent development of a producing geothermal facility on private land in Eastern Oregon. The Vale District has issued two ROWs for access to utilize geothermal resources on private mineral estate at the Neal Hot Springs Project. (BLM, 2013h, p.3-99, 102).

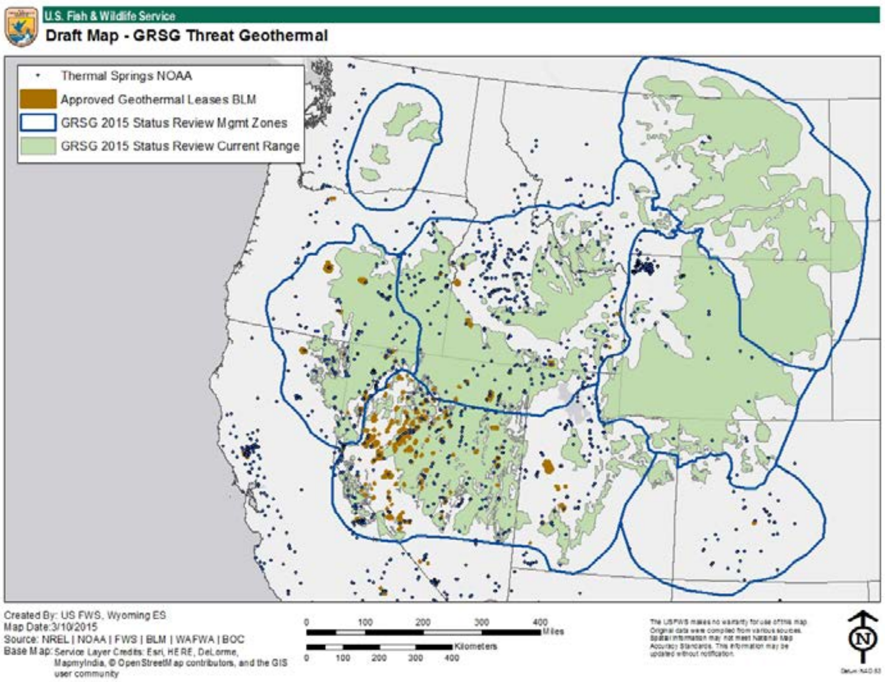
Geothermal heat is also considered a leasable mineral and is governed by the Geothermal Steam Act of 1970. There are no geothermal resources within the planning area (BLM, 2013g, p.3-29).

Currently, there are no geothermal energy production facilities within population areas in Utah.

Utah BLM currently has 59 authorized geothermal leases encompassing 162,205 acres within the Fillmore and Cedar City Field Office areas of the southern half of Utah's West Desert. As of early 2013, there were 41 geothermal wells in all of Utah, none of which are found in population areas or GRSG habitat. Currently, there are no geothermal energy production facilities within GRSG habitat in the planning area. Future development of geothermal resources within GRSG habitat in the planning area is also highly unlikely (BLM, 2013i, p. 3-186).

Geothermal resources are plentiful in the middle and northwest portions of the state, although a lack of transmission capacity may hinder electricity development in the northwest corner. Geothermal resources in Utah have the potential to supply 15,000 MW of electricity. The current installed capacity of Utah's two geothermal power plants is 42 MW. There are several additional geothermal prospects undergoing evaluation and exploration across the state (BLM, 2013i, p. *3-184*).

The planning area is generally open to consideration for exploration, leasing, and development for all leasable fluid minerals, which include oil, gas, and geothermal energy, in accord with all applicable provisions (e.g., restrictions and prohibitions). A steadily increasing interest in geothermal energy for space heating is a likely long-term trend but is unlikely to affect federal minerals. In addition, interest in commercial power generation has not been expressed in South Dakota (BLM, 2013k, p. 420).


U.S. Fish & Wildlife Service
Draft Map - GRSG Threat Geothermal
Thermal Springs NOAA
Approved Geothermal Leases BLM
GRSG 2015 Status Review Mgmt Zones
GRSG 2015 Status Review Current Range
Created By: US FWS, Wyoming ES
Map Date:3/10/2015
Source: NREL | NOAA | FWS | BLM | WAFWA | BOC
Base Map: Service Layer Credits: Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community
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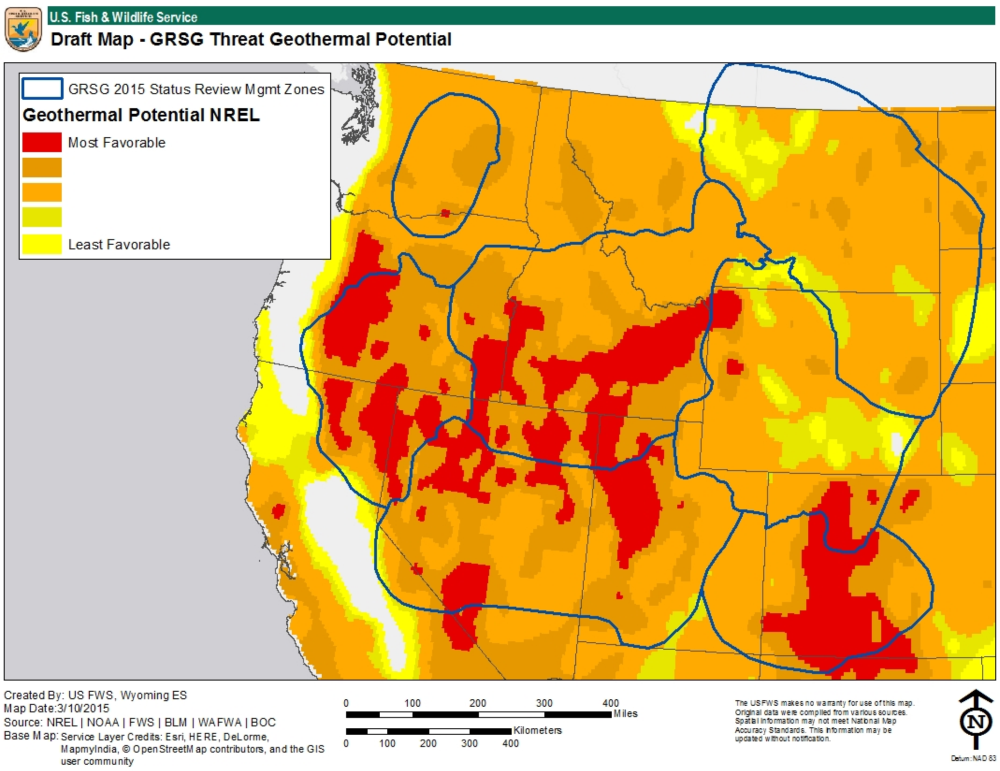

Table 11-8: List of impacts by management zone

Management Zone	Timing of Impacts (Season)	Immediacy of Impacts	Severity of Impacts	Extent of Impacts	Resource or Life stage impacted	Notes
	Ex. Spring (or all the time, etc.)	Happening right now (or, planned)	Direct mortality (or habiat destruction, etc)	Impacting x% of occupied range by MZ	Lekking adults, broods	This is an example
1 Wind	Year-round	Now	Direct mortality, habitat destruction, Habitat avoidance	0	Nesting, broods,	

Management Zone	Timing of Impacts (Season)	Immediacy of Impacts	Severity of Impacts	Extent of Impacts	Resource or Life stage impacted	Notes
2 Wind	Year-round	Now	Direct mortality, habitat destruction, Habitat avoidance	1	Nesting, broods	
3 Wind, Geothermal **Solar**	Year-round	Now	Direct mortality, habitat destruction, Habitat avoidance	1.77 0 0	Nesting, broods	
4 Wind, Geothermal	Year-round	Now	Direct mortality, habitat destruction, Habitat avoidance	1.96 0	Nesting, broods	
5 Wind, **Geothermal** **Solar**	Year-round	Now	Direct mortality, habitat destruction, Habitat avoidance	5.17 0 0	Nesting, broods	
6 Wind	Year-round	Now	Direct mortality, habitat destruction, Habitat avoidance	0.01	Nesting, broods	
7 Wind	Year-round	Now	Direct mortality, habitat destruction, Habitat avoidance	2.40	Nesting, broods	

~~Chapter 2:~~Chapter 1: Map Showing Current Threats (this is "Map 2" that the GIS team is working on; we will not have this map for all chapters)

Compounded effects

The compounding effects will be discussed in greater detail in the Compounded Effects chapter. In brief, the following impacts are likely to interact with the threat described in this chapter. All of these compounding effects are either causing habitat fragmentation, destruction, and removal; or are using these as tools to aid their expansion further into sage-grouse habitats (i.e. Predation and invasives).

- Infrastructure
- Predation
- Noise
- Invasives
- Genetics
- Fire

Projected Future impacts

Timescale for Projecting this Threat

Wind

The maximum potential development scenario (MPDS) was constructed by the National Renewable Energy Laboratory (NREL), a DOE laboratory focused on research of renewable energy resources. NREL has modeled and mapped the wind resources in each of the states and has assigned class designations to indicate the potential for wind power generation. Wind power classes range from 1 to 7; Class 7 has the highest potential wind power generation and Class 1 has the lowest. On the basis of projected wind technology development, NREL has determined that wind resources in Class 3 and higher could be economically developable over the next 20 years (i.e., the time frame for the PEIS analysis). In this PEIS, Class 3 resources have been characterized as having medium potential; resources in Classes 4 and higher have been characterized as having high potential (BLM, 2005, p.2-3). All of the MZs exibit areas where Class 3-7 have been modeled. However as you can see on the map titled GRSG Threat of Wind Power Development in MZs VI, V, IV, III, and even VII the wind resources are scattered and cover small patches of habitat. In MZ I and II where the wind resource has much more potential nearly the entire MZ is covered in classes 3-7.

Table 11-9: NREL Wind Potential within GRSG 2015 Status Review Current Range Source: (Service, 2015)

MZ	WPC 3 Acres	WPC3 % CR	WPC 4 Acres	WPC4 % CR	WPC 5 Acres	WPC5 % CR	WPC 6 Acres	WPC6 % CR	WPC 7 Acres	WPC7 % CR
1	23,941,216	50%	9,198,907	19%	1,530,751	3%	345,782	1%	56,692	0%
2	7,471,162	20%	3,412,153	9%	1,538,397	4%	1,080,381	3%	403,859	1%
3	476,699	2%	152,181	1%	61,528	0%	46,626	0%	26,840	0%
4	2,350,426	6%	498,516	1%	182,839	0%	81,459	0%	25,826	0%
5	1,153,113	6%	252,096	1%	92,930	0%	52,044	0%	22,545	0%
6	248,594	9%	94,480	3%	27,686	1%	6,757	0%	79	0%
7	3,918	0%	659	0%	130	0%	11	0%	1	0%
Total:	35,645,128	20%	13,608,992	8%	3,434,261	2%	1,613,060	1%	535,842	0%

Solar

The scope of the Final Programmatic Environmental Impact Statement for Solar Energy Development impact analysis includes an assessment of the potential environmental, social, and economic impacts of utility-scale solar facilities and required transmission connections from these facilities to the existing electricity transmission grid andother associated infrastructure such as roads over an approximately 20-year time frame (i.e., until about 2030) (BLM, 2012).

Table X-17 presents the Reasonable Foreseeable Development Scenario (RFDS) for each state in terms of projected megawatts and estimated acres of land required to support that level of development. The calculated number of BLM- and non-BLM-administered acres likely to be developed over the next 20 years is based on the assumed RFDS and on a high-end estimated land requirement of 9 acres/MW (0.04 km2/MW) for development

(BLM, 2012, p.2-65). As shown, the estimated amount of solar energy generation on BLM-administered lands in the study area over the 20-year study period is about 24,000 MW,with a corresponding dedicated use of about 214,000 acres (866 km2) of BLM-administered lands. The estimated total amount of solar energy generation on all lands in the study area over the 20-year study period is 32,000 MW, with a corresponding dedicated use of about 285,500 acres (1,155km2) of land (BLM, 2012, p.ES-16).

Table 11-10: NREL DNI Solar Potential within GRSG 2015 Status Review Current Range Source: (Service, 2015)

MZ	4.0 - 4.5	4-4.5 % CR	4.5 - 5.0	4.5-5 % CR	5.0 - 5.5	5-5.5 % CR	5.5 - 6.0	5.5-6 % CR	6.0 - 6.5	6-6.5 % CR	6.5 - 7.0	6.5-7 % CR	> 7.5	> 7 % CR
1	630,660	1%	21,183,967	44%	19,391,101	40%	6,439,559	13%	34,620	0%		0%		0%
2		0%	70,149	0%	5,198,950	14%	29,585,551	80%	2,261,177	6%		0%		0%
3		0%		0%	94,277	0%	2,728,948	9%	13,361,629	46%	8,567,929	30%	71,772	0%
4		0%	2,537,302	7%	9,993,144	26%	23,549,337	62%	2,133,349	6%		0%		0%
5		0%	25,610	0%	2,247,078	12%	11,689,016	61%	5,069,284	26%	246,984	1%		0%
6	81,879	3%	2,281,951	83%	394,079	14%		0%		0%		0%		0%
7		0%		0%		0%	333,679	28%	842,742	71%	4,007	0%		0%
Total:	712,539	0%	26,098,979	15%	37,318,629	21%	74,326,090	42%	23,702,801	13%	8,818,920	5%	71,772	0%

* Direct Normal Index (DNI) Solar Potential = NREL 10km DNI data for Concentrating Solar Resource

* NREL data measured in kWh/m2/Day

* Ranges above taken from NREL

Table 11-11: Projected 1 Megawatts of Solar Power Development by 2030 and Corresponding Developed Acreage Estimates for the RFDSa Source: (Service, 2015)

State	Landholding	Estimated MW under RFDS	Estimated Acres under RFDSb
California	BLM	15,421	138,789
	Non-BLM	5,140	46,260
Colorado	BLM	2,194	19,746
	Non-BLM	731	6,579
Nevada	BLM	1,701	15,309
	Non-BLM	567	5,103
Utah	BLM	1,219	10,971
	Non-BLM	406	3,654
Total	BLM	20535	184815
	Non-BLM	6844	61596

a See Appendix E of the Draft Solar PEIS for details on the methodologies used to calculate the RFDS.

b Acreage calculated assuming land use of 9 acres/MW (0.04 km2/MW). To convert acres to km2, multiply by 0.004047.

Geothermal

A geothermal lease is issued for a primary term of 10 years and may be extended for two five-year periods. Each of these extensions is available provided the lessee meets the work commitment requirements or lessee made payment in lieu of minimum work requirements of each year. At any time a lease may receive a 5-year drilling extension. Once commercial production is established, the lease may receive a production extension of up to 35 years and a renewal period of up to 55 years. The lease must continue to produce to remain in effect. BLM may grant a suspension of operations and production on a lease when justified by the operator (see 43 CFR 3207) (BLM and USFS, 2008).

Table 11-12: Acres of Geothermal Resource Potential within GRSG Habitat (Manier, et al., 2013, p.71), Source: (Service, 2015)

Management Zone Entity	PPH SG Habitat (acres)	PPH SG Habitat (acres)
MZ I–GP	1,636,400	34,663,000
MZ II and VII–WB & CP	17,476,000	19,200,200
MZ III–SGB	10,028,500	33,970,100
MZ IV–SRP	21,930,600	10,958,500
MZ V–NGB	7,097,200	5,808,000

Table 11-13: BLM Approved Geothermal Leases within GRSG 2015 Status Review Current Range Source: (Service, 2015)

Management Zone	BLM Lease Acres	% of Current Range
1	0	0
2	0	0
3	322,593	1.12%
4	111,522	0.29%
5	74,098	0.38%
6	0	0
7	0	0
Total:	508,213	0.29%

Table 11-14: NREL Geothermal Potential within GRSG 2015 Status Review Current Range Source: (Service, 2015)

	Most Favorable									Least Favorable
MZ	**Class 1**	**Class 1 % CR**	**Class 2 Acres**	**Clas s2 % CR**	**Class 3 Acres**	**Clas s3 % CR**	**Class 4 Acres**	**Class 4 % CR**	**Class 5 Acres**	**Clas s5 % CR**
1		0%	3,212,742	7%	37,586,886	78%	3,895,528	8%	1,417,934	3%
2	577,712	2%	2,334,455	6%	24,105,904	65%	7,914,169	21%	1,939,862	5%
3	5,191,238	18%	12,675,295	44%	10,936,768	38%		0%		0%
4	16,520,232	43%	15,416,834	40%	6,239,141	16%	36,964	0%		0%

	Most Favorable									Least Favorable
MZ	Class 1	Class 1 % CR	Class 2 Acres	Class2 % CR	Class 3 Acres	Class3 % CR	Class 4 Acres	Class 4 % CR	Class 5 Acres	Class5 % CR
5	6,079,095	32%	11,591,848	60%	1,607,028	8%		0%		0%
6		0%	797,664	29%	1,960,245	71%		0%		0%
7	12,894	1%	74,838	6%	1,092,696	93%		0%		0%
Total:	28,381,171	16%	46,103,676	26%	83,528,668	48%	11,846,661	7%	3,357,796	2%

Likelihood of future impacts

The Department of Energy (DOE) predicts that wind may provide 20 percent of the nation's energy needs by the year 2030, in order for this to occur, substantial growth of wind development will be required. Wind energy technology has been improving in two different ways, first to become more energy efficient turbines have gotten taller and blades longer to be able to capture wind in low potential areas. Larger rotors, taller towers, and better siting techniques have enabled wind developers to increase power production while simultaneously reducing costs (NREL, 2014, entire). Energy developers will be able to put wind turbines in locations that were previously considered uneconomical expanding into habitats they may not have previously considered for development. In response to bird collisions wind companies are trying different techniques for bird deterrance and even detection such as: radar, gps tracking, ultrasonic acoustics, designing new turbine shapes, forward looking infra-red camera (FLIR), and strike detection (Drouin, 2014, entire, Bevanger, *et al*, 2008, entire). Unfortunately, there is not any information at this time to show whether any of these methods are preventing bird collision. Focusing new mitigation techniques on bird strikes does not address the more pertinent issues for sage-grouse such as, habitat fragmentation and habitat avoidance due to these changes in the landscape. Energy companies are trying to find mitigation practices that minimize the impacts to sage-grouse, however, as long as there are anthropogenic features on the landscape, habitat fragmentation and avoidance will still occur. Therefore, there is a high likelihood of continued future impacts in sage-grouse habitats due to renewable energy on the landscape.

Comment [SSLM145]: I was unable to find anything in scientific literature that was as extensive as this article, I'm hoping its ok to leave it in. even the bevanger article only looked at radar and the FLIR.

The BLM recently completed a programmatic EIS on solar development in six southwestern States including Nevada and California, and through this process identified exclusion areas or areas where solar development would not be allowed (BLM 2012b, p. ES-7). The EIS only affects utility-scale developments (greater than 20 megawatts) occurring on BLM-managed lands, and recognized occupied sage-grouse habitat as a criterion for exclusion (BLM 2012b, p. ES-8). Solar array development requires similar infrastructure as other renewable and nonrenewable energy sources. Direct habitat loss can be significant because much of a solar project site would have vegetation removed. Currently, there are two solar plants within the current range of sage-grouse impacting a total of 6 acres of habitat. 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 due to the fact that at least on federal lands these projects will be sighted outside of sage-grouse habitats. The uncertainty lies in whether these projects would be sighted on private lands within sage-grouse habitats, there was no information available concerning proposed projects. 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.

The Geothermal leasing in the Western United States ROD (2008), did not provide any specific lease stipulations for the protection and conservation of sage-grouse. However, geothermal leases would be subject to same restrictions that are being developed by the BLM/USFS as part of the rangewide sage-grouse land use amendments for fluid mineral development. Therefore, there is the potential for the likelihood of future impacts due to geothermal development within MZ II, III, IV, V, and VII due to the fact that there will still be some measure of habitat removal from development, habitat, fragmentation, and noise impacts despite the management actions in place. There is the potential for future impacts in MZ I only because there are far fewer geothermal resources identified for leasing in this MZ, otherwise the impacts would be the same. Geothermal development poses a widespread threat due to the extent of the development potential (see GRSG Threat Geothermal Potential Maps).

Anticipated changes from present

Sage-grouse populations in existing wind developments are likely to see continued declines due to habitat fragmentation and infrastructure. Sage-grouse are subjected to predation pressures from mortality of adults, eggs, and chicks are moving out of the edge habitats to denser cover away from predators causing behavioral avoidance of previously suitable habitats (Dinkins *et al* 2014, p. 640). Female sage-grouse are moving farther away from edge habitats and anthropogenic features as their nests and young are predated, yearling females are locating their nests at even greater distances (Dinkins *et al* 2014, p.638). These behaviors will result in no further recruitment of sage-grouse in these habitats, changing life history strategies in previously functioning habitats.

It is unknown at this time to what extent geothermal development would occur within sage-grouse habitats. The Geothermal leasing in the Western United States ROD (2008), did not provide any specific lease stipulations for the protection and conservation of sage-grouse In the BLM NV/CA sage-grouse amendment (BLM, 2013a, p.2-37) there are 1,350,600 acres of sage-grouse habitat closed to geothermal development. However, there are 1,1600,100 acres open to geothermal development (BLM, 2013a, p.2-37). On BLM lands in Utah there is a No Surface Occupancy (NSO) within 4 miles of occupied leks and Controlled Surface Use (CSU) in outside of 4-mile lek buffers. (p.2-155). In areas where geothermal development may occur the BLM sage-grouse amendments are applying the stipulations subject to the oil and gas leasing, since geothermal leasing falls under that program area.

Threat amelioration

Active Conservation

Through the Conservation Efforts Database (CED), the Service collected information relating to conservation actions that were completed, in progress, or planned. Based on a summary report of that information created on XXXXXX, the following table indicate the number of actions and approximate areas for threat amelioration. These numbers are self-reported; the Service will further review and certify these actions if they are pivotal to any determination.

Best management practices (BMPs) prescribed in the Wind Energy EIS (BLM, 2005, p.5-89-112) 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 depends on how many turbines and infrastructure are necessary, for instance the Chokecherry Sierra Madre wind development project in WY developed a 171,251-acre site-specific Project Area to include areas in which CCSM Project components (infrastructure, wind turbines, etc.), this facility will have 1,000 turbine generators (BLM, 2014, p.1-2 and 1-3). 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 sage-grouse range.

In MZ I, II, III, IV, V, VII the BLM/FS lands are precluding wind and solar development in PPH (see table X-3). Primarily ROW permitting for wind and solar energy facilities will be designated as exclusion areas. These designations will presumably cause no impacts due to wind and solar development with the assumption that there will be no exemptions to the exclusion of wind and solar energy developments in areas with this designation. However, transmission lines have both exclusion and avoidance areas within all of the MZs. (The definitions of avoidance and exclusion can be found on p. 1-34 after the Summary of BLM/USFS Draft RMP/EIS Wind/Solar Energy Actions table). The intent of an avoidance designation is to primarily exclude projects, however permits may be granted under an avoidance designation which allows for more flexibility for the Authorizing Officer (AO) (Field Manager, District Ranger, District Manager, etc.). Because there may come a time when the AO may want to grant a ROW permit within these habitats. With these management actions in place there is still a widespread threat present because it is unknown to what extent and where transmission projects may occur, and under which circumstances they may occur.

The BLM and USFS are proposing to exclude wind development in priority habitats (PH) until there are no longer impacts to sage-grouse populations. Some plans are extending this protection to right-of-way (ROW) exclusion, which will cause no impacts due to wind and solar development with the assumption that there will be no exceptions to these designations. Many of the plans have designated areas as avoidance for transmission lines, which may have ROW permits granted at any time in the future. The exclusion designations provides protections for sage-grouse from wind turbines, however cross county transmission lines and roadways could still be constructed under an avoidance designation,creating habitat fragmentation, behavioral avoidance, and change life history strategies for sage-grouse. (See Table X- Summary of BLM/USFS Draft RMP/EIS Wind/Solar Energy Actions for the complete actions in the BLM/FS plan amendments.)

The Solar EIS recognized occupied sage-grouse habitat as a criterion for exclusion of solar energy development.

The Service addresses regulatory actions in a separate chapter????

Comment [SSLM146]: I didn't fill in this table because as far as I know there is no CEA data for renewable energy.

Comment [KNorman147]: Do we want to make this easier on folks? Does that undermine the "take away"?

Table 11-15: List of Conservation Efforts (ameliorating threat described in this chapter) by management zone

Management Zone	Type of Conservation Effort	Sum of Acres or Miles	Number of Actions	Notes
1				
2				
3				
4				
5				
6				
7				
8				

Threat Amelioration Summary

Table 11-16: Summary of BLM/USFS Draft RMP/EIS Wind/Solar Energy Actions

NV and NE CA Draft RMP/EIS		
	Exclusion	Avoidance
ROW exclusion areas on BLM-and Forest Service-administered lands within PPH, PPMA, or SGMA (occupied) (144,200 acres) (p.2-36)	X	

ROW exclusion areas on BLM-and Forest Service-administered lands within PGH, PGMA, or SGMA (suitable) (37,000 acres) (p.2-36)	X	
Solar energy ROW variance area within PPH, PPMA, or SGMA (occupied) 10,655,300 acres (p.2-36)		X
Solar energy ROW variance area within PGH, PGMA, or SGMA (suitable) 2,295,500 acres (p.2-36)		X
Fluid Mineral Leasing (oil and gas and geothermal)		
Closed to fluid mineral leasing within PPH, PPMA, or SGMA (occupied) 1,161,500 acres (p.2-37)		
Closed to fluid mineral leasing within PGH, PGMA, or SGMA (suitable) 189,100 acres (p.2-37)		
Open to fluid mineral leasing within PPH, PPMA, or SGMA (occupied) 9,493,800 acres (p.2-37)		
Open to fluid mineral leasing within PGH, PGMA, or SGMA (suitable) 2,106,300 acres (p.2-37)		
Open to fluid minerals but requires application of the avoid, minimize and mitigation evaluation in SGMA (occupied) 9,493,800 acres (p.2-37)		
Open to fluid minerals but requires application of the avoid, minimize and mitigation evaluation in SGMA (suitable) 2,106,300 acres (p.2-37)		
NW CO Draft RMP/EIS		
ROW Designation in PPH for large transmission lines on 68,000 acres (p.146)		X
ROW Designation in PPH for large transmission lines on 881,000 acres (p.146)	X	
Geothermal (is managed as a fluid leasable mineral) Unleased Fluid Minerals **GRSG PPH NSO-46d.** Apply NSO stipulation for fluid mineral leasing in PPH. **GRSG ADH NSO-46d.** Apply NSO stipulation for fluid mineral leasing in ADH within a minimum distance of 0.6-mile from active leks. **GRSG ADH TL-46d.** Within ADH, prohibit surface occupancy within a minimum of 4 miles from active leks during lekking, nesting, and early brood rearing. **Ecological Sites that Support Sagebrush in PPH CSU-46d.** Surface		

disturbance within ecological sites that support sagebrush in PPH would not exceed 5 percent within the corresponding Colorado MZ. See **Appendix E**, Stipulations Applicable to Fluid Mineral Leasing and Land Use Authorizations and **Appendix F**, Disturbance Cap Management. (p.161)		
Leased Fluid Minerals **GRSG PPH COA-47-51d.** Prohibit surface occupancy or disturbance within 4 miles of a lek during lekking, nesting, and early brood rearing. **GRSG Ecological Sites that Support Sagebrush in PPH COA-47-51d.** Limit permitted disturbances to 5 percent in any Colorado MZ. **GRSG PPH COA-47-51d.** Prohibit surface occupancy or disturbance within 4 miles of a lek during lekking, nesting, and early brood rearing. **GRSG Ecological Sites that Support Sagebrush in PPH COA-47-51d.** Limit permitted disturbances to 5 percent in any Colorado MZ. **GRSG PPH COA-47-51d.** Prohibit surface occupancy or disturbance within 4 miles of a lek during lekking, nesting, and early brood rearing. **GRSG Ecological Sites that Support Sagebrush in PPH COA-47-51d.** Limit permitted disturbances to 5 percent in any Colorado MZ. **GRSG PPH COA-47-51d.** Prohibit surface occupancy or disturbance within 4 miles of a lek during lekking, nesting, and early brood rearing. (See **Table 2.5**, Existing Habitat Timing Limitations by Field Office.) **GRSG Ecological Sites that Support Sagebrush in PPH COA-47-51d.** Limit permitted disturbances to 5 percent in any Colorado MZ. **GRSG PPH COA-47-51d.** Prohibit surface occupancy or disturbance within 4 miles of a lek during lekking, nesting, and early brood rearing. (See **Table 2.5**, Existing Habitat Timing Limitations by Field Office.) **GRSG Ecological Sites that Support Sagebrush in PPH COA-47-51d.** Limit permitted disturbances to 5 percent in any Colorado MZ. **GRSG PPH Notice to Lessees-54d.** Within PPH, complete Master Development Plans instead of single-well Applications for Permit to Drill for all but exploratory wells. GRSG PPH COA-55d. For leases that are not yet developed, the proposed surface disturbance cannot exceed 5 percent for ecological sites that support sagebrush in PPH for that Colorado MZ **GRSG PPH Notice to Lessees-58d**. Encourage unitization within Colorado MZs when necessary for proper development and operation of an area or to facilitate more orderly (i.e., phased and/or clustered) development as a means of minimizing adverse impacts to GRSG. (ADH) For future actions, require a full reclamation bond specific to the site in accordance with 43 CFR 3104.2, 3104.3, and 3104.5. Ensure bonds are sufficient for costs relative to reclamation (Connelly *et al*. 2000a; Hagen *et al*. 2007) that would result in full restoration of the lands to the condition it was found prior to disturbance. Base the reclamation costs on the assumption that contractors for the BLM and USFS will perform the work. (p.162)		
ID and SW MT Draft RMP/EIS		
PPMA: Solar and wind energy development is not allowed. (p.2-161)	X	
PMMA: Wind and solar energy development would be restricted where adverse effects could not be mitigated. Ancillary facilities such as roads, electric lines, etc. could potentially be authorized provided there is no net loss of GRSG habitat through mitigation (p.2-161, 162).		X

PGMA: Lands shall be considered avoidance areas for wind and solar development. (p.2-162)		X
Designate PPMA as ROW Avoidance areas and exclusion areas for wind and solar development . New authorizations for the following uses are not allowed: Transmission facilities (greater than 50kV in size), wind energy testing and development, commercial solar development, commercial geothermal development, nuclear development, oil and gas development, mineral development, airports, and ancillary facilities associated with any of the aforementioned development; paved roads and graded gravel roads, landfills, airports, and hydroelectric projects. Communication sites would be allowed. (p.2-162)	X	X
PMMA: Designate PMMA as ROW Avoidance areas. Access roads or loop roads would be addressed during the ROW authorization processing and on a case-by-case basis. (p.2-162)		X
PGMA: Same as PMMA. (p.2-162)		X
ROW Designation in Idaho-CHZ (p.2-162)		X
ROW Designation in Idaho-IHZ (p.2-162)		X
MT-HiLine Draft RMP/EIS		
ROW Designation for Commercial Wind Energy Development of 885, 661 acres		X
ROW Designation for Commercial Wind Energy Development of 1,518,695 acres	X	
BLM lands in the planning area will be available for geothermal leasing, unless located within the Burnt Lodge or Bitter Creek WSAs or in instances where it is determined that issuing the lease would cause unnecessary or undue degradation to BLM lands or resources.		
Opportunities for solar development will be provided consistent with the other goals, objectives, and requirements of this plan. Applications for solar energy projects will be processed and authorized as rights-of-way. Utility-scale concentrating solar power or photovoltaic electric generating facilities must comply with the BLM's planning, environmental, and right-of-way application requirements as established by BLM guidance (WO IM No. 2011-003) or additional Bureau guidance and/or policy.		
MT-Miles City Draft RMP/EIS		
Renewable energy ROW (wind and solar) of 1.2 million acres (p.2-6)		X

Renewable energy ROW (wind and solar) of 12,000 acres (p.2-6)	X	
Geothermal leasing would be offered in compliance with the Record of Decision and Resource Management Plan Amendments for Geothermal Leasing in the Western United States(p.2-40)		
MT-Billings Resource Management Plan and EIS		
Renewable Energy (wind and solar) on 78,088 acres (p.2-21)	X	
Renewable Energy (wind and solar) on 331,088 acres (p.2-22)		X
Lands in the planning area would be available for geothermal leasing, unless located within wilderness or WSAs or in instances where it is determined that issuing the lease would cause unnecessary or undue degradation to public lands or resources. Other areas that would be made unavailable are listed in the Record of Decision and RMP Amendments for Geothermal Leasing in the Western United States (December, 2008) which is incorporated in this RMP. A site-specific environmental analysis would be prepared as needed should interest be expressed in exploring for or developing geothermal resources in the planning area. This analysis would address the application of stipulations and develop any additional mitigating measures over and above the lease stipulations required. (p.2-101)		
ND Greater sage-grosue Draft RMPA/EIS		
ROW Designation in PH on 32,000 acres (p.2-27)	X	
ROW Designation in PH on 80 acres (p.2-27)		X
There are no geothermal resources within the ND Greater sage-grosue Draft RMPA/EIS planning area. (p.3-29)		
Oregon Sub-Region Greater sage-grouse Draft RMP/EIS		
Exclusion Area: PPH/PPMA/Core Area habitat (257,154 acres). (p.2-53)	X	
Exclusion Area: PGH/PGMA/Low Density habitat (288,195 acres) (p.2-53)	X	
Avoidance Area: PPH/PPMA/Core Area habitat (4,289,889 acres) (p.2-53)		X
Avoidance Area: PGH/PGMA/Low Density habitat (1,672,025 acres) (p.2-53)		X
Leasable Minerals – Leased Federal Fluid Mineral Estate (Including Geothermal) (MLS) In PPMA, apply the following conservation measures through RMP implementation decisions (e.g., approval of an Application for Permit to Drill and Sundry Notice) and upon completion of the environmental record of review (43 CFR 3162.5), including appropriate documentation of compliance with NEPA. In this process evaluate, among other things: 1. Whether the conservation measure is “reasonable” (43 CFR 3101.1-2) with the valid existing rights 2. Whether the action is in conformance (p.2-94) Additionally, apply the 3% disturbance limitation for development within PPMA. Issue Written Orders of the Authorized Office requiring reasonable protective measures consistent with the lease terms where necessary		

to avoid or minimize impacts on GRSG populations and its habitat. Include actions in the authorization that would minimize habitat loss and promote restoration of habitat when development activities cease in areas where GRSG populations have been substantially diminished and where few birds remain. (p.2-94)		
South Dakota Draft RMP/EIS		
Renewable energy ROWs within Sage-grouse PPAs and areas outside of PPAs within 4.0 miles of leks, sage-grouse wintering areas 55,761 acres (p.59)	X	
Renewable energy ROWs within Sage-grouse nesting and brood rearing areas outside of PPAs 84,384 acres (p.57)		X
Oil and gas stipulations as described by each alternative would also apply to geothermal exploration and development.		
Utah Greater Sage-grouse Draft LUPA/EIS		
PPMAs Designation for Wind Energy Development 2,760,300 acres (p.2-105)	X	
PPMAs Designation for Wind Energy Development 9,400 acres (p.2-105)		X
Wind Energy Development outside of GRSG habitat 82,400 acres (p.2-106)	X	
Wind Energy Development outside of GRSG habitat 462,500 acres (p.2-106)		X
Areas outside PPMAs but within 1.0 mile of an occupied lek, if the lek is located within a PPMA (p.2-106)	X	
Areas outside PPMAs but within 4 miles of an occupied lek located within a PPMA (p.2-106)		X
wind energy development within 1.0 mile of an occupied lek located in PGMA (p.2-106)	X	
Above-ground Site-type ROWs/SUAs (non-wind or solar) Avoided-51,700 acres (p.2-94)		X
Above-ground Site-type ROWs/SUAs (non-wind or solar) Excluded-81300 acres (p.2-94)	X	
Geothermal: NSO within 4 miles of occupied leks. CSU/TL in outside of 4-mile lek buffers. (p.2-155)		
Wyoming Sage-grouse Land Use Plan Amendment		
New ROW or SUA permits within Sage-grouse core habitat areas (p.2-18)		X
sage-grouse general habitat areas (p.2-20)		X
Wind energy development within sage-grouse core habitats	X	

(p.2-30)		
Geothermal: Leasing of non-energy leasable minerals would be considered within sage-grouse core habitat areas, except in areas that are unavailable for leasing due to the need to protect sensitive resources Exploration licenses and prospecting permits would be considered with appropriate mitigating measures. All non-energy leasable mineral activities would be considered in sage-grouse core habitats, provided that the activities can be completed in compliance to surface occupancy and disturbance and density stipulations analyzed through the DDCT process. (p.2-86)		

Glossary

Avoidance/avoidance area. These terms usually address mitigation of some activity (i.e., resource use). Paraphrasing the CEQ regulations (40 CFR 1508.20), avoidance means to circumvent, or bypass, an impact altogether by not taking a certain action, or parts of an action. Therefore, the term "avoidance" does not necessarily prohibit a proposed activity, but it may require the relocation of an action, or the total redesign of an action to eliminate any potential impacts resulting from it. Also see *"right-of-way avoidance area"* definition.

Exclusion area. An area on the public lands where a certain activity(ies) is prohibited to insure protection of other resource values present on the site. The term is frequently used in reference to lands/realty actions and proposals (e.g., rights-of-way, etc.), but is not unique to lands and realty program activities. This restriction is functionally analogous to the phrase "no surface occupancy" used by the oil and gas program, and is applied as an absolute condition to those affected activities. The less restrictive analogous term is avoidance area. Also see *"right-of-way exclusion area"* definition.

Assessment of Potential Threat

Sage-grouse could be killed by flying into turbine rotors or towers (Erickson *et al*. 2001, entire) although reported collision mortalities have been few. Behavioral avoidance, alteration of habitat quality, or changes in trophic interactions may have more important implications to greater sage- grouse population responses to wind energy development and could be more pervasive than direct effects of collisions (Winder *et al* 2014, p.2). In addition, sage-grouse are also being negatively impacted by the associated habitat loss and fragementation that results from development (Dinkins *et al* 2014, p. 640). The transmission line and road infrastructure associated with wind energy development has revealed behavioral impacts to sage-grouse. (For further information see the chapter X infrastructure). Further anthropogenic features such as roads, powerlines, fences and wind towers are linked to elevated mortality rates and shifts in life history strategies (Winder *et al* 2014, p.11).

Habitat removal, fragmentation, and degradation is the primary threat to sage-grouse as a result of renewable energy development. Recent studies on the impacts of predators in sage-grouse habitats, show the common raven in particular selects anthropogenic features and edge habitats for nesting and foraging. Female sage-grouse that have had nests predated are moving their nest locations, older females at smaller increments than yearlings, suggesting that predation pressures are overriding female sage-grouse habitat site fidelity. Human manipulation of habitat that promotes increased densities of avian predators may limit sage-grouse populations, because even habitat that has high quality cover and forage may become functionally unavailable to sage-grouse as avian predator densities increase (Dinkins *et al*, 2014). The noise disturbance due to development also impacts sage-grouse abundance, stress levels, and behaviors cause sage-grouse to avoid areas impacted by noise. Habitat fragmentation and behavioral avoidance are occurring as a result of the associated infrastructure for renewable energy development (Pruett *et al* 2009, p. Dinkins *et al* 2014, p. 640). In addition, sage-grouse nest and brood survival is decreasing in habitats in close proximity to wind turbines (LaBeau *et al* 2014, p.522). At this time with the current technology, exclusion of these activities in sage-grouse breeding, nesting, foraging, and winter habitats is the only way to ensure this threat does not persist. Critics of this strategy may outline the economic losses incurred with such a plan, however, restricting development in sage-grouse priority habitats only reduces wind energy development by 1.82 percent with a reduction of 4 percent of wind energy profits (Macsalka, 2011, p. i). If exclusion of these activities in not enforced in the future, the development would be subject to the development restrictions of 1/640 and the 5% disturbance cap. These measures would limit the anthropogenic features on the landscape, however, they would still be permissible causing habitat removal, fragmentation, and degradation in the habitats in which they would occur.

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Chapter 12: Infrastructure

Introduction

asdfasdf

Threat description

Infrastructure is a broad category of manmade physical structures. Our analysis focuses on those known to be relevant to sage-grouse. These types of infastructure include linear features (roads, railroads, powerlines, fences) and site-specific features (communication towers, landfills, solar cells, well pads, and wind towers). Wind and solar [Chapter XX], oil and gas [Chapter XX]), fences (Chapter XX), range management structures (i.e. grazing, Chapter XX), and landfills (i.e. ex-urban development, Chapter XX) are called out as separate threats in the COT Report and are found in the aforementioned chapters. This chapter focuses on the direct and indirect effecs associated with roads, railroads, powerlines, and communication towers.

Current impacts

Mechanism

Infrastructure impacts sage-grouse and their associated habitat both directly (physical footprint) and indirectly (ecological footprint). The physical footprint of roads, power lines, railroads, and communication towers degrade and fragment sage-grouse habitat, and contribute to direct mortality through collisions. In addition, roads, power lines, railroads, landfills, reservoirs, and communication towers have a much larger ecological footprint which influences sage-grouse use of otherwise suitable habitats adjacent to current active areas, and increase predators and invasive plants. A brief summary for each of the above mentioned types of infrastructure is provided, below.

Roads

Comment [KNorman148]: The Elevator Speech (please write this last)
- What is the take home message (this is very bad across the range, this may be bad locally, this really isn't a big deal for all but a few populations)
- What has changed since 2010? What's new or different in a nutshell?

Comment [JD149]: See new guidance from the writing team leads on summarizing change from 2010 and new info/conclusions at the end of the chapter.

Comment [JD150]: Where is this addressed? What chapter?
HM: land fills should be addressed in urban development

Comment [JD151]: Is this something that is relevant to sage-grouse – addressed anywhere in the species report? If not, delete.
HM: deleted

Comment [JD152]: This is described below.

HM: deleted

Roads are a linear feature on the landscape that can contribute to loss and fragmentation of habitat and can cause segregations of populations as a result of behavioral avoidance (Aldridge and Boyce 2007, entire; Lyon and Anderson 2003, entire). Road associated impacts to sage-grouse include habitat loss and avoidance (Blickley *et al*. 2012, p. 26; Knick *et al*. 2013, p. 1544; LeBeau 2012, p. 28; Lyon and Anderson 2003, p. 489; Wisdom *et al*. 2011, p. 18), barriers to migration corridors or seasonal habitats, facilitation of predators (Connelly *et al*. 2004, p. 7-25; Forman and Alexander 1998, p. 212; Forman 2000, p. 33), and spread of invasive plant species (Connelly *et al*. 2004, p. 7-25; Forman and Alexander 1998, p. 210; Forman 2000, p. 32; Gelbard and Belnap 2003, p. 426; Knick *et al*. 2003, p. 619). Additionally, direct mortality of sage-grouse from vehicle collisions does occur (Patterson 1952, p. 81). Roads can increase human access and ultimately lead to disturbance effects in otherwise remote areas (Forman and Alexander 1998, p. 221; Forman 2000, p. 35; Connelly *et al*. 2004, pp. 7-6 to 7-25).

The mechanism by which road presence reduces male lek attendance is not entirely clear. However, chronic noise may contribute to these decreases (Blickley *et al*. 2012, pp. 467-469). Male sage-grouse are dependent on acoustical signals to attract females to leks (Gibson and Bradbury 1985, p. 82; Gratson 1993, p. 692). Therefore, if noise interferes with mating displays, and thereby female attendance, younger males will not be drawn to the lek and eventually leks could become inactive (Amstrup and Phillips 1977, p. 26; Braun 1986, pp. 229–230). Alternative mechanisms may influence attendance, such as increased on-lek mortality due to masked predator sounds.

Railroads

Railroads presumably have the same potential mechanisms for impacts to sage-grouse as do roads because they create linear corridors within sagebrush habitats.

Comment [JD153]: Any literature on this? As written this is an unsupported assumption.

HM: This is the same uncited sentence from the 2010 finding. I have found no literature yet that describes the effect of railroads specifically to sage-grouse habitats, will continue to look.

Powerlines

Power lines can directly affect sage-grouse by posing collision and electrocution hazards (Braun 1998, pp. 145–146; Connelly *et al*. 2000a, p. 974) and can have indirect effects by decreasing lek recruitment (Braun *et al*. 2002, p. 10), increasing predator abundance (Connelly *et al*. 2004, p. 13-12, Gibson *et al*. 2013a, p. 27, Howe *et al*. 2014, p. 41), facilitating the invasion of nonnative invasive annual plants (Knick *et al*. 2003, p. 612; Connelly *et al*. 2004, p. 7-25), influencing avoidance (Gillan *et al*. 2013, p. 307), and potentially acting as a barrier to movement (Pruett *et al*. 2009, pp. 1255–1256; WHCWG 2012, entire). Due to the potential spread of invasive species and facilitation of predator occurrence as a result of power line construction, the indirect influence power lines can have on vegetation community dynamics and species occurrence often extends out further than the physical footprint (Dinkins *et al*. 2014b, p. 325; Gibson *et al*. 2013, p. 23; Knick *et al*. 2011, p. 219).

Communication Towers

Communication towers are antenna structures taller than 200-feet above ground level which include cellular and radio towers. For a description of the meteorlogical towers (met towers), refer to the discussion of wind and solar [Chapter XX]. Communication towers have specifically been identified to potentially cause sage-grouse mortality via collisions (Citation needed), facilitate the spread exotic plant species, and to influence predation risk by providing perches for corvids and raptors (Connelly *et al*. 2004, p. 13-11).

Results of impact

Infrastructure results in habitat loss and fragmentation, direct mortality, decreased lek persistence and attendance, recruitment, yearling annual survival rate, and female nest site choice, increased predation, and increased invasive plants. Since the 2010 listing, the scientific literature has remained consistent about general negative correlation between infrastructure's physical footprint on sage-grouse habitat loss and expanded our knowledge of the ecological footprint, sometimes great distances from the physical footprint (Knick *et al*. 2011, p. 219; Gibson *et al*. 2013, p. 23; Dinkins *et al*. 2014b, p. 325; Howe *et al*. 2014, p. 43).

Comment [LW 154]: Add Howes et al. 2014 corvid paper…?

HM: thanks, added.

Comment [JD155]: So, is it just cell towers that are a threat, or radio towers? What other types of communication towers are we talking about? If it is just cell towers, then change the heading.

HM: clarified in text

Comment [HM156]: still looking for appropriate citation, reference to migratory birds removed.

Comment [HM157]: more can be added

Comment [JD158]: Place in chronological order.

HM: change to text made

Estimating the impact of habitat fragmentation caused by infrastructure on sage-grouse is complicated by the nonrandom placement of these features and time lags in the species' response to habitat changes (Garton *et al*. 2011, p. 371). These relatively long-lived birds continue to return to altered breeding season habitatsdue to strong site fidelity despite nesting or productivity failures (Harju *et al*. 2010 p. 441-445; Wiens and Rotenberry 1985, p. 666). Furthermore, these factors likely act in concert with other impacts, which only adds to the difficulty in accurately estimating the impacts of habitat fragmentation caused by infrastructure. Since the 2010 listing decision, scientific literature has A summary of the sage-grouse response to each of the types of infrastructure mentioned in this chapter is provided, below.

Roads

Effects of roads to sage-grouse may result from the bird's behavioral avoidance of road areas because of noise or visual disturbance. Recent rangewide analyses demonstrate that extirpated sage-grouse range is found 60 percent closer to highways (mean = 5 km (3.1 mi)), generally closer to secondary roads, and had a 25 percent higher road density than occupied range (Wisdom *et al*. 2011, p. 18). Furthermore, most valuable sage-grouse habitats had densities of secondary roads that were below 1.0 km/sq km, highway densities below 0.05 km/sq km, and interstate highway densities at or below 0.01 km/sq km (Knick *et al*. (2013, p. 1544).

Localized studies looked at the specific mechanisms which may be influencing the range-wide conclusions. Declines in male sage-grouse lek attendance are observed within 3 km (1.9 mi) of a road with traffic volume exceeding one vehicle per day in Wyoming (Holloran 2005, p. 40). No leks are found within 2-km (1.25-mi) and male attendance and number of leks increases with greater than 7.5-km (4.7-mi) from Interstate 80 through Wyoming and Utah (Connnelly *et al*. 2004, pp. 12–13). In an experimental study in central Wyoming, lek attendance at leks treated with road noise relative to paired controls exhibited a 73 percent decrease in lek attendance, likely suggesting noise avoidance to be the causal factor (Blickley *et al*. 2012, pp. 467–469).

In south-central Wyoming, sage-grouse avoided nesting and summering near major roads with light use (1 to 12 vehicles/day) within 3-km (1.9-mi) of leks during breeding season (LeBeau 2012, p. 28), resulting in a 24

Comment [LW 159]: Do we want to restrict this statemenmt only to breeding season habitats?

HM: change to text made

Comment [JD160]: Run on sentence. Split up.

HM: change to text made

Comment [JD161]: Need to describe the location and extent of these studies. Again, maybe start off with the rangewide generalization (last sentence) then offer specific studies that support that thesis statement.

HM: text revised

Comment [LW 162]: ?
HM: text edited and moved to mechanism section

Comment [JD163]: Suggest moving this more general information on mechanisms to after the first sentence in the paragraph, then go into specific study results.

HM: text edited and moved to mechanism section

Comment [JD164]: Looks like some words are missing here.

HM: text edited and moved to mechanism section percent reduction in nest-initiation rates and a 100 percent increase in distance moved by females to nest (Lyon and Anderson 2003, p. 489). Ultimately, road proximity lowered female fecundity and population recruitment by 10 percent (Lyon 2000, p. 33; Lyon and Anderson 2003, pp. 489–490).

If traffic intensity was not accounted for in studies, roads do not significantly influence persistence or rangewide patterns in sage-grouse extirpation, indicating that traffic volume may be an important factor in sage-grouse habitat selection (Gillan *et al*. 2013, p. 307; Aldridge *et al*. 2008, p. 992). Generally, the documented negative effects (described above) of distance to road are positively correlated with increased traffic density and speed (Forman and Alexander 1998, p. 214); however, the timing of the vehicle activity can also affect the response of sage-grouse to traffic (Holloran 2005, p. 40). For example, the upgrade of haul roads associated with coal mining activity in Colorado resulted in increased traffic levels and was correlated with declines in the number of displaying males on leks situated within 2 km (1.25 mi) of the road (Braun 1986, p. 229). In southwestern Wyoming, male lek attendance rate declined as traffic volumes on roads near leks increased (Holloran 2005), with vehicle activity during the early morning strutting period having a greater influence on male lek attendance compared to roads with no vehicle activity during the strutting period (Holloran 2005, p. 40). Thus, impact of roads on sage-grouse appears to vary by road type, activity level, and timing of traffic events.

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 like roads as travel routes, expanding into new regions (Knight and Kawashima 1993, p. 268; Connelly *et al*. 2004, p. 12-3). Roads can facilitate foraging activity, such that ravens have been observed following roads to scavenge food (Bui 2009, p. 31) Furthermore, some roads provide a source of food and perches for corvids and raptors, facilitating their movements into surrounding areas through highway rest areas, road kill, and road kill dump sites (Connelly *et al*. 2004, p. 7-25).

Road networks contribute to the spread of nonnative invasive plants via introduced road fill, vehicle transport, and road maintenance activities (Forman and Alexander 1998, p. 210; Forman 2000, p. 32; Gelbard and

Comment [DP165]: Is there any information available regarding the effects of roads on food quality and abundance? A MS thesis studing passerines in sage found that food quality and abundance were negatively affected by road traffic – through dust covering leaves and a decline in air quality facilitating carbon fixing plants. I don't know if there is any literature out there on grouse or other birds describing this, but thought I'd float it out there.

HM – Note to self to revisit

Comment [JD166]: ?? in sage-grouse what?

HM: text edited

Comment [JD167]: Citation?

HM: citation added

Comment [HM168]: Note to self: Revisit Forman and Alexander

Comment [DP169]: do either of these citations provide an example of a predator for grouse? if so I would include.

HM: not specifically to sage-grouse

Comment [JD170]: What are we saying here - that they are finding more food along roads and these concentrations of food near roads can result in increased raven densities.

HM: added text to clarify

Comment [JD171]: ?? Rework this sentence. Doesn't make sense as written.

HM: sentence reworked

Belnap 2003, p. 426; Knick *et al*. 2003, p. 619; Connelly *et al*. 2004, p. 7-25). Invasive plant species are not restricted to roadsides, but also encroach into surrounding habitats (Forman and Alexander 1998, p. 210; Forman 2000, p. 33; Gelbard and Belnap 2003, p. 427). Converting unpaved four-wheel drive roads to paved roads has been shown to increase cover of nonnative invasive plant species within the interior of adjacent plant communities (Belnap 2003, p. 426). This effect was associated with road construction and maintenance activities and vehicle traffic, and not differences in site characteristics (Gelbard and Belnap 2003, p. 426). The incursion of nonnative, invasive plants into adjacent native habitat systems result in habitat loss and ecosystem conversions.

Railroads

Railroads presumably have the same potential impacts to sage-grouse as do roads because they create linear corridors within sagebrush habitats. Additionally, railways and the cattle they transported were primarily responsible for the initial spread of Bromus tectorum in the intermountain region (Connelly *et al*. 2004, p. 7-25). B. tectorum, an invasive, exotic species that is unsuitable for sage-grouse habitat, readily invaded the disturbed soils adjacent to railroads. Fires created by trains facilitated the spread of B. tectorum into adjacent areas. Avian collisions with trains occur, although no estimates of sage-grouse mortality rates are documented in the literature (Erickson *et al*. 2001, p. 8).

Powerlines

In a comparative study between extirpated and extant sage-grouse populations, distance to power lines was a strong explanatory variable inferring extirpation, and that extirpated populations were on average within 6 km (3.7 mi) of a power line (Wisdom *et al*. 2011, p. 463). The physical footprint of powerlines covers a minimum of 2 million acres. With inclusion of indirect effects buffered out to 6.9-km from the centerline (e.g., spread of invasive species, predators), the ecological footprint is likely toinclude 44% of sage-grouse priority and general habitats throughout the range of the species (Manier *et al*. 2013, p. 44). Direct powerline collision has been documented? (Beck *et al*. 2006, p. 1075; Braun 1998, p. 145; Connelly *et al*. 2000, p. 974). These studies document that collisions are occurring, but were not designed to estimate the extent to which collision mortality plays a role in population dynamics.

Comment [JD172]: Unclear from this paragraph whether the citations refer to sagebrush ecosystems or invasive species and roads in general.

HM: edited text to try to provide clarity

Comment [DP173]: We should crosswalk wit hthe invasives section to see if that chapter has more updated information specific to grouse habitats on this. As I did not review that chapter I don't know.

HM: Note to self visit the fire chapter when completed.

Comment [JD174]: See comment above regarding the need for a citation.

HM: This is the same uncited sentence from the 2010 finding. I have found no literature yet that describes the effect of railroads specifically to sage-grouse habitats, will continue to look.

Comment [JD175]: Citation? How common is this – fires created by trains in sagebrush? Need to cross-reference the fire and invasives chapters here.

HM: Note to self visit the fire and invasives chapters when completed

Comment [JD176]: Is there a documented occurrence of sage-grouse being killed by a train?

Comment [JD177]: Also see and cite: Schroeder, M.A. 2010. Greater sage-grouse and power lines: reasons for concern. Report, Washington Department of Fish and Wildlife, Olympia, Washington. 95% vacancy rate of leks within 7.5 km of 500 kv power lines. Vacancy rate further than 7.5 km is 59%.

Comment [JD178]: Citations??? Also, need to know if this is 2 million acres of sage-grouse habitat or range – or does it include areas outside of the range of sage-grouse?

Comment [DP179]: how estimated?

HM: buffer explanation added

Comment [JD180]: Is likely to?

HM: text revised

Comment [JD181]: Citation??

Citation added

Comment [JD182]: Telephone lines, not powerlines.
HM: citation removed

Comment [JD183]: Haven't reviewed all of these, but the Beck et al. study was peer reviewed and published in the wildlife society bulletin.

HM: wording revised

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

Presumably, based on presence of power lines and associated increased presence of predators, sage-grouse and other related species have been observed to shift their use of habitat away from these areas. Sage-grouse use of suitable habitat near powerlines decreased approximately 500-m from the pole (Braun 1998, p. 146; Gillan *et al*. 2013, p. 307; Hanser *et al*. 2011, p. 130). Additionally, sage-grouse are observed to particularly avoid transmission lines while brood-rearing (Dinkins *et al*. 2014a, p. 636). In addition, both lesser and greater prairie-chicken, prairie grouse with similar reproduction and life history strategies, crossed power lines less often than nearby roads, which suggests that power lines are a relatively strong barrier to movement (Pruett *et al*. 2009, pp.1255–1256). Synthesis of connectivity work in Washington state suggests that transmission lines show a great resistance to sage-grouse movement, gene flow, and lek activity (Shirk *et al*., in press, p. 14)

Research suggests that power lines are influencing sage-grouse demographic vital rates and these vital rates are likely being ultimately influenced by increased predation (Ellis 1985, p. 10; Gibson *et al*. 2013, p. 23; Dinkins *et al*. 2014b, p. 325). Due to sage-grouse strong site fidelity, sage-grouse do not appear to select nest sites away from the transmission line, but those sage-grouse that nested closer to the line were more likely to demonstrate decreased nest success and lowered hen survival (Gibson *et al*. 2013, p. 22). Observed results

Comment [JD184]: Need to make it clear that this study was limited to the Virginia mts. Of northwestern Nevada. From this sentence, one could conclude that this applies to the whole range of the species.

HM: text added for clarity

Comment [DP185]: I'm not getting the tie between powerlines and efficiency of a predator. is it simply that they are exploiting a broader range of resources/habitats than they could have without the powerlines? I suggest a brief explanation.

HM: text revised

Comment [JD186]: Is this what we mean?

HM: yes, thanks

Comment [LW 187]: We may need to discuss this paper. I'll revisit Coates and Lockyer. I think an argument could be made that correlates the in the increased presence of corvids may hinder reproduction success, and the infratsurcture facilities 'habitat' that might otherwise not be present.

HM: yes lets discuss, seems like literature infers that we can't make the direct link with a true "experimental" study, but I'd love to hear your thoughts.

Comment [DP188]: place-holder – we need to establish the link between grouse and prairie chickens to justify bringing in that literature.

HM: added some clarifiying text – what you were looking for?

Comment [LW 189]: 'suggests' ?

HM: text edited

Comment [LW 190]: 'increased' ?

HM: text edited

Comment [DP191]: arrange by date
HM: rearranged

Comment [JD192]: Citation?

HM: citation added

indicate that nest survival improves 6 percent and hen survival improves approximately 3 percent for each 5-km between the nest and the transmission line with inferences out to 20-km from the project centerline (Gibson *et al.* 2013, p. 23). In another study, density of powerlines within a 0.27-km radius of hen locations negatively affected nesting hen survival, similar effects were not seen for non-reproductive hen or hens in flocks (Dinkins *et al.* 2014b). The overall increase in fragmentation of the landscape working in concert with the spread of non-native plants, increased presenceof predators, and disturbance related with the entire transmission line project will likely lead to decreased sage-grouse productivity and survival.

The construction and maintenance of power lines can also facilitate the spread of nonnative invasive plant species (such as cheatgrass) as equipment is found off road and in habitats that would not normally be traveled (Gelbard and Belnap 2003, pp. 424–426; Knick *et al.* 2003, p. 620; Connelly *et al.* 2004, p. 1-2). However, we are unaware of any scientific or commercial information regarding the amount of invasive species incursions as a result of power line construction.

Sage-grouse may also avoid the electromagnetic fields produced by power lines (Wisdom *et al.* 2011, p. 467). Electromagnetic fields can alter behavior, physiology, endocrine systems and immune function in birds, with negative consequences on reproduction and development (Fernie and Reynolds 2005, p. 135). Fernie and Reynolds (2005, p. 135) note that birds vary in their sensitivities to electromagnetic fields, with domestic chickens being very sensitive and many raptor species less affected. Ground nesting birds may be sensitive to ultraviolet light (not visible to the human eye) which are emitted by transmission lines as standing coronas and irregular flashes on insulators (Tyler *et al.* 2014, p. 1). This untested hypothesis has been suggested as a plausible explanation for continued avoidance of transmission lines by some birds and mammals after decades on the landscape (Tyler *et al.* 2014, p. 1).

Communication Towers

When compared to sage-grouse locations in extirpated areas of their range (as determined by museum species and historical observations) and currently occupied habitats, proximity to communication towers was a

Comment [DP193]: This is a fairly definitive statement. If there is a citation please provide. If not we should qualify with a "likely" in front of "lead", especially given the statements in the following paragraph.

HM: added a qualifier

Comment [JD194]: Okay, but isn't this really through the construction and maintenance of roads (as opposed to the powerlines themselves)? Maybe just refer to the road discussion.

HM: revised text

Comment [LW 195]:
I wonder if BLM has language describing the required reclamation (and restoration?) standards following construction of these structures on the landscape.
I'm envisioning sites where reclaimed roads/scars from pipelines and/or power lines have had large infestations of cheatgrass – as recent as our fields trip in Nevada last summer.

HM: like the BLM management plans that will be released soon or talking about something else? I don't know of anything that categorically documents the invasive species infestations following construction, but we all know it happens thus why we prescribe lots of weed BMPs. Will circle back after the BLM plans?

Comment [JD196]: Need to clarify that this was not a research study – just a hypothesis.

HM: thanks for the wording, accepted changes

Comment [JD197]: Check page numbers.

HM: page numbers consistent

Comment [LW 198]:
Direct mortality – collision with guy lines…? Mentioned earlier, does it belong here as well?

HM: so far I haven't found documentation about sage-grouse collisions. I touched on it in mechanisms, but without literature its hard to touch on the "impacts of" the way the species report chapters call out the two different sections. That's my weasel explanation.

strong indicator of extirpation, and the distance to cellular towers was nearly twice as far from grouse locations in currently occupied habitats than extirpated areas (Wisdom *et al*. 2011, p. 463). Distance to communication towers are also indicative of the most intensive human developments, concentrated along major highways, and within and near larger urban areas which could confound the effect of communication towers. However, such associations between communication towers and other indicators of human development were low (Wisdom *et al*. 2011, p. 467).

Additionally, high levels of electromagnetic radiation within 500 m (1,640 ft) of towers have been linked to decreased populations and reproductive performance of some bird and amphibian species (Balmori 2005, 2006; Balmori and Hallberg 2007; Everaert and Bauwens 2007). Similar to power lines, we are unaware of any information that documents if sage-grouse are negatively impacted by electromagnetic radiation or if their avoidance of towers is a response to increased predation risk.

Timing

Habitat effects (loss, modification, and fragmentation) and introduction of invasive plants resulting from infrastructure are long-term rather than periodic or seasonal, remaining throughout the lifespan of the infrastructure presence on the landscape. Even if infrastructure is removed, some fragmentation and invasive plant invasion may remain. Therefore habitat effects are irrespective of discrete life stages or seasonal habitat requirements.

Comment [DP199]: citation? If not we should provide a qualifier unless we can definitively state this based on information received.'

HM: qualifier added

In contrast, organism effects (collision, predation, recruitment) may be more prominent during various lifestages and ultimately depend upon the vector of impact. Roads and the associated noise would have increased effects during the breeding and nesting seasons (Blickley *et al*. 2012, p. 469). Most collisions occur during the breeding season as sage-grouse are flying in low light conditions to lek locations. Nest depredation resulting from increased egg predators will be isolated to the nesting season. Predation of juveniles can occur during the brood-rearing season. Predation of adults can occur year-round.

Location and extent

Comment [HM200]: Would like to expand on the indirect effects. GIS analyses were only run on the "physical footprint" per Nicole and Kate.

Impacts from infrastructure are present throughout the range of sage-grouse, however, distribution and quantity of infrastructure impact each Management Zone to varying degrees. Existing roads, railroads, power lines, and communication towers degrade and fragment sage-grouse habitat and contribute to direct mortality through collisions. In addition, infrastructure can influence a much larger ecological footprint by negatively affecting sage-grouse use of otherwise suitable habitats adjacent to current active areas, and increased predators and invasive plants. Additional information about location and extent of impacts by type of infrastructure is presented, below.

Table 12-1: Summary of the direct and indirect influences of infrastructure across Management zones

	MZ 1		MZ 2		MZ 3		MZ 4		MZ 5		MZ 6		MZ 7		Total	
	48,359,844		37,115,827		28,803,339		38,213,133		19,277,972		2,757,910		1,180,428		175,708,452	
	Acres	% of MZ	Acres	% of MZ	Acres	% of MZ	Acres	% of MZ	Acres	% of MZ	Acres	% of MZ	Acres	% of MZ	Acres	% of Current Range
High Voltage Line >115kv (200-m footprint)	226,064	0.47%	427,658	1.15%	235,834	0.82%	364,805	0.95%	120,817	0.63%	65,726	2.38%	2,161	0.18%	1,443,065	0.82%
Low Voltage Line <= 115kv (200-m footprint)	298,648	0.62%	282,707	0.76%	80,061	0.28%	102,457	0.27%	70,569	0.37%	36,684	1.33%	96	0.01%	871,221	0.50%
All powerlines	524,712	1.09%	710,365	1.91%	315,895	1.10%	467,262	1.22%	191,387	0.99%	102,410	3.71%	2,257	0.19%	########	1.32%
FAA obstacles of interest to aviation Total (buffered to 56.4m)	1,862	0.00%	4,881	0.01%	1,371	0.00%	1,155	0.00%	802	0.00%	112	0.00%	8	0.00%	10,191	0.01%
FCC	5,642	0.01%	6,251	0.02%	2,504	0.01%	2,570	0.01%	1,367	0.01%	686	0.02%	125	0.01%	19,145	0.01%
All communication towers	7,504	0.02%	11,132	0.03%	3,875	0.01%	3,725	0.01%	2,169	0.01%	798	0.03%	133	0.01%	29,336	0.02%
Interstate (73.2-m footprint)	15,989	0.03%	15,402	0.04%	6,888	0.02%	11,026	0.03%	994	0.01%	1,772	0.06%	0	0.00%	52,070	0.03%
Highway Federal or State, Canadian (25.6-m footprint)	23,752	0.05%	26,614	0.07%	14,142	0.05%	17,326	0.05%	10,021	0.05%	2,450	0.09%	0	0.00%	94,305	0.05%
Other roads	219,125	0.45%	200,736	0.54%	117,263	0.41%	176,980	0.46%	132,926	0.69%	25,042	0.91%	7,553	0.64%	879,625	0.50%
All roads	258,866	0.54%	242,752	0.65%	138,293	0.48%	205,331	0.54%	143,941	0.75%	29,264	1.06%	7,553	0.64%	1,026,000	0.58%
Railroad Line (9.4-m footprint)	5,610	0.01%	5,416	0.01%	2,622	0.01%	2,491	0.01%	919	0.00%	605	0.02%	3	0.00%	17,666	0.01%
TOTALs	796,691	1.65%	969,664	2.61%	460,686	1.60%	678,809	1.78%	338,416	1.76%	133,076	4.83%	9,945	0.84%	3,387,288	1.93%

Roads

Using GIS analysis, we calculated the extent of sage-grouse habitat potentially impactecd by roads. Roads were split in to three categories – interstates, highways, and other roads and buffered by 6.2-meters to calculate the physical footprint. An extensive road network occurs throughout the range of the sage-grouse directly influencing more than 3.3 million acres or 1.93% of sage-grouse current range. Roads vary from paved, multi-lane highways to rough jeep trails, but the majority of road miles are unpaved, dirt two-track roads. Traffic volume varies substantially across all roads in the range, as does individual populations' exposure. In general, locations associated with energy development and major travel corridors have the most significant daily road traffic. The greatest density of roads in sage-grouse habitat occurs in the Columbia Basin Management Zone (MZ VI) and the lowest density of roads is found in the Southern Great Basin (MZ III).

Table 12-2: Impacts of Road by Management Zone

Management Zone	**Timing of Impacts (Season)**	**Current Extent of MZ (in acres)**				**Notes**
		Interstate	Highway/ Federal	Other Roads	Total	
Great Plains (MZ I)	Year-round	15,989	23,752	219,125	258,866 (0.54%)	
Wyoming Basin (MZ II)	Year-round	15,402	26, 614	200,736	242,752 (0.65%)	
Southern Great Basin (MZ III)	Year-round	6,888	14,142	117,263	138,293 (0.48%(	
Snake River Plain (MZ IV)	Year-round	11,026	17,326	176,980	205,331 (0.54%)	
Northern Great Basin (MZ V)	Year-round	994	10,021	132,926	143,941 (0.75%)	
Columbia Basin (MZ VI)	Year-round	1,722	2,450	25,042	29,264 (1.06%)	
Colorado Plateau (MZ VII)	Year-round	0	0	7,553	7,553 (0.64%)	

Comment [HM201]: These are the numbers as of April 1, 2015 . I hear that there might be changes to the current range polygon, therefore these might change

Comment [HM202]: Confirm with Ed Turner, only saw documentation for other roads, assume that the larger highways may have had a larger buffer

Comment [LW 203]: Miles?

Acres would be related to the indirect and we have yet to resolve that issue.

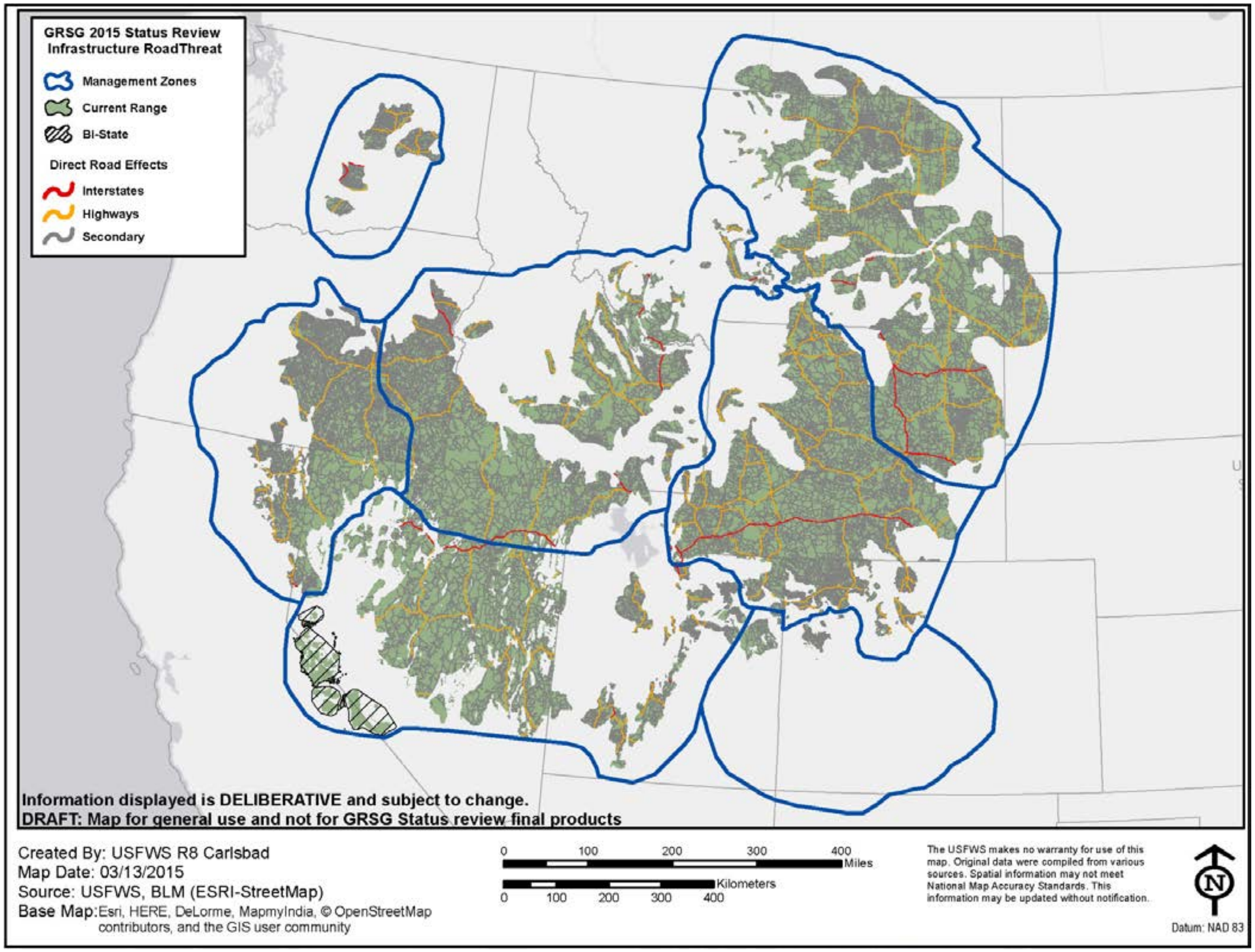
HM: we have a slight buffer on centerline leading to actual acres of impact, added text to demonstrate our physical footprint buffers

Comment [JD204]: Miles, kilometers? What is the unit of measurement?

I'm assuming this is just based on the range map – will need some measure of how these overlay with numbers and distribution maps that Kevin is working on.

HM: these are based on the GIS team's occupied habitat numbers and I think are ubiquitous across all threats chapters. I am not sure what Kevin's distribution maps mean or how they comport to what the GIS team has been using.

Comment [LW 205]: Miles or acres? acres


GRSG 2015 Status Review
Infrastructure RoadThreat
Management Zones
Current Range
Bi-State
Direct Road Effects
Interstates
Highways
Secondary
Information displayed is DELIBERATIVE and subject to change.
DRAFT: Map for general use and not for GRSG Status review final products
Created By: USFWS R8 Carlsbad
Map Date: 03/13/2015
Source: USFWS, BLM (ESRI-StreetMap)
Base Map: Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community
0 100 200 300 400 Miles
0 100 200 300 400 Kilometers
The USFWS makes no warranty for use of this map. Original data were compiled from various sources. Spatial information may not meet National Map Accuracy Standards. This information may be updated without notification.
N
Datum: NAD 83

Railroads

Railroads do not occur in large numbers, impacting only 17,666 acres (0.01%) of total current range. Likely, the largest impact from railroads is through the past and continuing spread of invasive plants (Connelly *et al*. 2004, p. 7-25) and human-induced fire starts (Havlina *et al*. 2014, p. 2). The highest density of railroads occurs in the Columbia Basin (MZ VI) which also has the highest density of human populations (Knick *et al*. 2011, p. 212), powerlines, and roads. The Great Plains (MZ 1; 5,610 acres) and Wyoming Basin (MZ 2; 5,416 ares) contain more than half of the railroads present within the current range, presumably due to their large amounts of mineral resources and the transport necessity as well as strategic ease of transport to the northwestern US.

Table 12-3: Impacts of Railroads by Management Zone

Management Zone	Timing of Impacts (Season)	Current Extent of MZ (acres)	Notes
Great Plains (MZ I)	Year-round	5,610 (0.01%)	
Wyoming Basin (MZ II)	Year-round	5,416 (0.01%)	
Southern Great Basin (MZ III)	Year-round	2,622(0.01%)	
Snake River Plain (MZ IV)	Year-round	2,491(0.01%)	
Northern Great Basin (MZ V)	Year-round	919 (<0.01%)	
Columbia Basin (MZ VI)	Year-round	605 (0.02%)	
Colorado Plateau (MZ VII)	Year-round	3 (<0.01%)	

Comment [JD206]: Will need a placeholder for impacts to numbers and distribution per kevin's modeling efforts.

HM: same comment as above – not sure what kevin's modeling has to do with the infrastructure chapter? Haven't been instructed that we are using anything other than the "current range" depicted by the GIS team

Comment [JD207]: Do we know what percentage of fires were started by railroads? I bet it would be a small percentage, but might be good to include for context if we are saying this is one of two largest impacts from railroads.

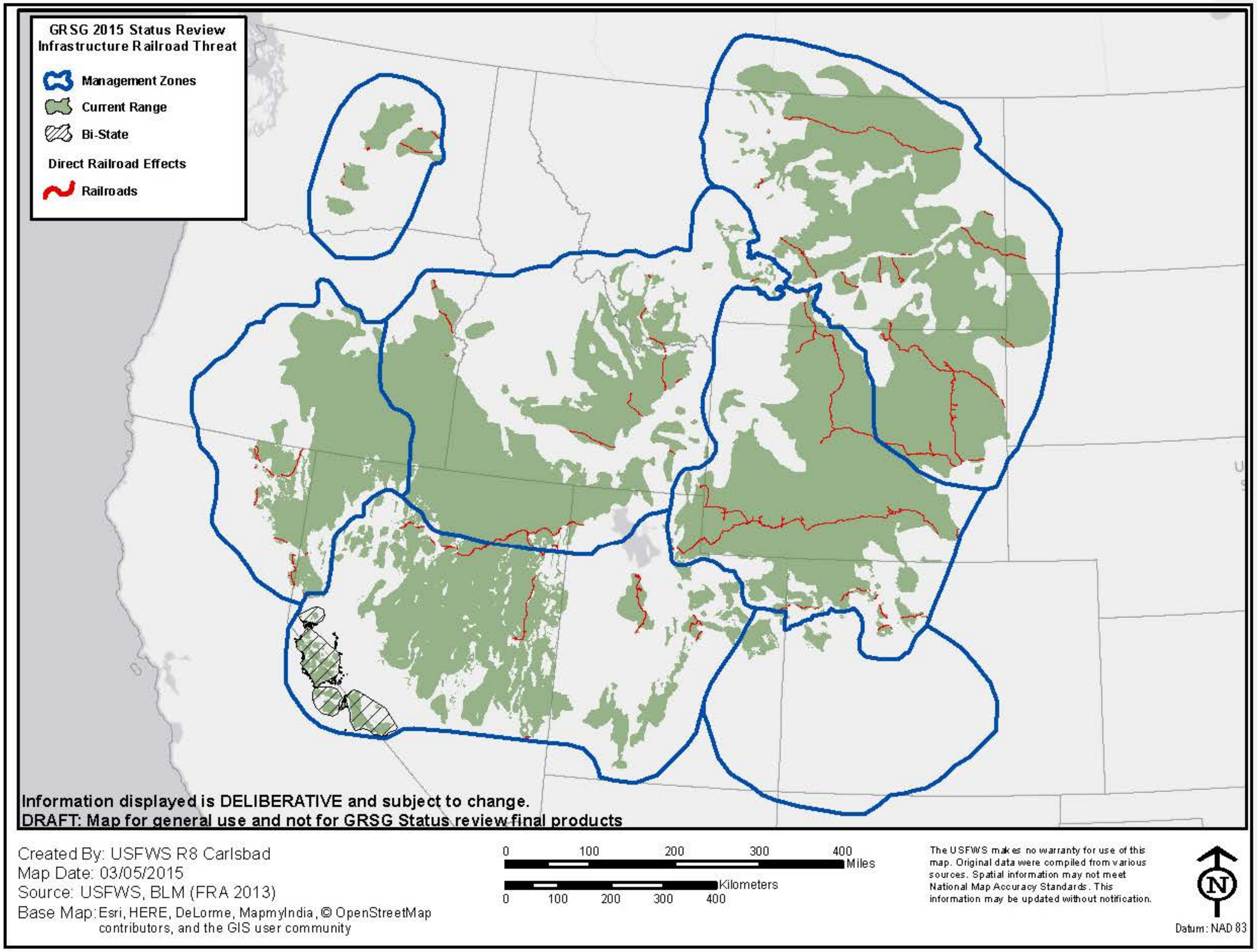
HM: can't find % by rail alone, its lumped with other similar ignition sources in Havlina et al. 2014. Also added citation

Comment [DP208]: I'm not sure what this means when looking at the following sentence and the accompanying table and map. Is this based on a density estimate?

HM: density, clarified

Comment [DP209]: citation?

HM: citation added


GRSG 2015 Status Review
Infrastructure Railroad Threat
Management Zones
Current Range
Bi-State
Direct Railroad Effects
Railroads
Information displayed is DELIBERATIVE and subject to change.
DRAFT: Map for general use and not for GRSG Status review final products
Created By: USFWS R8 Carlsbad
Map Date: 03/05/2015
Source: USFWS, BLM (FRA 2013)
Base Map: Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community
0 100 200 300 400 Miles
0 100 200 300 400 Kilometers
The USFWS makes no warranty for use of this map. Original data were compiled from various sources. Spatial information may not meet National Map Accuracy Standards. This information may be updated without notification.
N
Datum: NAD 83

Powerlines

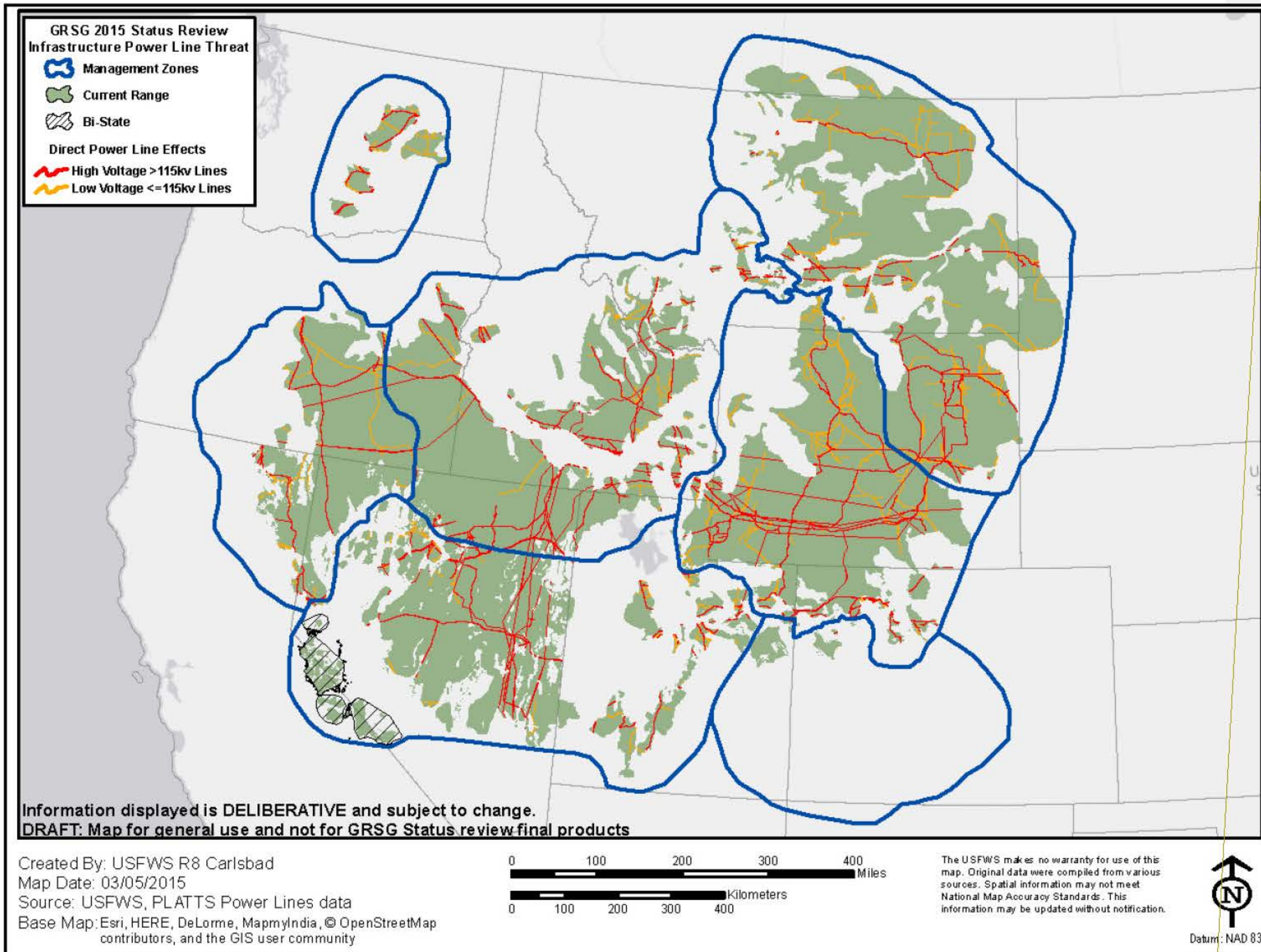
Comment [HM210]: Gave updated shapefile to Ed Turner on 4/3/15. Will need to reanalyze some of these numbers.Will add more text.

Transmission lines and local distribution lines are widespread throughout the range of sage-grouse, directly impacting over two million acres within the current range of sage-grouse. Powerlines are present at the greatest density within the Columbia Basin (MZ VI; 3.71%), due to the large production of hydroelectric power stemming from the Columbia River system and relatively smaller amount of sage-grouse habitat remaining. The largest direct footprint of powerlines occurs in the Wyoming Basin (MZ II) which serves to to transport energy between Management Zones.

Table 12-4: Impacts of Powerlines by Management Zone

Comment [LW 211]: What are these numbers? Acres or miles?

Management Zone	Timing of Impacts (Season)	Current Extent of MZ (acres)			Notes
		High Voltage Lines	Low Voltage Lines	Total	
Great Plains (MZ I)	Year-round	226,064	298,648	524,712 (1.09 %)	
Wyoming Basin (MZ II)	Year-round	427,658	282,707	710,365 (1.91 %)	
Southern Great Basin (MZ III)	Year-round	235,834	80,061	315,895 (1.10 %)	
Snake River Plain (MZ IV)	Year-round	364,805	102,457	467,262 (1.22 %)	
Northern Great Basin (MZ V)	Year-round	120,817	70,569	191,387 (0.99 %)	
Columbia Basin (MZ VI)	Year-round	65,726	36,684	102,410 (3.71 %)	
Colorado Plateau (MZ VII)	Year-round	2,161	96	2,257 (0.19 %)	



Comment [JD212]: This map obviously doesn't contain all powerlines. Need to specify what the minimum kv voltage is that is displayed, instead of <=115kv lines.

Baseline environmental report has more powerlines in some areas – e.g., see SW Idaho. Less in others – eg., eastern NV. Not sure what to make of this, but maybe at least cross check to see if there is anything major that our map is missing….e.g., SW Idaho powerline.

Also, I think we may be losing some info by clipping linear features to the occupied range layer. What about potential barriers to movement between occupied range. Again, see the BER. I think we should consider showing those lines within the WAFWA management zones for linear features that might influence connectivity.

HM: need more time to address this. Current map depicts both existing and future potential lines. The Eastern Nevada extra lines have been addressed, but I gave the shapefile to Ed on 4/3/15 and haven't given him time to redo map or numbers. This section will need more effort from me.

Also – we only included larger lines, need to look in to addressing smaller powerlines.

Communication Towers

Comment [HM213]: Numbers to be completed when GIS team analyzes FCC data. Add description of MZs with highest, lowest, etc. Provide rationale for why.

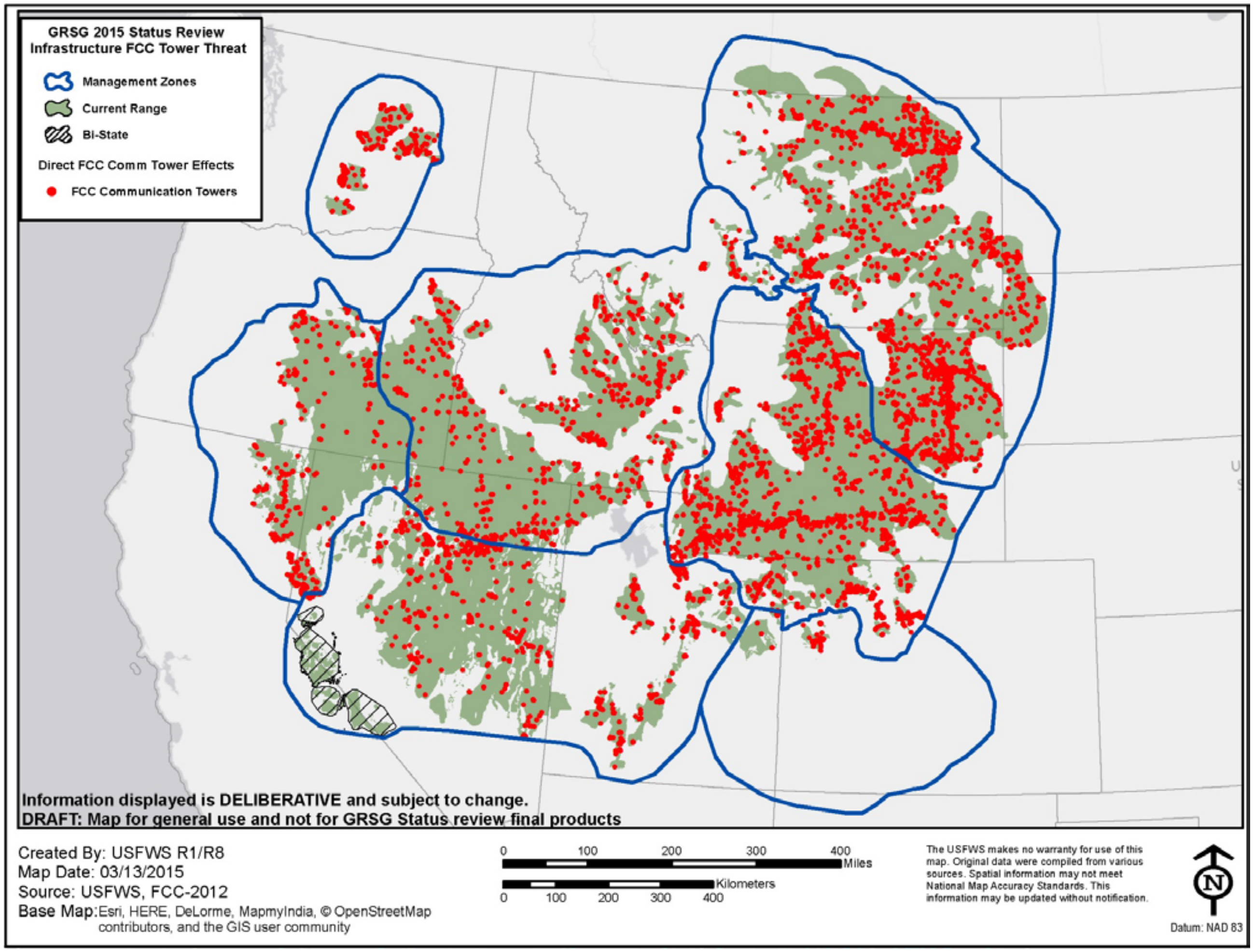
HM: still need some clarification on the maps and analysis produced by the GIS team. Will continue to work on this section.

Relative to other types of infrastructure, small impact

MZ II highest density – continue to be true with fcc data? Provide rationale.

Table 12-5: Impacts of Communication Towers by Management Zone

Management Zone	Timing of Impacts (Season)	Current Extent of MZ	Notes
Great Plains (MZ I)	Year-round	1,862	
Wyoming Basin (MZ II)	Year-round	4,881	
Southern Great Basin (MZ III)	Year-round	1,371	
Snake River Plain (MZ IV)	Year-round	1,155	
Northern Great Basin (MZ V)	Year-round	802	
Columbia Basin (MZ VI)	Year-round	112	
Colorado Plateau (MZ VII)	Year-round	8	



Comment [JD214]: Unclear from the map – are these communication towers only? Or all FAA obsticles (e.g., including wind turbines, which are addressed elsewhere).

See Baseline Environmental Report which seems to show quite a few more verticle structures (non-wind) from the FAA database.

Delete the note at the top regarding secondary roads.

HM: New Map, will get with Ed Turner to confirm whether this is both FAA and FCC and what the overlap is. They do not include wind towers as those are covered elsewhere. Look at those road associations!

Comment [DP215]: presumably the FFA obstacles to aviation = communication towers? Can we get a handle on towers < 200 feet? this map seems to be an underestimate – perhaps that is coming with the new analyses?

HM: see response to Jesse's comment above

Compounded effects

The compounding effects will be discussed in greater detail in the Compounded Effects chapter. In brief, the following impacts are likely to interact with the threat described in this chapter.

Oil, gas, mining, wind, and solar development are specific types of infrastructure. Development also leads to increases in the amount of roads, powerlines, railroad use, and other infrastructure.

Ex-urban development and increasing human populations result in increased roads, powerlines, and other associated infrastructure which fragment habitat, cause sage-grouse mortalities from collision and disturbance, and result in other indirect effects that reduce sage-grouse survival and nesting success (Braun 1998, p. 145; Knick *et al*. 2011, pp. 203 and 219; U.S. Fish and Wildlife Service 2013, p. 50).

Fences are a type of infrastructure which can cause direct sage-grouse mortality from collision, indirect mortality by providing providing perches for sage-grouse avian predators and potential creation of predator corridors along fences, and habitat degredation through fragmentation and the spread of invasive species (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).

Increased hunting and recreation is facilitated by infrastructure. Roads and powerline corridors can be used by hunters to ease access in to sage-grouse hunting areas leading to sage-grouse mortality. Recreationalists, such as OHV users using roads and corridors through sage-grouse increase disturbance to lekking and nesting activities as well as lead to frequent flushing (Patterson 1952, p. vi). Actual current effects of increased hunting and recreation has not been determined.

Contaminants and pesticides are likely to be used in and around infrastructure to limit the spread of invasive weeds but could cause additional exposure to sage-grouse. Also, chemical run off caused by vehicular use of roads could introduce contaminants. Dust produced from vehicular use is likely to affect vegetation and the insect component of sage-grouse diets.

Comment [DP216]: This is key and I would suggest adding a few more sentences regarding how much of the powerlines, railroad demands, new roads are the direct result of energy development and the need to transport.

HM: need to review oil and gas chapter when complete, will add more description

Comment [DP217]: increasing human populations are also likely to result in increased infrastructure simply due to volume.

HM: text added

Comment [DP218]: impacts of dust on roadside vegetation affecting plants and bugs as well.

HM: added some text

Genetics of populations are influenced by the connectivity and movements between populations. Roads and powerlines lead to increasing resistance on the landscape and hinder movement thus resulting in small isolated populations, less frequent dispersal and movement of genetic information.

Comment [DP219]: should we add small population sizes as a compounded effect?

HM: added small tid bit

Invasive vegetation species are facilitated and spread by railroads (Connelly *et al*. 2004, p. 7-25), roads, and other linear corridors (Gelbard and Belnap 2003, p. 23). Invasives eliminate habitat and reduce quality. Non-native predators are also attracted to areas containing infrastructure, thus increasing predator presence and increasing sage-grouse mortality.

Fire can be started as a result of infrastructure in sage-grouse habitats and is particularly correlated with road presence (Miller *et al*., in press p. 40) From 2005 to 2014, the most common human-caused fire starts were from powerlines, vehicles, equipment use, and railroads (Havlina *et al*. 2015).

Predation risk is increased by infrastructure by providing perches for avian predators, nesting habitat in ecosystems typically devoid of tall structures, corridors that facilitate movement of mammalian predators, and encouraging the presences of the common raven (Coates *et al*. 2008, p. 426; Bui 2009, p. 4; Howe *et al*. 2014, p. 41)

Projected Future impacts

Comment [JD220]: Will need to revise when we get the BLM/FS data that would likely restrict some of these infrastructure developments from proceeding in the future.

I suggest combining this section with the assessment of potential threat section.

HM: great idea, can't wait to get those plans

Roads

An extensive network of roads and trails currently occurs throughout the range of sage-grouse. We anticipate that most existing paved roads will remain in place for the foreseeable future. Small dirtroads may be enlarged as infrastructure needs are increased. Many roads constructed in support of building projects may later be reclaimed (e.g. oil fields, coal mines, etc.). We also anticipate that new roads will be added to accompany growth in energy development and/or human population growth and expansion based on past trends in site development, however we are unable to predict how much construction will occur. Since a road network already

Comment [DP221]: we may want to qualify this as many dirt roads constructed in support of building projects are subsequently reclaimed (e.g. oil fields, coal mines, etc). That's not saying they are ever fully reclaimed, but the CED will likely have some reclamation stories and we need to at least acknowledge that (if qualified).

HM: added tid bit

occurs throughout the range and roads are known to result in both direct and indirect impacts to sage-grouse, we anticipate impacts will continue to increase in the forseeable future.

Railroads

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

Powerlines

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

Since a power line network already occurs throughout the range and power lines are known to result in both direct and indirect impacts to sage-grouse, we anticipate impacts will continue to increase in the forseeable

Comment [DP222]: we should define whatthe direct footprint of a powerline is (and much earlier in the chapter).

HM: it is defined on page 1

Comment [DP223]: do we want to mention some the big ones currently proposed?

Also, do I suggest talking about the width of powerline corridors, particularly where there are multiple powerlines. The width of such corridors could compound effects of the impact. this might necessitate a discussion about homeland security restrictions.

In some states corridors are designated, potentially minimizing impacts simply be co-location. I don't remember that being discussed in this chapter yet.

HM: waiting for updated GIS numbers, will complete section at that time future. Of greatest concern is the addition of new power line development and increasing width of powerline corridors as multiple transmission lines are expected to be consolidated into common corridors.

Comment [DP224]: and increasing width of powerline corridors

HM: text added

Communication Towers

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

Comment [DP225]: do we have any information about the demand for new communication towers? I would assume its increasing simply due to the number of new cell phones, etc. If we can get that information it would be helpful (the demand for new towers, not the number of new cell phones ☺)

HM: haven't yet found data, will continue to look.

Threat amelioration

Comment [KNorman226]: The CED reports will include a summary of conservation actions designed to ameliorate each threat.

Based on January In-Person meeting, this list may include ALL self-certified actions. Service personnel may need to further review these actions in future.

Active Conservation

Through the Conservation Efforts Database (CED), the Service collected information relating to conservation actions that were completed, in progress, or planned. Based on a summary report of that information created on XXXXXX, the following table indicate the number of actions and approximate areas for threat amelioration. These numbers are self-reported; the Service will further review and certify these actions if they are pivotal to any determination.

Comment [KNorman227]: Kate's attempt…

The Service addresses regulatory actions in a separate chapter????

Comment [KNorman228]: Do we want to make this easier on folks? Does that undermine the "take away"?

Table 12-6: List of Conservation Efforts (ameliorating threat described in this chapter) by management zone

Management Zone	Type of Conservation Effort	Sum of Acres or Miles	Number of Actions	Notes
1				
2				
3				

Management Zone	Type of Conservation Effort	Sum of Acres or Miles	Number of Actions	Notes
4				
5				
6				
7				

Threat Amelioration Summary

asdfasdf

Assessment of Potential Threat

Large, contiguous tracts of sagebrush habitats are 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*. 2011, p. 461). Increasing expansion of human populations into the western US has led to an increase in demand for natural resources and the necessary infrastructure (e.g. roads, railroads, powerlines, communication towers, etc.) to support them. Development of roads, railroads, powerlines, and communication towers result in habitat loss, fragmentation, and may cause sage-grouse habitat avoidance. These types of infrastructure can also provide sources for the introduction and propogation of invasive plant species, increase fire, and increase concentrations of predators.

Within the current range of sage-grouse, the physical footprint of infrastructure is approximately 2.3 million acres (1.93%). The largest acreage of infrastructure is found in the Wyoming Basin (MZ II; approximately 969,000 acres); the least amount of infrastructure is found in the Colorado Plateau (MZ VII; 9,945 acres). The Columbia Basin (MZ VI) which is considerably smaller than MZ II contains the highest density of infrastructure (4.83% of sage-grouse habitat impacted; USFWS GIS data). Infrastructure associated with powerlines accounts for the greatest disturbance (2.3 million acres) across the range.

Comment [HM229]: This is what the data is saying, but this seems suspect to me. Will need to check with GIS team. Possibly due to overcountin some projects?

Comment [DP230]: presumably this will be updated, or are these current figures?

HM: updated to current figures. However, do expect potential change with some additional questions to the GIS team

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

The 2010 12-month finding for the sage-grouse concluded habitat loss and fragmentation resulting from infrastructure development is a primary threat to the species and could be expected to continue in to the foreseeable future (75 FR 13910, March 23, 2010). There have been no substantial changes to the stressors posed by infrastructure, growth and necessity for continued increases in infrastructure, or the regulatory mechanisms the would prevent development within important sage-grouse habitats. Therefore, based on the best available science, we conclude that infrastructure continues to be a primary threat to the species by directly contributing to the destruction, modification, and curtailment of sage-grouse habitat and range (Factor A) and indirectly increasing predation (Factor C) and that these will continue to increase in to the foreseeable future.

Comment [HM231]: Confirm with review of the BLM Plans

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Chapter 13: Fences

Introduction

Fences can potentially improve localized habitat conditions for greater sage-grouse (*Centrocercus urophasianus*; hereafter sage-grouse) by preventing degradation and protecting sensitive areas (e.g., protecting riparian areas from overgrazing enhances brood-rearing habitats) (USFWS 2013, p.52). More often, however, fences can result in direct mortality to sage-grouse via collisions and the presence of fences can increase predation risk by creating predator perches and by fragmenting habitat (Call and Maser 1985, p. 22; Braun 1998, p. 145; Connelly *et al*. 2000a, p. 974; Beck *et al*. 2003, p. 211; Knick *et al*. 2003, p. 612; Connelly *et al*. 2004, p. 1-2; Stevens *et al*. 2012a, p. 1370; Dinkins *et al*. 2014a, p. 637; 75 FR 13929).

Sage-grouse can be killed or injured when they collide with fences (Call and Maser 1985, p. 22; Connelly *et al*. 2004, p. 13-12; Christiansen 2009, p. 1; Beck *et al*. 2006, p. 1070; Stevens 2011, p. 60), and biological, topographical, meteorological, and technical fence design factors are known to influence collision probabilities for sage-grouse on local scales (75 FR 13929; Christiansen 2009; Stevens *et al*. 2012a, p. 1379; Stevens *et al*. 2012b, p. 6). Population level impacts of collision will likely depend on the relative numbers of male and female sage-grouse fatalities and the distribution of fatalities across the species' range, but this information is not currently known (Stevens *et al*. 2013, p 413). In order to adequately assess population level repercussions of fence collisions, we would need quantitative fence mortality data for both sexes rangewide, an accurate and complete rangewide database on fence locations and densities, and a clearer understanding of the variability in collision likelihood given the diversity of fence types and topography across the species' range. With the aforementioned data, we may be able to determine whether collision mortality is additive or compensatory to natural mortality for sage-grouse.

In addition to direct mortality and injury, the presence of fences can increase predation risk by creating predator perches and by fragmenting habitat (Call and Maser 1985, p. 22; Braun 1998, p. 145; Connelly *et al*. 2000a, p. 974; Beck *et al*. 2003, p. 211; Knick *et al*. 2003, p. 612; Connelly *et al*. 2004, p. 1-2; Stevens *et al*.

2012a, p. 1370; Dinkins *et al*. 2014a, p. 637; 75 FR 13929). Avian predators use vertical structures, such as powerlines, as perch sites because they can improve prey detection and attack success due to increased visibility of the surrounding area (APLIC 2006, p. 5, Lammers and Collopy 2007, p. 2752, Slater and Smith 2010, p. 1080, APLIC 1996, p. 23). Predation is the leading source of mortality for sage-grouse (Hagen 2011, p. 95; Blomberg *et al*. 2014, p. 354). Female sage-grouse choose nesting and brood-rearing locations with lower densities of avian predators (Dinkins *et al*. 2012, p. 600), possibly because they experience higher mortality rates adjacent to potential avian predator perches (Dinkins *et al*. 2014b, p. 319). If sage-grouse are balancing habitat use with the risk of predation, then they may avoid areas near fence posts since these structures can be used as perch sites by avian predators. Although sage-grouse avoidance behavior towards fences has not been analyzed, grouse do avoid other anthropogenic structures (Pruett *et al*. 2009, p. 1253; Dinkins *et al*. 2014a, p. 629; Fedy *et al*. 2014, p.1; Hovick *et al*. 2014, p. 1681). Such avoidance behavior can lead to habitat fragmentation even though habitat is physically present (75 FR 13929; Dinkins *et al*. 2012, p. 600; Hovick *et al*. 2014, p. 1680). The type, size, amount of time present on the landscape, and the density of anthropogenic structures can all influence how wildlife use habitat and the magnitude of the behavioral response (Lyon and Anderson 2003, p. 486; Harju *et al*. 2010, p. 437). The population level effects of indirect impacts from fences and other types of anthropogenic development are difficult to quantify because immediate effects on mortality or survival are not always apparent due to staggered entry of individuals into the population and time lags exhibited when survival deteriorates (Blomberg *et al*. 2013, p 348; Hovick *et al*. 2014, p. 1681). In a review of 3,003 existing studies analyzing the effect of anthropogenic structures on grouse avoidance behavior or survival, Hovick *et al*. (2014, p. 1680) determined that too few studies existed to examine the specific effect of fences on grouse species and none of the 10 studies focusing on fences were conducted on sage-grouse.

In the 2010 decision concluding that sage-grouse were warranted but precluded for listing under the Endangered Species Act of 1973, a determination on the specific impact of fences was not made. Rather, conclusions regarding fences were lumped into infrastructure along with roads, communication towers, and powerlines. The 2010 finding stated that collectively, infrastructure fragments sage-grouse habitat (75 FR

13931), encourages the presence of the common raven (Corvus corax) (75 FR 13972), and contributes to the destruction, modification, or curtailment of the sage-grouse's habitat (75 FR 13986). In this chapter, fences are highlighted individually because they continue to be identified as a source of mortality to sage-grouse and we expect this to continue given the widespread distribution of fences across the range of the species.

Threat description

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

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

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

Historical source(s)

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

Current source (s)

Fences are ubiquitous across the landscape (75 FR 13929) and occur across all sage-grouse management zones. Although specific numbers showing miles of fence lines over time are unavailable, production of barbed wire increased from 4.5 metric tons in 1879 to 210,600 metric tons in 1945 (Jones 2014, p. 150). Fences continue to be used to restrict access to anthropogenic structures (e.g., energy development sites, residential areas, railroads) and to modify livestock movements and grazing patterns by modifying access and use of specific areas, thus fences create or alter disturbance patterns on the landscape for sage-grouse(75 FR 13929; Knick *et al*. 2011, p. 232). Unfortunately, there are no rangewide geospatial datasets available on fence locations or fence density (Poor *et al*. 2014, p. 2). Some datasets have been created locally or regionally to determine impacts to big game species (Poor *et al*. 2014, p. 2) or that have come from limited numerical data from land management agencies. For instance, just over 51,000 km (31,690 miles) of fence were added on BLM administered lands in the range of sage-grouse to facilitate livestock grazing between 1962 and 1997 (Connelly *et al*. 2000, p. 974) and between 1996 and 2002, more than 1,000 km (621 miles) of fences were constructed each year with densities of 2 km/km2 or higher in some areas (primarily Montana, Nevada, Oregon, and Wyoming) (Knick *et al*. 2011, p. 224).

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

Current impacts

Mechanism

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

The presence of fences can increase predation risk by creating predator perches and by fragmenting habitat (Call and Maser 1985, p. 22; Braun 1998, p. 145; Connelly *et al*. 2000a, p. 974; Beck *et al.* 2003, p. 211; Knick *et al*. 2003, p. 612; Connelly *et al*. 2004, p. 1-2; Stevens *et al*. 2012a, p. 1370; Dinkins *et al.* 2014a, p. 637; 75 FR 13929). Sage-grouse avoid areas with potential predator perches (Dinkins *et al*. 2014a, p. 637) and since fence posts can create perching places for avian predators, sage-grouse may choose not to use available habitat adjacent to fences. This can result in fragmentation and loss of functional habitat even though suitable habitat is present ((75 FR 13929; Dinkins *et al*. 2012, p. 600; Hovick *et al.* 2014, p. 1680).

Results of impact

Sage-grouse can be killed or injured when they collide with fences (Call and Maser 1985, p. 22; Connelly *et al*. 2004, p. 13-12; Christiansen 2009, p. 1; Beck *et al*. 2006, p. 1070; Stevens 2011, p. 60), however, there are discrepancies concerning the impacts of mortality associated with fence collisions in grouse. In sage-grouse, mortality from fences was documented in only one out of eighty-seven fatalities in Nevada (Blomberg *et al*. 2013, p. 351) but thirty-six carcasses of sage-grouse were found along a 3.2-km (2- mi) fence within 3 months of its construction in Utah (Call and Maser 1985, p. 22) and twenty-one incidents of fence collisions were reported in 2003 to the BLM in Wyoming (Connelly *et al*. 2004, p. 13-12). Also in Wyoming, a study confirmed 146 sage-grouse fence strike mortalities over a 31–month period along a 7.6-km (4.6- mi) stretch of 3-wire BLM range fence (Christiansen 2009, p.1). In Idaho, 86 of 111 fence collisions were sage-grouse (Stevens 2011, p. 60). Of 135 sage-grouse deaths in the Dakotas, none were confirmed as fence collisions (Swanson 2009, cited in SDDFGP 2014, p. 24). In lesser prairie chickens, fence collision was not documented as a source of mortality at all in Kansas (Hagen *et al*. 2007, p. 518); however, fence collisions were the leading cause of mortality (40%) in Oklahoma and New Mexico (Wolfe *et al*. 2007, p. 95). In Europe, fence collisions accounted for 32% of mortality of capercaillie, which live in forested areas, (Catt *et al*. 1994, p. 105), leading to the hypothesize that fence collisions are exacerbating population declines from low breeding success (Moss *et al*. 2000, p. 47). Differences in habitat requirements or habitat use may explain some variation in mortality with localized impacts being substantial if fences occur close to leks or in areas of high density. y.. Stevens and Dennis (2013, p. 2094) cautioned using uncorrected fence collision data because of possible misinterpretation of the models as a result of lack of comparability of data from different regions or time frames.

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

Timing

Sage-grouse can collide with fences at any time of the year; however, the likelihood of collisions may be higher when sage-grouse congregate on lekking grounds in the spring (Stevens 2011, p. 68; Stevens *et al*. 2012b, p. 3).

Fences can pose an indirect threat to sage-grouse due to increased predation risk and habitat fragmentation (75 FR 13929; Braun 1998, p. 145; Connelly *et al*. 2004, p. 7-3). The timing of these potential effects are uncertain and further research is necessary, as there have not been any studies investigating the impact of fences on sage-grouse displacement behavior or survival (Hovick *et al*. 2014, p. 1680).

Compounded effects

The compounding effects will be discussed in greater detail in the Compounded Effects chapter. In brief, the following impacts are likely to interact with the threat of fences.

Invasive plants can spread along fencing corridors (75 FR 13929) in part due to the association between fences and roads (paved and unpaved) and fragment habitat across the landscape (75 FR 13929; Braun 1998, p. 145; Connelly *et al*. 2000, p. 973; Gelbard and Belnap 2003, p. 421; Connelly *et al*. 2004, p. 7-3).

Ravens, a known predator of sage-grouse, preferentially occupy areas that have been converted from sagebrush to nonnative, invasive grasses (Coates *et al*. 2014, p. 76) and both ravens and raptors use fences as hunting perches. Thus, if avian predator densities increase with the arrival of disturbed landscapes, predation pressure near fences may also increase, such that sage-grouse may be displaced further away from fences and forego suitable habitat to reduce their risk of predation but research is needed to clearly elucidate the interactions between fences, sage-grouse, and predator perches. See Predation Chapter.

The Great Basin and the Intermountain West, where sage-grouse reside, are both arid regions, which are predicted to become hotter and drier due to climate change (See Climate Change Chapter; Brown *et al*. 2004, pp. 382-383; Chambers and Pellant 2008, p. 31). As habitat quality and quantity are altered by temperature and precipitation changes, land management changes may occur and affect fence placement and use.

Projected Future impacts

Timescale for projecting this threat

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

Anticipated changes from present

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

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

Threat amelioration

Active Conservation

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

Actions and Effectiveness

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

A rangewide management strategy does not exist for fences but the Fence Collision Risk Tool is the start of a strategy to reduce fence collisions and the USFWS (2013, p. 52) provides recommendations for minimizing fence impact on sage-grouse regardless of location. With these two tools, conservation actions can be implemented at the local level, taking into account the topography of the area and local sage-grouse information such as lek densities and areas of preferred use. However, Stevens *et al*. (2013, p. 413) cautioned against making population level inferences from reduced collision risk because “We cannot say how many sage-grouse would be added to a population by reducing collisions because we lack demographic data to know whether populations can compensate for mortality via increased productivity. Population-level impacts of sage-grouse fence collision also likely depend on proportional mortality of male and female grouse, which is currently unknown (Stevens *et al*.

2012a). Moreover, the ability to compensate for collision mortality probably varies spatially, further complicating our ability to predict the number of birds added to a population as a result of fence-marking efforts."

Threat Amelioration Summary

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

Assessment of Potential Threat

Fences result in direct mortality and injury to sage-grouse due to collisions, and the presence of fences can increase predation risk by creating predator perches and by fragmenting habitat (Call and Maser 1985, p. 22; Braun 1998, p. 145; Connelly *et al*. 2000a, p. 974; Beck *et al*. 2003, p. 211; Knick *et al*. 2003, p. 612; Connelly *et al*. 2004, p. 1-2; Stevens *et al*. 2012a, p. 1370; Dinkins *et al*. 2014a, p. 637; 75 FR 13929). Biological, topographical, meteorological, and fence design factors can influence collision probabilities for grouse on local scales (75 FR 13929; Christiansen 2009; Stevens *et al*. 2012a, p. 1379; Stevens *et al*. 2012b, p. 6). Although methods exist to reduce sage-grouse collisions with fences, population level repercussions of reduced collisions are not well understood (Stevens *et al*. 2013, p. 413). It is difficult to determine population level effects because we lack demographic data to know whether populations can compensate for mortality via increased productivity, data on proportional mortality of male and female grouse, and data on fence location and density across the species range. Further information is needed to verify that sage-grouse avoid fences due to perceived predation risk and to evaluate the impacts on sage-grouse survival and reproduction.

Our 2010 finding stated that collectively, infrastructure (which included fences) fragments sage-grouse habitat (75 FR 13931), encourages the presence of the common raven (Corvus corax) (75 FR 13972), and contributes to the destruction, modification, or curtailment of the sage-grouse's habitat (75 FR 13986). Since 2010, fences have continued to be a source of mortality and injury to sage-grouse and we expect this to continue, even with threat amelioration measures in place, given the widespread distribution of fences across the range of the species.

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Chapter 14: Grazing and Rangeland Management

Introduction

By grazing on plants that provide food and cover, livestock grazing may reduce the quality and quantity of habitats used by greater sage-grouse (*Centrocurecus urophasianus*; hereafter sage-grouse). Livestock may compete with sage-grouse for food, trample and alter sage-grouse habitats, and promote the spread of invasive weeds. Additionally, the mechanical and chemical treatment of sagebrush habitats to improve rangeland conditions for livestock reduced the quality of sagebrush habitats in the past. However, livestock grazing may also improve habitats by stimulating the regrowth of food plants, diversifying habitat structure, reducing invasive weeds, and reducing fire risk. Since 2010, stocking rates of livestock within sage-grouse habitats have remained stable. Although livestock grazing is the predominant land use across the range, livestock grazing impacts individual sage-grouse and does not likely impact populations across management zones (MZs).

Comment [Craig239]: I either need to work in native ungulates into this introduction, or move them to a separate chapter. I'm leaning to separate chapter.

Threat description

With the arrival European settlers, livestock grazing became widespread across the range of the greater sage-grouse. Before European settlers introduced domesticated livestock, native herbivores had not significantly grazed the sagebrush ecosystem (Osborne 1953, p. 267; Mack and Thompson 1982, p. 768; Miller *et al.* 1994, pp. 111, 113; Plew and Sundell 2000, p. 132; Grayson 2006, p. 921). But as European settlements expanded across the western States between 1860 and the early 1900s, unregulated numbers of cattle, sheep, and horses rapidly increased and peaked at the turn of the century (Oliphant 1968, p. vii; Young *et al.* 1976, pp. 194–195; Carpenter 1981, p. 106; Donahue 1999, p. 15; Knick *et al.* 2011, p. 220). Between 1870 and 1900, the number of cattle increased by approximately 378 percent and the number of sheep increased by approximately 423 percent (Donahue 1999, p. 15; Knick *et al.* 2011, p. 220). During this period, excessive overgrazing by domestic livestock, along with severe drought, significantly changed plant communities and soils across the sagebrush ecosystem (Knick *et al.* 2003, pp. 116, 616; Knick *et al.* 2011, p. 220). Although the number of livestock and the intensity of livestock grazing has decreased since its historical peak in the early 1900s (Laycock *et al.* 1996,

Comment [Craig240]: [with an estimated 19.6 million cattle and 25 million sheep (BLM 2009a, p. 1).]

Comment [Craig241]: I would probably delete this historical stuff, but a similar paragraph is in both bi-state and 2010, so leaving for now.

p. 3), this period's lasting impact on plants and soils are now commonplace in sagebrush ecosystems (Knick *et al.* 2003, p. 116; Knick *et al.* 2011, pp. 220, 221).

Livestock grazing is the most widespread land use across the sagebrush ecosystem (Connelly *et al.* 2004, pp. 7–29; Knick *et al.* 2003, p. 616; Knick *et al.* 2011, p. 219). XX percent in active allotments. Nearly all sagebrush habitats have been grazed at some point during the last 150 years (Knick *et al.* 2003, p. 616; Knick *et al.* 2011, p. 219). (Figure 1) IN PROGRESS - Throughout the range of the greater sage-grouse, there are XXX grazing allotments.. Of these, XX are active allotments that occupy approximately XX percent of suitable sage-grouse habitat (XX). The BLM and USGS manage most of the grazed lands. STATE/MZ TABLE. RHAs and AUMs

Comment [Craig242]: Craig is calculating from the GIS and finalizing this data. I am putting a summary of magnitude here.

Comment [Craig243]: AUM Allotment and RHA data here. Craig is working on this.

In general, livestock grazing can change the diversity of plants, reduce food available to grouse, and reduce the protective cover of shrubs and grasses in sage-grouse habitats (Fleischner 1994, pp. 633–635). Livestock may compete with sage-grouse for food, and may trample sage-grouse nests and food plants (Rasmussen and Griner 1938, p. 863; Patterson 1952, p. 111; Call and Maser 1985, p. 17; Vallentine 1990, p. 226; Holloran and Anderson 2003, p. 309; Coates 2007, p.28). Livestock grazing may also promote the establishment of invasive species, such as cheatgrass (*Bromus tectorum*) (Masters and Sheley 2001, p. 503), which degrades sagebrush habitats. Further, infrastructure associated with livestock grazing, such as watering structures and fencing, may concentrate disturbance, fragment habitats, kill sage-grouse during collisions, and create perches and access corridors for predators (Call and Maser 1985, p. 3; Connelly *et al.* 2000, p. 974; Connelly *et al.* 2004, pp. 1–2). However, grazing may also improve sage-grouse habitats by stimulating the regrowth of food and cover, creating openings, reducing invasive weeds and undesirable woody plants, and reducing fine fuels and the risk of fires (Klebenow 1981, p. 121; Evans 1986, p. 67; Riggs and Urness 1989, p. 358; Mosley 1996 as cited in Connelly *et al.* 2004, pp. 7–49; Merritt *et al.* 2001, p. 4; Olsen and Wallander 2001, p. 30; Stand *et al.* 2008, p. XX; Reisner *et al.* 2013, p. 10; Sheley *et al.* 2014, p. XX).

The intensity, duration, and distribution of livestock grazing likely influence the condition of the rangeland habitats more than the density of livestock (Aldridge *et al.* 2008, p. 990). However, relationships between livestock grazing and sage-grouse population levels are not well understood (Braun 1987, p. 137; Connelly and Braun 1997, p. 231). Over the last 150 years, livestock have grazed throughout nearly all sage-grouse habitats, confounding any evaluation of potential impacts, especially at the large landscape scales that are important to sage-grouse (Knick *et al.* 2011, p. 232). Although livestock grazing may impact individual sage-grouse, livestock does not likely impact sage-grouse populations. However, we discuss the potential impacts to sage-grouse from livestock grazing in more detail below.

By reducing protective cover and promoting the spread of invasive weeds, livestock grazing may make nesting and brood-rearing habitats less suitable for sage-grouse. Sage-grouse rely on the cover of tall grasses and shrubs to hide from predators, especially during the nesting season, and hens will preferentially choose nesting sites based on the height of grasses and shrubs (Hagen *et al.* 2007, p. 46). If livestock graze the grasses and shrubs below certain heights, females may not be able to avoid predators when nesting or brood-rearing, and reproductive success rates may decline (Gregg *et al.* 1994, p. 165). Livestock grazing may also reduce water infiltration rates, reduce the cover of herbaceous plants and vegetative litter, compact soils, and increase soil erosion in mesic (wet), brood-rearing areas (Braun 1998, p. 147; Dobkin *et al.* 1998, p. 213). These changes may reduce the diversity of plants and promote invasive weeds, such as cheatgrass (Leopold 1949, p. 165; Billings 1951, p. 112; Mack and Thompson 1982, p. 761; Miller and Eddleman 2000, p. 19; Knick *et al.* 2011, p. 232; Reisner *et al.* 2013, p. 10). However, sage-grouse may also seek out and use openings in meadows created by cattle grazing (Klebenow 1981, p. 121). Further, livestock grazing may help control invasive weeds and woody plants (Mosley 1996 as cited in Connelly *et al.* 2004, pp. 7–49; Merritt *et al.* 2001, p. 4; Olsen and Wallander 2001, p. 30) and woody plant encroachment (Riggs and Urness 1989, p. 358) which may improve habitats, although removing the grazing may better prevent a cheatgrass invasion (Reisner *et al.* 2013, p. 10).

Comment [Craig244]: START OF CONSOLODATION REMOVAL? SO, I've left most of these detail paragraphs here, because they appear in bi-state and 2010, but it could be removed or condensed even more.

Comment [Craig245]: Check.

Comment [Craig246]: KEVIN's GRASS HEIGHT STUDY HERE? No correlation to livestock or grazing. ..

Comment [Craig247]: Needs paragraph conclusion.

Livestock and sage-grouse feed on the same food plants, including grasses, shrubs, and forbs (flowering plants other than grasses) (Vallentine 1990, pp. 240–241, 226; Pederson *et al.* 2003, p. 43), and sage-grouse may compete with livestock for food. Livestock grazing can reduce the food plants available to the sage-grouse (Braun 1987, p. 137; Dobkin 1995, p. 18; Connelly and Braun 1997, p. 231; Beck and Mitchell 2000, pp. 998–1,000). For example, forbs provide important nutrients to pre-laying hens and their availability may influence a hen's overall nutrition, which in turn may influence nest initiation rates, clutch sizes, and reproductive success rates (Barnett and Crawford 1994, p.117; Coggins 1998, p. 30). Livestock may feed on more forbs if they congregate in wet areas, and a reduction in forbs can reduce the survival of chicks (Aldridge and Brigham 2002, p. 441; Aldridge and Brigham 2003, p. 30). However, grazing can also improve forage conditions for sage-grouse by stimulating the regrowth of forbs (Evans 1986, p. 67). Therefore, although livestock and sage-grouse feed on similar plants, there is no evidence that competition between sage-grouse and livestock impacts sage-grouse population levels.

As livestock graze, they may trample sage-grouse nests and food plants, and hens may abandon their nests if livestock approach too closely (Rasmussen and Griner 1938, p. 863; Patterson 1952, p. 111; Call and Maser 1985, p. 17; Holloran and Anderson 2003, p. 309; Coates 2007, p.28). Nearby livestock frequently force skittish hens to flush from their nests (Coates 2008b, p. 462), inadvertently revealing the nest and its eggs to predators, such as ravens (Coates 2007, p.33). Livestock also may trample sagebrush seedlings, which could provide food and cover (Connelly *et al.* 2004, pp. 7–31). Trampling by livestock can also reduce or eliminate biological soil crusts, which may promote a cheatgrass invasion (Mack and Thompson 1982, p. 764; Young and Allen 1997, p. 531; Reisner *et al*. 2013, p. 10). However, there is no evidence that trampling of nests, habitats, or soils by livestock impacts population levels of sage-grouse.

Developments that deliver water to livestock, such as springs, tanks, and guzzlers, are common on public lands in sage-grouse habitats (Connelly *et al.* 2004, pp. 7–35). Domestic livestock may artificially congregate around water developments, concentrating the grazing and trampling of vegetation around these structures (Braun 1998, p. 147; Knick *et al.*, 2011, p. 230), which could also protect other habitats by localizing and minimizing the area of impact. Diverting water from waterways for livestock can reduce riparian and wet meadow habitats for sage-grouse and water developments could also breed mosquitos that spread the West Nile virus (WNv; see the

Diseases section). However, there is no evidence that intensified grazing of livestock around water developments impacts sage-grouse populations.

IN PROGRESS - 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 the Infrastructure section). 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, pp. 1–2).

Comment [Craig248]: I am working on this fence paragraph.

Historically, Federal land managers and private landowners mechanically and chemically treated sagebrush habitats to reduce shrub cover and improve forage conditions to benefit livestock throughout the sagebrush-steppe ecosystem (Connelly *et al.* 2004, pp. 7–28; Knick *et al.* 2011, p. 220; Pyke 2011, p. 534). Ssagebrush was deliberately eliminated and then seeded with nonnative grasses (Connelly *et al.* 2004, p. 7–28), effectively reducing, and in some cases eliminating, many native grasses and forbs used by the sage-grouse for food and cover (Hull 1974, p. 217; Connelly *et al.* 2004, p. 4-4). Due to the widespread presence of livestock grazing across the sagebrush ecosystem, nearly all sage-grouse habitats were treated at some point to reduce shrub cover (Braun 1998, p. 146; Crawford *et al.* 2004, p. 12). Historically, these sagebrush removal treatments may have reduced the quality of habitats and population numbers of sage-grouse (Crawford *et al.* 2004, p. 12). Below, we describe potential impacts to sage-grouse and their habitat from two types of land conversion techniques used more frequently in the past to improve rangeland conditions for livestock:

Breeding populations of sage-grouse in a particular area may decline following the chemical control of sagebrush (Connelly *et al.* 2000a, p. 972). In addition to removing food plants and cover, chemical control can also force sage-grouse to flee habitats and may reduce nesting success rates, brood carrying capacity, food available during the winter, and thermal cover (Klebenow 1970, p. 399; Connelly *et al.* 2000a, p. 973). However, chemical treatments to reduce sagebrush cover may increase food plants available to sage-grouse (Autenrieth 1981, p. 65), and small chemical treatments may not impact sage-grouse if intact sagebrush remains nearby (Braun 1998, p. 147).

Mechanical treatments used to remove sagebrush, such as mowing, burning, plowing, grubbing, and bulldozing can reduce the quality and quantity of sage-grouse habitats and may impact some sage-grouse populations (Swenson *et al.* 1987, p. 128; Bruan 1998, p. 147; Connelly *et al.* 2000a, p. 973; Connelly *et al.* 2004, pp. l7–47). Mechanical treatments were used more in the past than today (Braun 1998, p. 147). If carefully designed and implemented, mechanical treatments can benefit sage-grouse by improving cover, increasing growth of food plants, and re-sprouting sagebrush (Braun 1998, p. 147).

The success of restoring or rehabilitating overgrazed areas depends on the condition of the area relative to its site potential (Knick *et al.* 2011, p. 232). In areas with a balanced mix of shrubs and native understory vegetation, a change in grazing management can restore the habitat to its potential vigor (Pyke 2011, p. 538). Rest from grazing is known to have a more substantial influence on perennial grass response than other treatments (Wambolt and Payne 1986, p. 318). Active restoration is required where the native understory is reduced (Pyke 2011, p. 539). If an area has soil loss or invasive species, returning the native plant community may be impossible (Daubenmire 1970, p. 82; Knick *et al.* 2011, p. 232; Pyke 2011, p. 539).

Comment [Craig249]: I am working on this paragraph.

Grazing by Wild Ungulates

Native herbivores, such as elk (*Cervus elaphus*), mule deer, and pronghorn antelope share the sagebrush ecosystem with sage-grouse (Miller *et al.* 1994, p. 111) and feed on the same grasses, forbs, and shrubs (Kufeld 1973, p. 106–107; Kufeld *et al.* 1973 as cited in Wallmo and Regelin 1981, pp. 387–396 and 389–396; Allen *et al.* 1984, p. 1; Vallentine 1990, pp. 235, 236; Wambolt and Sherwood 1999, p. 225). Like livestock near watering structures, concentrated grazing by native ungulates (hoofed mammals) in localized areas may reduce vegetation available to sage-grouse for food and cover. Elk and deer may concentrate and overgraze near small-scale, supplemental feeding and watering stations (Doman and Rasmussen 1944, p. 319; Smith 2001, pp. 179–181).

Additionally, native ungulates may graze heavily on sagebrush during the winter, when food is scarce, and overgrazing can kill sagebrush and reduce shrub cover in specific areas (Wambolt 1996, p. 502; Wambolt and Hoffman 2004, p. 195). However, unlike domestic livestock, wild, native ungulates roam freely, spreading potential impacts diffusely across the landscape or concentrating it in specific areas. Therefore, there is no evidence that grazing by wild ungulates impacts sage-grouse population levels.

Current impacts

Mechanism

Livestock graze on the plants that sage-grouse depend on for food and cover and may reduce the quality and quantity of these resources that are available to sage-grouse. As they graze, livestock may also trample sage-grouse habitats and nests, may change soil properties to favor invasive weeds, and force hens to flee their nests. Water developments, fences, and land conversion to benefit livestock may further degrade sage-brush habitats and increase mortality from collisions. However, livestock grazing may also benefit sage-grouse by stimulating the growth of important food plants, creating openings in sagebrush habitats, reducing noxious weeds, and reducing the risk of wildfire.

Results of impact

By reducing food and cover, altering habitats, introducing noxious weeds, and increasing disturbance and potential collisions, livestock grazing may impact individual sage-grouse by reducing foraging and breeding success rates. However, there is no evidence that livestock grazing impacts vital rates or population levels of sage-grouse.

Timing

Impacts to sage-grouse from grazing by livestock and native ungulates may occur throughout the year.

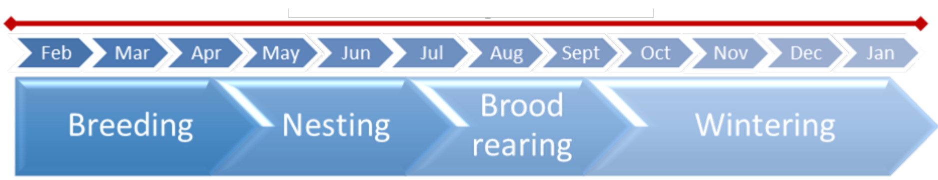

Table 14-1: List of impacts by management zone.

Management Zone	Timing of Impacts (Season)	Immediacy of Impacts	Severity of Impacts	Extent of Impacts	Resource or Life stage impacted	Notes
Example	Spring (or all the time, etc.)	Happening right now (or planned)	Direct mortality (or habitat destruction, etc.)	Impacting X% of occupied range by MZ ~~pops~~ (see Kevin's models)	Lekking adults, broods	This is an example…
1						
2						
3						
4						
5						
6						
7						

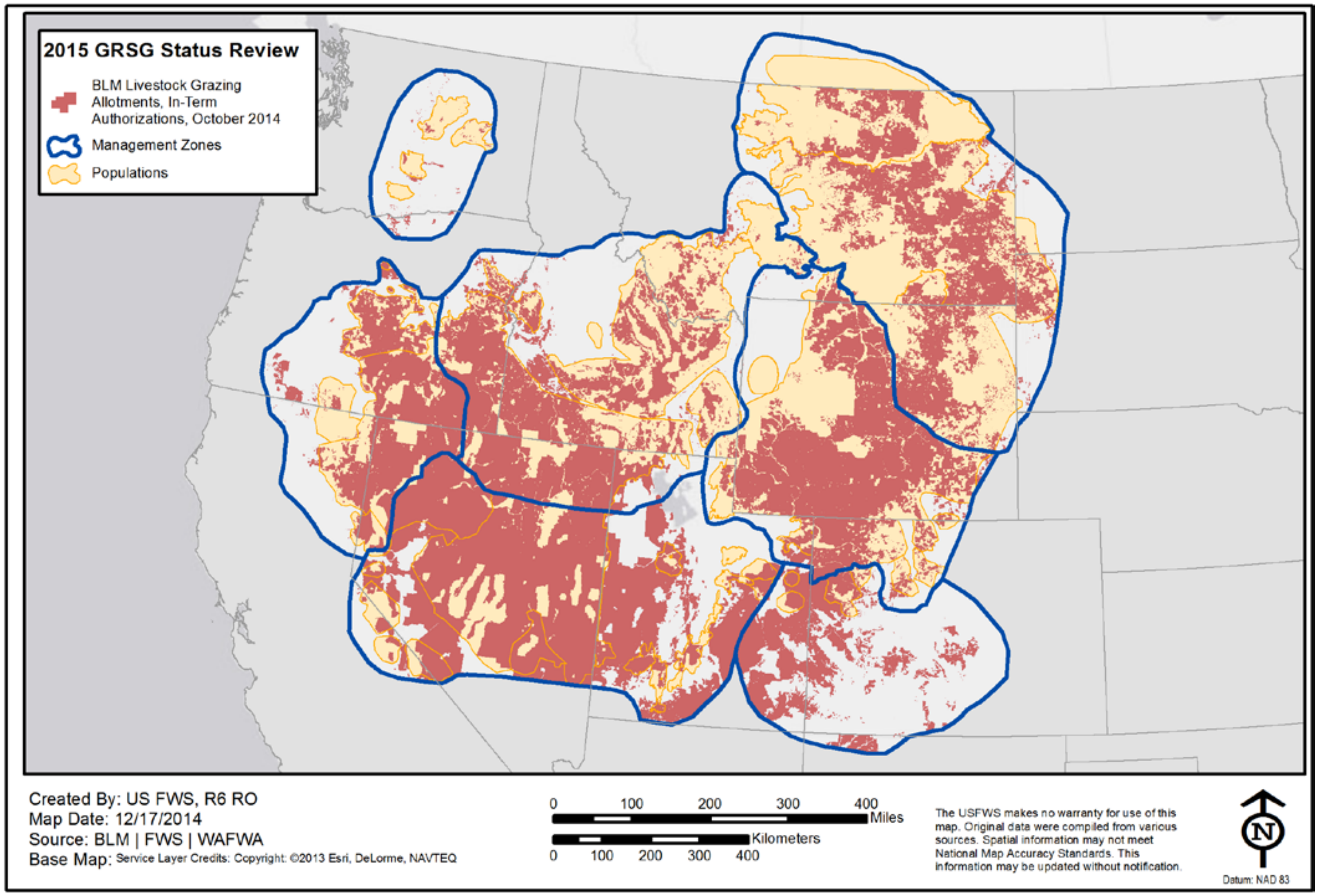

Figure 1-. BLM Livestock Grazing Allotments, In-Term Authorizations as of October 2014

Compounded effects

The compounding effects will be discussed in greater detail in the Compounded Effects chapter. In brief, the following impacts are likely to interact with livestock grazing described in this chapter.

- Noxious weeds;
- Infrastructure to water and contain livestock (water developments and fences); and
- Land conversion, such as mechanical and chemical treatments to reduce sagebrush cover to improve rangeland conditions for livestock.

Projected Future impacts

Timescale for Projecting this Threat

asfasfd

Likelihood of future impacts

Impacts to individual sage-grouse will continue throughout the range. However, it unlikely that livestock grazing will impact populations or MZs within the foreseeable future.

Anticipated changes from present (direct, indirect; same amount of range? Populations?)

asfasf

Threat amelioration

Active Conservation

Comment [KNorman250]: How far into the future can we reasonably predict this threat

Comment [acn251]: Clearly articulated, fact-based rationale for timeframe.

Comment [KNorman252]: The CED reports will include a summary of conservation actions designed to ameliorate each threat.

Based on January In-Person meeting, this list may include ALL self-certified actions. Service personnel may need to further review these actions in future.

Comment [Craig253]: Holding.

Through the Conservation Efforts Database (CED), the Service collected information relating to conservation actions that were completed, in progress, or planned. Based on a summary report of that information created on XXXXXX, the following table indicate the number of actions and approximate areas for threat amelioration. These numbers are self-reported; the Service will further review and certify these actions if they are pivotal to any determination.

The Service addresses regulatory actions in a separate chapter????

Comment [KNorman254]: Kate's attempt…

Comment [KNorman255]: Do we want to make this easier on folks? Does that undermine the "take away"?

Table 14-2: List of Conservation Efforts (ameliorating threat described in this chapter) by management zone

Management Zone	Type of Conservation Effort	Sum of Acres or Miles	Number of Actions	Notes
1				
2				
3				
4				
5				
6				
7				

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Threat Amelioration Summary

asdfasdf

Assessment of Potential Threat

Although livestock grazing impact individual sage-grouse, it does not likely impact sage-grouse populations or MZs. These magnitude and intensity of impacts from livestock grazing will remain stable into the foreseeable future.

Citations

Chapter 15: Free-Roaming Equids

Introduction

In our 2010 finding, we reported that there were approximately 36,000 free-roaming equids (wild horses (Equus caballus) and burros (E. asinus)) occurring in 10 western States (including 2 States outside the range of greater sage-grouse (*Centrocercus urophasianus*, hereafter sage-grouse)), occupying approximately 12 percent of the range of sage-grouse. These figures largely only reported the free-roaming equids managed by and occurring on Bureau of Land Management (BLM)-administered lands. The BLM manages approximately 90 percent of the free-roaming equid population (NAS 2013, p. 15; Table X-1).

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

Free-roaming equids, in designated BLM- and USFS-managed equid areas, impact approximately 12 percent of the sage-grouse's current range, but are disproportionately distributed. Approximately half the federally-managed free-roaming equids occur within the State of Nevada (BLM 2015, p. 1; Table X-1). In MZs III (Southern Great Basin), nearly 30.5 percent of the sage-grouse's range is impacted by free-roaming equids; in MZ V and II (Northern Great Basin and Wyoming Basins), approximately 23.5 and 13.3 percent, respectively, of the range is impacted (Table X-1). Free-roaming equids 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 (Menard *et al.* 2002, p. 127, Beever *et al*. 2008, pp. 18–19, Loydi and Zalba 2009 in Beever and Aldridge 2011).

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

Threat description

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

Approximately 49,209 free-roaming equids (about 40,815 hourses and 8,394 burros) currently inhabit BLM-managed rangelands in 10 western States (including 2 states outside the range of the sage-grouse) (BLM 2015, p. 1). On FS-managed rangelands in 7 western States (including 2 states outside the range of the sage-grouse), there are approximately an additional 7,447 free-roaming equids (Frolli 2015b, pers. comm.). Using BLM and FS data for the 2013 year, equids (assuming a 1 to 1 ratio for AUMs) consume approximately 679,872 AUMs annually, as compared to over 7 million AUMs for domestic livestock within the range of sage-grouse (Beever and Aldridge 2011). The BLM and FS manage these free-roaming equids in equid management areas. These equid management areas overlap with about 12 percent (8,225,231 ha; 20,324,988 ac) or (82,252 km2; 31,758 mi2) of the current sage-grouse range (Table X-1).

Comment [GS256]: Preference on format?

However, as free-roaming equid populations expand, they can expand their range outside of the designated Federal equid management areas. The extent to which BLM- and FS-managed free-roaming equids use land outside of designated management areas is difficult to quantify, but may be considerable. This is compounded as BLM and FS are not the only entities (e.g., many Native American Tribes, the Nevada Department of Agriculture, the Fish and Wildlife Service (Service), and the National Park Service(NPS)) managing equids that may utilize Federal lands (Sheperd and Frolli 2015, pers. comm.). Although equids are being removed from some Service and NPS units (Connelly *et al*. 2004, p. 7–36). Across the West, Native American Tribes are estimated to manage over 200,000 free-roaming equids (Sheperd and Frolli 2015, pers. comm.). Howeverabout 100,000 of the Native American-managed equids are managed by the Navajos in Arizona and New Mexico (Shepherd and Frolli 2015, pers. comm.) and therefore do not overlap with the current sage-grouse range. The remaining approximately 100,000 free-roaming equids occur on Tribal lands within or near the current range of the sage-grouse. However, they typically are not fenced and an unknown number also utilize adjacent Federal lands (FS 2015, p. 1). Furthermore, there are an unknown number of estray equids, both from the Tribes and the public, that may utilize Federal lands (Shepherd and Frolli 2015, pers. comm.).

Current impacts

Mechanism

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

The local effects of ungulate (hoofed mammal) grazing depend on a host of abiotic and biotic factors (e.g., elevation, season, soil composition, plant productivity, and composition). Also, significant biological and behavioral differences influence the impact of equids as compared to domestic cattle grazing on sagebrush ecosystems (Beever 2003, pp. 888–890) and as compared to wild ungulates. Equids are generalists, but grasses comprise the majority of their diet throughout the year (McInnis and Vavra 1987, p. 61). Due to physiological differences, an equid forages longer and consumes 20 to 65 percent more forage than a cow of equivalent body mass (Wagner 1983, p. 121; Menard *et al*. 2002, p. 127). Unlike domestic cattle and other wild ungulates, equids can crop vegetation closer to the ground, potentially limiting or delaying recovery of plants (Menard *et al*. 2002, p. 127). Equids tend to move to higher elevations in late spring until early fall, which may increase the interactions between equids and sage-grouse as sage-grouse often move to higher-elevation communities to utilize more mesic habitats with forbs throughout the summer (Beever and Aldridge 2011, pp. 285–286). On the other hand, equids tend to spend less time at water, and range farther from water sources than cattle (Beever and Aldridge 2011, p. 286), which can segregate them from sage-grouse.

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

Results of impact

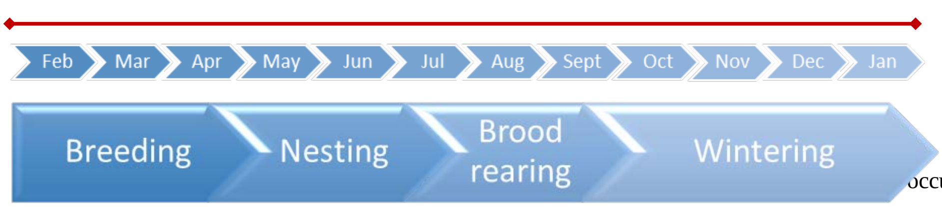
Preliminary research looking at differences in sage-grouse nesting success and survival on sites with various grazing regimes (i.e., no grazing, grazing by equids only, grazing by both equids and cattle) suggest that nest success is three times higher at sites without any grazing (Jaster and Sedinger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

Herrick 2006, p. ; Davies *et al*. 2014, pp. 10–11). Lek success, nest success, chick survival, or other aspects of fitness and survival could also be affected by free-roaming equid grazers; all of which could ultimately affect the viability of some sage-grouse populations.

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

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

Timing



occurring on the landscape in relation to the sage-grouse life cycle is indicated by the red bar. Depending on site-specific details, sage-grouse may be impacted more during one season than another by equids (i.e., if equids have changed the vegetation composition of a site to reduce diversity and structure, sage-grouse nesting and brood-rearing habitat will be more severely impacted).

Mesic habitats – forbs and insects as food resources from pre-laying in early spring through brood-reading and into the fall (Drut *et al*. 1994, pp. 92–93).

Loss of productive mesic habitats – linked to low productivity of sage-grouse and linked to population declines (Connelly *et al*. 2004, p. 7–37).

Heavy use of mesic habitats by equids could increase conflicts and reduce the availability and quality (Beever and Aldridge 2011, p. 285).

The extent to which free-roaming equids in sagebrush communities directly or indirectly alter the availability of insects important to sage-grouse broods through degredation of mesic sites is currently unknown (Beever and Aldridge 2011, p. 285).

Disturbance to lekking behavior

Disturbance/mortality to nests and young

Impact on food resources – degredation of sagebrush – all year (Beever and Aldridge 2011, p. 282).

Reducing grass and shrub cover for nesting and brood-rearing

In the Red Desert of Wyoming, peak use of sagebrush-grass vegetation occurred in the fall and winter (Miller 1980 in Beever and Aldridge 2011, p. 286)

The peak spatial overlap in use of sagebrush habitat with sage-grouse may occur during the breeding or late brood-rearing periods (Beever and Aldridge 2011, p. 286).

Location and extent

It is difficult to assess the overall magnitude of the impact of free-roaming equids on the landscape in general, or on sage-grouse habitat in particular. Furthermore, whether the impacts of equids and cattle grazing are synergistic or simply additive is currently unknown (Beever and Aldridge 2011, p. 286). Analyses for grazing impacts at landscape scales important to sage-grouse are confounded by the fact that almost all sage-grouse habitat has at one time been grazed and thus no ungrazed control areas exist for comparisons (Knick *et al*. 2011, p. 232).

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

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

Management Zone	Total Acres of Current GrSG Range	Acres Impacted by Free-roaming Equids	Total Hectares of Current GrSG Range	Hectares Impacted by Free-Roaming Equids	Percentage of GrSG Range Impacted by Free-roaming Equids
1	48,359,844	0	19,570,535	0	0 %
2	37,115,827	4,928,427	15,020,242	1,994,464	13.28%
3	28,803,339	8,780,092	11,656,298	3,553,177	30.48%
4	38,213,133	2,081,854	15,464,306	842,496	5.45%
5	19,277,972	4,526,080	7,801,518	1,831,639	23.58%
6	2,757,910	0	1,116,086	0	0%
7	1,180,428	8,535	477,702	3,454	0.72%
Total	175,708,452	20,324,988	71,106,688	8,225,231	11.57%

Over half of the total free-roaming equids that are managed by the BLM and FS occur in Nevada (BLM 2015, p. 1; Table X-2). MZs III and V (Southern Great Basin and Northern Great Basin) have the two highest percentages of current sage-grouse range impacted by free-roaming equids, 30.5 and 23.5 percent, respectively (Table X-1 and Figure X-1). Additionally in MZ II, the Wyoming Basin, free-roaming equids potentially inpact sage-grouse on 13.3 percent of the current range of the sage-grouse. Rangewide, free-roaming equids managed by the BLM and the FS directly impact nearly 12 percent of the sage-grouse's current range (Table X-2 and Figure X-1). This estimate does not account for the distribution of equids managed by entitities other than the BLM and the FS. Therefore, the extent to which equids impact sage-grouse outside BLM- and FS-administered lands is difficult to quantify, but may be considerable.

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

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

Furthermore, the estimated current free-roaming population is nearly double the amount that the BLM and FS have determined can exist in balance with other public land resources and uses (BLM 2015, p. 1; Table X-2). Free-roaming equids reproduce rapidly. They can have rates of increase averaging 15 to 20 percent annually

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

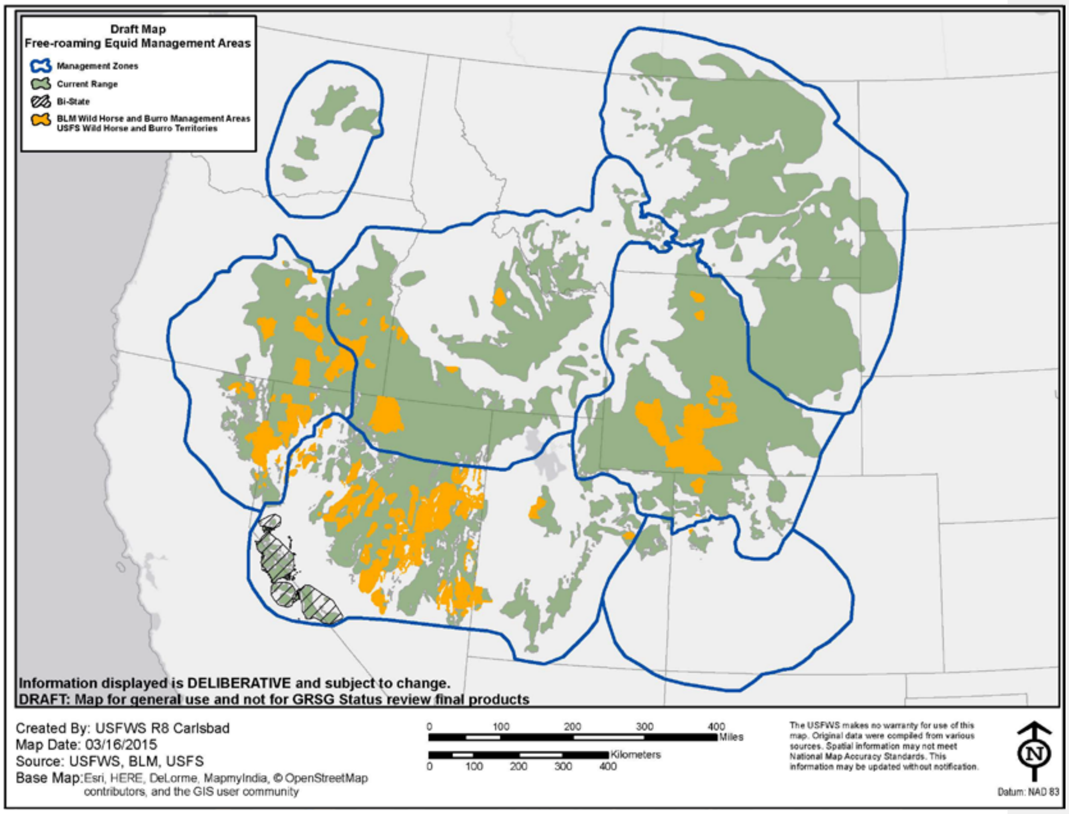


Figure X-1. Free-roaming Equid Management Areas shows the direct impacts of the areas managed by BLM and FS for free-roaming equids with the current greater sage-grouse range.

Compounded effects

The compounding effects will be discussed in greater detail in the Compounded Effects chapter. In brief, the following impacts are likely to interact with the threat described in this chapter.

Equids effects on sagebrush ecosystems may interact synergistically with livestock-grazing effects or simply be additive (Beever and Aldridge 2011, p. 286).

Equids effects on sagebrush ecosystems may be especially pronounced in periods of drought, which are forecasted to occur with increasing frequency in the southwestern United States under climate change (Beever and Aldridge 2011, p. 273; see Climate Change chapter).

Cheatgrass tends to be more abundant at equid-occupied than equid-removed sites (1.6 to 2.6 times greater abundance; Beever *et al*. 2003, 2008 in Beever and Aldridge 2011, p. 283). Dung piles of feral equids in montane natural grasslands of Argentina act as invasion windows for exotic plants (Loydi and Zalba 2009 in Beever and Aldridge 2011, p. 283). Domestic cattle disperse 1,200,000 germinable exotic seeds/km2 – about two orders of magnitude greater than that estimated for the wild ungulates in the same area (elk and mule deer) (Bartuszevige and Endress 2008 in Beever and Aldridge 2011, p. 283).

Increased abundance of cheatgrass and other nonnative invasive annual plants can contribute to an increase in fire frequency (see Fire chapter) and further degregdation of the sagebrush ecosystem.

Projected Future impacts

Timescale for Projecting this Threat

The Wild Free-Roaming Horses and Burros Act of 1971 (Public Law 92-195), as amended, protects free-roaming equids on public lands. Therefore, we expect that free-roaming equids will be present and have an effect on sagebrush ecosystems and sage-grouse where they overlap into the foreseeable future.

Comment [GS257]: Do we want to discuss this in this report?

In the absence of changes to the equid management abilities of the BLM and the FS, we expect free-roaming equids will continue to increase in numbers and have the potential to impact sagebrush ecosystems and sage-grouse where they overlap in range. As free-roaming equid numbers increase, they are likely to expand their range. This may cause an additional increase in impacts to sagebrush ecosystems and sage-grouse.

Threat amelioration

Active Conservation

Through the Conservation Efforts Database (CED), the Service collected information relating to conservation actions that were completed, in progress, or planned. Based on a summary report of that information created on XXXXXX, the following table indicate the number of actions and approximate areas for threat amelioration. These numbers are self-reported; the Service will further review and certify these actions if they are pivotal to any determination.

Table 15-3: List of Conservation Efforts (ameliorating threat described in this chapter) by management zone

Management Zone	Type of Conservation Effort	Sum of Acres or Miles	Number of Actions	Notes
1	None submitted	N/A	N/A	N/A
2	Conservation Plan	None submitted	1 plan	In Progress
3	Brood-rearing areas fenced to exclude equids Conservation Plans	53 ac None submitted	2 2 plans	Completed Information submitted does not address the threat of equids
4	Brood-rearing areas fenced to exclude equids Conservation Plans	105 ac N/A	2 6 plans	Completed Information submitted does not address the threat of equids (6 complete, 1 in progress)
5	Brood-rearing areas fenced to exclude equids Brood-rearing areas fenced to exclude equids Equid gathers Conservation Plans	13,761 ac 10,251 ac 2,957 equids N/A	10 2 2 6 plans	Completed In Progress Completed Information submitted does not address the threat of equids (6 complete, 1 in progress)
6	None submitted that address the threat of equids	N/A	N/A	N/A
7	None submitted that address the threat of equids		1 plan	Information submitted does not address the threat of equids (1 in

Management Zone	Type of Conservation Effort	Sum of Acres or Miles	Number of Actions	Notes
				progress)

Note – Not all the fences state excluding from brood-rearing/riparian areas. May need to split between brood-rearing and misc fences.

Threat Amelioration Summary

Some horses have been gathered and taken off the landscape. These actions have helped to allieviate localized impacts to sagebrush and sage-grouse in Nevada and California. Progress has been made towards protecting important brood-rearing habitat in many locations. However, without a broader look at the impacts on the larger landscapes of these locations, it is hard to say how effective these actions are at allievating impacts. Fencing a riparian area in one location could cause the free-roaming equids to utilize and impact another important riparian area. Additionally, we received information on several conservation plans that have been completed or are in progress. However, the information we received through the CED does not make it clear whether these plans have actions to allievate impacts of free-roaming equids or if those actions would be effective.

Assessment of Potential Threat

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Chapter 16: Urban and Exurban Development

Introduction

Greater sage-grouse (*Centrocercus urophasianus*; hereafter sage-grouse) are sagebrush (Artemisia spp.) obligates—dependent on large areas of contiguous sagebrush, especially for nesting, early brood-rearing, and wintering habitats (Girard 1937, p. 7; Connelly *et al*. 2004, p. 4-15). However, for more than 150 years humans modified, fragmented, and destroyed sagebrush rangelands (Knick *et al*. 2011, p. 207). Consequently, sage-grouse currently occupy approximately 56 percent of their historical potential habitat (Schroeder *et al*. 2004, p. 369). Sage-grouse abundance has decreased by as much as 93 percent from presumed historical levels (Braun 2006, p. 3).

Urban and exurban development are part of the human footprint on the landscape along with other anthropogenic features such as roads and power lines (Leu *et al*. 2008, p 1119; Bar-Massada *et al*. 2014, p. 429). Urban areas are densely developed residential, commercial, industrial, and other built-up areas (U.S. Census Bureau 2012, p. 1) and typically have a housing density of more than one unit per 0.4 hectares (ha) (more than one unit per acre (ac)) (Brown *et al*. 2005, p. 1853). Urban development eliminates sage-grouse habitat (Connelly *et al*. 2004, p. 7-25; Knick *et al*. 2011, p. 217). Exurban development includes both development at the fringe of urban areas and rural residential development; it is the fastest growing land use in the United States (Hansen *et al*. 2005, p. 1893–1894; Theobald 2005, p. 1). Exurban development typically has a housing density of one unit per 0.4–16 ha (1–40 ac) (Brown *et al*. 2005, p. 1853). It modifies, fragments, or eliminates sage-grouse habitat (Connelly *et al*. 2004, p. 7-26; Knick *et al*. 2011, p. 217).

Urban and exurban development impact sagebrush habitat at many locations scattered throughout the sage-grouse range (Braun 1998, p. 143–144; Connelly *et al*. 2004, p. 7-25–7-26; Davies *et al*. 2011, p. 2574; Knick *et al*. 2011, p. 214). If current projections of human population growth in the western United States continue, ranch and agricultural land will decrease due to exurban development of those lands (Leu *et al*. 2008, p.

1130). The Columbia Basin (Sage-grouse Management Zone (MZ) 6) has the highest density of humans; the lowest density is in the Great Plains (MZ 1) (Knick *et al*. 2011, p. 212).

THREAT DESCRIPTION

Historically, low densities of Native Americans limited human impact on the landscape; settlement by Euro-Americans had a much greater influence on sagebrush habitat (Connelly *et al*. 2004, p. 7-24). Impacts from settlement by Euro-Americans began in the southwestern portion of the sage-grouse range (Southern Great Basin––Management Zone 3 (MZ 3)) as early as the 1600s; widespread settlement in the northern portion of the range began in the mid-1800s (Schroeder *et al*. 2004, pp. 371–372). Urban development eliminates sage-grouse habitat; exurban development modifies, fragments, or eliminates habitat (Connelly *et al*. 2004, p. 7-25–26; Knick *et al*. 2011, p. 217). The 2010 12-month finding for the sage-grouse concluded that increasing human populations are increasing the impacts to sage-grouse habitat from development, particularly from exurban development (75 FR 13910, March 23, 2010).

CURRENT IMPACTS

Mechanism

Urban development eliminates sagebrush habitat through the removal of sagebrush and subsequent construction of buildings and associated infrastructure, resulting in an inhospitable environment for sage-grouse that lacks the food sources and shelter necessary for the species' survival (Knick *et al*. 2011, p. 217). Exurban development follows a similar process. However, the intensity of exurban development is less than urban development. In contrast to urban areas, exurban areas may continue to provide some sagebrush habitat, but it is typically less suitable habitat due to associated disturbances (Connelly *et al*. 2004, p. 7-26). For example, the construction of one house on 16 ha (40 ac) likely will have less impact on sage-grouse habitat than 40 houses, each on 0.4 ha (1 ac), although both are examples of exurban development. Exurban development occurs both at the fringe of urban areas and in rural residential areas (Hansen *et al*. 2005, p. 1894; Theobald 2005, p. 1). Both urban and exurban development can result in an increase in associated infrastructure, fences, predation, invasive species, and recreation; all of which can further impact the species. These impacts are discussed in detail in their respective chapters. Noise associated with urban and exurban development may also affect lek activity and other sage-grouse behavior; however, little information is currently available that assesses this impact (Blickley *et al.* 2012, p. 470).

Results of impact

Sage-grouse avoid human development for nesting and brood-rearing (Aldridge and Boyce 2007, p. 508). Sage-grouse extirpation is most likely in areas having a human population density of at least four persons per square kilometer (km²) (four persons per 247 ac) in 1950, suggesting that habitat stressors were well established by that time (Aldridge *et al.* 2008, pp. 983 and 991). Approximately 99 percent of active leks are in landscapes with less than 3 percent developed lands; inactive leks have more than 25 times the development and human density of active leks (Wisdom *et al.* 2011, p. 462; Knick *et al.* 2013, p. 6).

Timing

The modification, fragmentation, and elimination of sagebrush habitat from urban and exurban development are long-term effects rather than periodic or seasonal. Sage-grouse use sagebrush habitats year-round. Therefore, the impacts to sage-grouse from urban and exurban development occur throughout the year, persist from one year to the next, and have the potential to affect all life stages and seasonal habitats (Figure X-1).

Figure X-1–Annual life cycle of sage-grouse (timing of impacts from urban and exurban development in relation to this life cycle is indicated by the red bar)

In addition to long-term or permanent effects caused by the modification, fragmentation, and elimination of sagebrush habitat, urban and exurban development can result in the immediate removal of existing nests, eggs, and broods, if sagebrush is removed during the spring nesting or summer brood-rearing season.

Location and extent

The location of early human settlements was based on resource availability; later development was often minimized by large amounts of public land (Knick *et al*. 2011, pp. 212 and 217). As a result, most urban development is at the edge of the sage-grouse range (Connelly *et al*. 2004, p. 7-25). Major urban areas include the Columbia River Valley in Washington (MZ 6), the Snake River Valley in Idaho (MZ 4), and the Bear River Valley in Utah (MZ 2) (Connelly *et al*. 2004, p. 7-25). Urbanized areas directly impact 3,200 km^2 (1,236 square miles (mi^2))—approximately 0.56 percent of the species' range (Manier *et al*. 2013, p. 31). Indirect impacts of urban areas, based on the spatial foraging scale of avian predators attracted to urban areas (6.9 km/4.3 mi), influence approximately 5.7 percent of priority habitats throughout the sage-grouse range (Manier *et al*. 2013, p. 31).

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

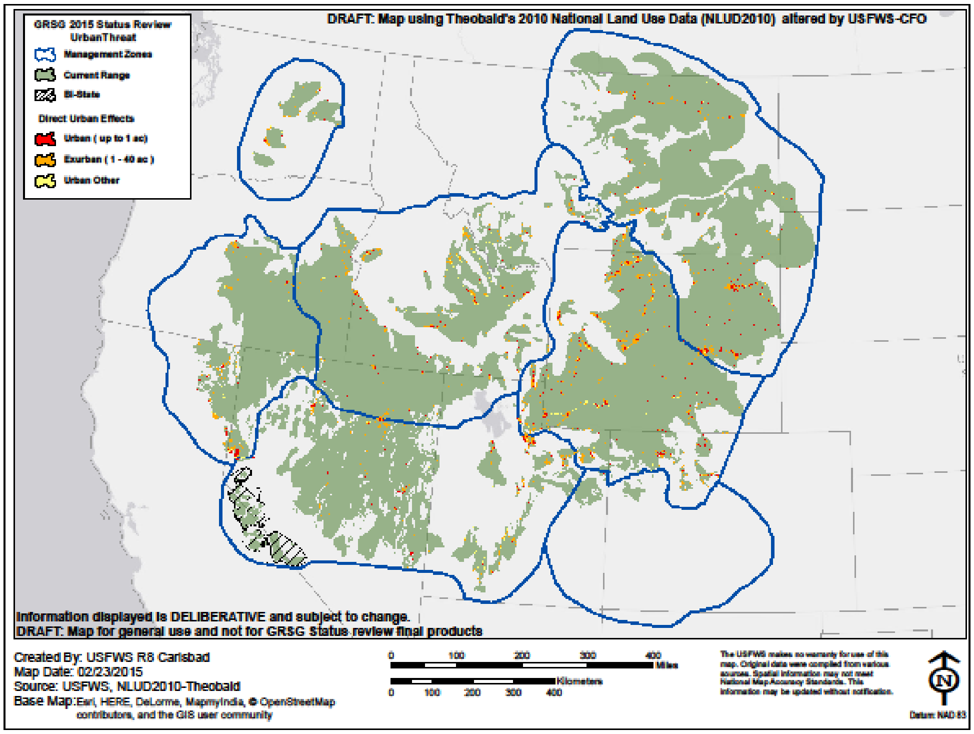
The following table provides the extent of direct impact from urban and exurban development within the current sage-grouse range based on data from Theobald (2014, entire), which uses United States Census Bureau data from 2010. Impacts to the Bi-State Distinct Population Segment (MZ 8) are not addressed.

Table 16-1: Direct impact from urban and exurban development within the current sage-grouse range.

Management Zone	Current Range	Urban Development (Percent of Current Range)	Exurban Development (Percent of Current Range)
Great Plains (MZ 1)	19,585,736 ha/ 48,359,844 ac	9,970 ha/24,618 ac (0.05 %)	43,809 ha/108,170 ac (0.22 %)
Wyoming Basin (MZ 2)	15,031,909 ha/ 37,115,827 ac	12,002 ha/29,635 ac (0.08 %)	99,227 ha/245,006 ac (0.67 %)
Southern Great Basin (MZ 3)	11,665,352 ha/ 28,803,339 ac	4,359 ha/10,762 ac (0.04 %)	56,277 ha/138,956 ac (0.48 %)
Snake River Plain (MZ 4)	15,476,318 ha/ 38,213,133 ac	2,834 ha/6,998 ac (0.02 %)	26,920 ha/66,468 ac (0.17 %)
Northern Great Basin (MZ 5)	7,807,579 ha/ 19,277,972 ac	7,174 ha/17,714 ac (0.09 %)	35,684 ha/88,109 ac (0.46 %)
Columbia Basin (MZ 6)	1,116,954 ha/ 2,757,910 ac	691 ha/1,705 ac (0.06 %)	7,647 ha/18,881 ac (0.68 %)
Colorado Plateau (MZ 7)	478,073 ha/ 1,180,428 ac	3 ha/8 ac (<0.01 %)	66 ha/162 ac (0.01 %)
Bi-State (MZ 8)	not evaluated	not evaluated	not evaluated
Total	71,161,922 ha/ 175,708,453 ac	37,033 ha/91,440 ac (0.05 %)	269,629 ha/665,751 ac (0.38 %)

The information from Table X-1 is displayed in the following map. The category of Urban Other in the map key refers to non-residential urban areas including commercial, industrial, and other built-up areas.

Figure X-2. Urban and exurban development within the current sage-grouse range



The following table assesses the combined impact from urban and exurban development by management zone, based on conclusions of Knick *et al*. (2011, p. 214) and U.S. Fish and Wildlife Service (2013, pp. 16–29). Impacts to the Bi-State Distinct Population Segment (MZ 8) are not addressed.

Table 16-2: List of impacts by management zone

Management Zone	Timing	Immediacy	Severity4	Current Extent of MZ5	Resource/Life stage	Notes

[4] Impacts from urban and exurban development are documented at the population level, as described in the Notes column.

[5] Addresses only direct impacts

Management Zone	Timing	Immediacy	Severity[4]	Current Extent of MZ[5]	Resource/Life stage	Notes
Great Plains (MZ 1)	Year-round	Imminent	Minor	0.2%	Sagebrush habitat/all sage-grouse life stages	Impacts to Powder R. Basin population
Wyoming Basin (MZ 2)	Year-round	Imminent	Moderate	0.2%	Sagebrush habitat/all sage-grouse life stages	Impacts to several populations
Southern Great Basin (MZ 3)	Year-round	Imminent	Minor	0.6%	Sagebrush habitat/all sage-grouse life stages	Impacts to two populations
Snake River Plain (MZ 4)	Year-round	Imminent	Moderate	0.4%	Sagebrush habitat/all sage-grouse life stages	Impacts to several populations
Northern Great Basin (MZ 5)	Year-round	Imminent	Minor	0.5%	Sagebrush habitat/all sage-grouse life stages	Impacts to two populations
Columbia Basin MZ 6)	Year-round	Imminent	Moderate	1.1%	Sagebrush habitat/all sage-grouse life stages	Impacts to several populations
Colorado Plateau (MZ 7)	Year-round	Imminent	Minor	0.5%	Sagebrush habitat/all sage-grouse life stages	Impacts to Meeker-White R. population
Bi-State (MZ 8)						Not evaluated

The data in Tables X-1 and X-2 are from different sources and derived using different methodologies. Consequently, there are small differences between the two tables regarding the extent of impact to sage-grouse habitat from urban and exurban development. However, all management zones show a footprint of approximately one percent or less from this factor.

Compounded effects

Sage-grouse population persistence is influenced by a combination of factors acting in synergy (Leu and Hanser 2011, p. 21). The factors listed below are discussed in detail in their respective chapters. The compounding effects of these factors are discussed in greater detail in the Compounded Effects chapter. In brief, the following factors are likely to interact with urban and exurban development.

Infrastructure—urban and exurban development can result in increased roads, powerlines, and other associated infrastructure, which fragment habitat and can cause sage-grouse mortalities from collisions (Braun 1998, p. 145; Knick *et al*. 2011, pp. 203 and 219; U.S. Fish and Wildlife Service 2013, p. 50).

Fences—urban and exurban development can result in increased fencing, which fragments habitat and can cause sage-grouse mortalities from collisions (Connelly *et al*. 2004, p. 1-2).

Predation—urban and exurban development favor generalist species that prey on sage-grouse nests—such as the common raven (Corvus corax)—by providing supplemental food, water, and nest sites (Bui *et al*. 2010, p. 66; U.S. Fish and Wildlife Service 2013, p. 50).

Invasive Species—urban and exurban development can result in increased abundance of exotic plants that degrade sagebrush habitat, and increased non-native predators such as domestic cats (Felis catus) and dogs (Canis familiaris) that harass and prey on sage-grouse (Maestas *et al*. 2003, p. 1430; Hansen *et al*. 2005, p. 1893; Davies *et al*. 2011, p. 2576; U.S. Fish and Wildlife Service 2013, p. 50).

Recreation—increasing human populations can result in increased recreational use of the surrounding landscape, which can fragment or modify sagebrush habitat (Connelly *et al*. 2004, p. 7-25).

Energy development—oil and gas and mining may increase local human populations, leading to expanded urban and exurban development (Copeland *et al*. 2013, p. 1).

PROJECTED FUTURE IMPACTS

Timescale for projecting impacts from urban and exurban development

Determination of the likelihood that impacts to at-risk species will continue in the future is a fact-based analysis specific to the species and to the potential threat. Projections should only extend as far into the future as predictions are reliable. Habitat modification, fragmentation, and elimination due to urban and exurban development that already occurred in the sage-grouse range are permanent. Additional impacts from future development are likely for some sage-grouse populations and would also be permanent (see following section). Consequently, we anticipate that urban and exurban development will contribute to the present and threatened destruction (i.e., direct habitat loss), modification (i.e., compounded effects from associated infrastructure, fences, predation, invasive species, recreation, and energy development), and curtailment (i.e., fragmentation) of sage-grouse habitat and range.

Likelihood of future impacts

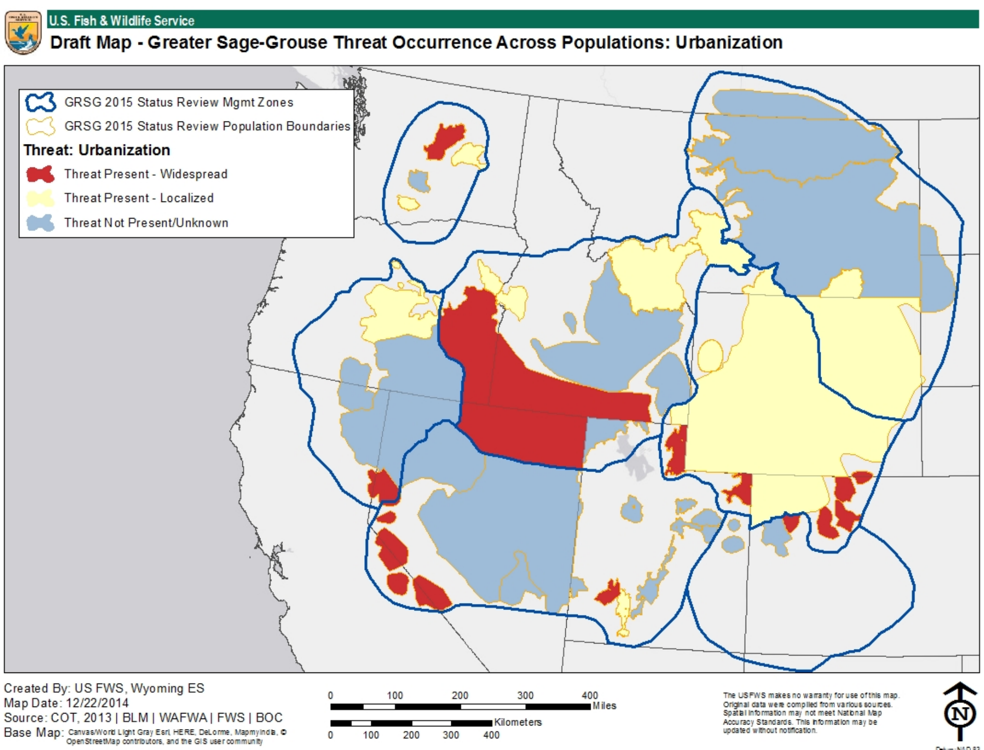
Based on recent trends and projections regarding human populations and associated urban and exurban development, there is a likelihood of increasing impacts to sage-grouse from this factor. Urban densities throughout the conterminous United States doubled in extent from 1950–2000; exurban densities experienced a five-fold increase (Brown *et al*. 2005, pp. 1855–1856). Exurban development is the fastest growing land use in the United States (Hansen *et al*. 2005, p. 1893). For example, in the Great Basin (MZs 3, 4, and 5), the human population increased 69 percent from 1990–2004 (Torregrosa and Devoe 2008, p. 10). The national projected rate of human population increase from 2000–2030 is 29 percent; the projected increases for States that are partially within the Great Basin during the same timeframe are 114 percent in Nevada, 56 percent in Utah, 52 percent in Idaho, 41 percent in Oregon, and 37 percent in California (Torregrosa and Devoe 2008, p. 10).

Anticipated changes from present

Human populations increased in size and spatial extent over the past century, particularly in the western portion of the sagebrush biome (Stiver *et al*. 2006, Appendix C-2; Torregrosa and Devoe 2008, p. 10). If current projections of human population expansion in the west continue, the human footprint from development and resultant impacts will also continue to increase, leading to additional habitat modification, fragmentation, and elimination.

The U.S. Fish and Wildlife Service (Service) drafted a collaborative report on conservation objectives for the sage-grouse with representatives from 10 states within the current range of the species (U.S. Fish and Wildlife Service 2013, p. ii). This effort is referred to as the Conservation Objectives Team (COT) Report. The following map illustrates the COT report's conclusions regarding the impact to sage-grouse from urban and exurban development.

Figure X-3. Rangewide impact to sage-grouse from urban and exurban development



The data used to derive Figures X-2 and X-3 are from different sources and use different methodologies. Figure X-2 depicts all urban and exurban development within the current sage-grouse range; Figure X-3 assesses whether the impacts from urban and exurban development are substantial enough to be considered a threat to a given population. Consequently, some portions of the range may depict urban and exurban development in Figure X-2 without a corresponding threat being noted in Figure X-3.

THREAT AMELIORATION

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

Voluntary conservation efforts related to ranch management practices may address some impacts from exurban development related to construction and siting of buildings.

Candidate Conservation Agreements with Assurances (CCAAs) provide assurances to private landowners that if agreed-upon conservation measures are undertaken by the landowner, no further requirements will be made of the landowner if, in the future, the species is listed under the Endangered Species Act. CCAAs often include avoiding subdivision of rangeland, new building construction, or other new associated infrastructure as potential conservation measures.

Conservation easements allow private landowners to enter into a voluntary agreement with a land trust (e.g., The Nature Conservancy), the Natural Resources Conservation Service (NRCS), or other organizations or agencies that maintain the land in private ownership with development restrictions that are typically permanent. Conservation easements can permanently protect sagebrush habitat from subdivision while providing compensation to landowners.

Active Conservation

Through the Conservation Efforts Database (CED), we collected information relating to conservation actions for the sage-grouse that are completed, in progress, or planned. The following table lists conservation efforts described in the CED or provided by Service Field Offices that address impacts from urban and exurban development. Please note that the amount of lands conserved may not be additive for all stressors. For example, conservation easements can protect habitat from both exurban development and agricultural conversion. However, the same lands are being protected.

Table X-3: List of conservation efforts addressing urban and exurban development

Management Zone	Type of Conservation Effort	Lands Conserved	Number of Actions	Citation
Great Plains (MZ 1)	Conservation Easements	26,682 ha/65,881 ac	multiple	NRCS (2015)
Wyoming Basin (MZ 2)	Conservation Easements	95,260 ha/235,210 ac	multiple	NRCS (2015)
Southern Great Basin (MZ 3)	Conservation Easements	4,532 ha/11,191 ac	multiple	NRCS (2015)
Snake River Plain (MZ 4)	Conservation Easements	39,758 ha/98,167 ac	multiple	NRCS (2015)
Northern Great Basin (MZ 5)	Conservation Easements	11,693 ha/28,871 ac	multiple	NRCS (2015)
Columbia Basin (MZ 6)	Conservation Easements	1,769 ha/4,369 ac	multiple	NRCS (2015)
Colorado Plateau (MZ 7)	Conservation Easements	3,318 ha/8,193 ac	multiple	NRCS (2015)

Management Zone	Type of Conservation Effort	Lands Conserved	Number of Actions	Citation
Bi-State (MZ 8)				Not evaluated

Summary

The NRCS estimates that since the Sage Grouse Initiative was begun in 2010, approximately 183,013 ha (451,884 ac) have been enrolled in conservation easements in the sage-grouse range (Natural Resources Conservation Service 2015, p. 6). This habitat is permanently protected from development).

ASSESSMENT OF POTENTIAL THREAT

The 2010 12-month finding for the sage-grouse concluded that growing human populations are increasing the impacts to sage-grouse habitat from development, particularly from exurban development. Furthermore—in combination with agricultural conversion, infrastructure, fire invasive species, piñon-juniper encroachment, grazing, energy development, and climate change—urban and exurban development contribute to the present and threatened destruction, modification, and curtailment of sage-grouse habitat and range (75 FR 13910, March 23, 2010). Urban and exurban development by a rapidly expanding human population continue to impact sagebrush habitat at many locations scattered throughout the sage-grouse range (see Figures X-2 and X-3). If current projections of human population growth in the western United States continue, ranch and agricultural land will decrease due to conversion to exurban development (Leu *et al*. 2008, p. 1130). Indirect effects from associated factors such as infrastructure, fences, predation, invasive species, and recreation further impact sage-grouse habitat.

Within the current range of the sage-grouse approximately 0.05 percent of sage-grouse habitat has been eliminated due to urban development and 0.38 percent of sage-grouse habitat has been modified, fragmented, or eliminated due to exurban development (see Table X-1). Impacts from urban and exurban development may occur at the individual or population level. The COT Report concluded that, based upon the best available information, exurban development and associated infrastructure are the primary threats to the Eagle-South Routt, Colorado and Middle Park, Colorado sage-grouse populations in the Wyoming Basin (MZ 2) (U.S. Fish and Wildlife Service 2013, Appendix A). Despite the intensity and permanence of impacts, urban and exurban development are not a threat to sage-grouse at a management zone or rangewide scale, inasmuch as only approximately 0.4 percent of the current range is impacted.

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Chapter 17: Recreation

Introduction

A variety of recreational activities occur across the range of the greater sage-grouse (Centrocurecus *urophasianus*; hereafter sage-grouse). Human use of sage-grouse and sage-grouse habitat for recreational purposes can degrade habitat and/or influence sage-grouse behavior. The intensity of threats associated with recreational activities varies based on the behavior of people utilizing the area and the location, type, frequency, timing, and magnitude of the activity. However, recreational activities are often low impact and concentrated to specific recreational areas. Therefore, the current assessment is that recreation threats do not result in local or range-wide declines of sage-grouse.

Threat description

Recreational activities of bird watching, lek visitation, general wildlife viewing, and wildlife photography use sage-grouse as the primary subject. Hiking, camping, fishing, horseback riding, mountain biking, off-highway vehicle (OHV; e.g.., all-terrain vehicles, motorbikes, snowmobiles) use, and recreational hunting (for other species) may occur in sage-grouse habitat. Hunting of sage-grouse (consumptive use) is discussed in Chapter X and is therefore not included in this chapter.

Historical source(s)

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

Current source(s)

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

Current impacts

Mechanism

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

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

Results of impact

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

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

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

Timing

Impacts from recreational activities, such as bird watching and lek visitation occur primarily during the spring breeding season while sage-grouse are at leks. Other recreational activities, such as hiking, biking, camping, and OHV use, may occur year-round, though are less common during the winter. Use of snowmobiles would occur primarily in the winter. Human presence from recreational activities is typically temporary (short intervals of movement or noise as humans or vehicles pass).

Location and extent

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

Table 17-1: BLM Recreation Visits by State, 2013 (ECONorthwest 2014, p. 13)

State	Total Visits	Total Visits in BLM Sagebrush Regions	Total Regional Visits Scaled by % Sagebrush
California	8,706,000	1,426,544	648,699
Colorado	6,963,000	5,185,041	1,220,282

State	Total Visits	Total Visits in BLM Sagebrush Regions	Total Regional Visits Scaled by % Sagebrush
Idaho	5,536,000	4,105,056	2,853,006
Montana	5,215,000	4,932,743	2,506,253
Nevada	6,185,000	3,854,694	1,975,786
North Dakota	Included in MT Total	729	200
Oregon	8,170,000	2,080,321	1,493,792
South Dakota	Included in MT Total	44,611	5,104
Utah	6,844,000	5,322,927	997,848
Washington	Included in OR Total	479,034	230,948
Wyoming	2,915,000	2,914,533	1,912,439
Total	50,534,000	30,346,233	13,844,327

Compounded effects

Threats associated with recreation activities are often tied with other threats described in this document. These associated threats may increase the number of humans or access to recreational areas within sage-grouse habitat. Urbanization and increases in human population centers (Chapter X) may increase recreation activities near those urban centers and expand the areas where recreation activities occur. Hunting of sage-grouse (Chapter X) or other species occurring in sage-grouse habitat, including, but not limited to, pronghorn (Antilocapra americana), mule deer (Odocoileus hemionus), elk (Cervus canadensis), and upland game birds, may increase human presence in an area and have similar impacts as other recreational activities (noise, garbage, and/or habitat impacts). Infrastructure (Chapter X), such as roads, trails, camping areas, restrooms, and visitor centers, would likely increase recreational activities.

Invasive plants (Chapter X) may be introduced to sage-grouse habitats through recreational activities. Contaminants (Chapter X) to sage-grouse, such as fuel for OHVs, pet waste, and garbage, are associated with recreational activities. Pesticide (Chapter X) use may increase in areas used by humans for recreation, as herbicides may be used in trail maintenance and humans may use insecticides during recreational activities. Predators of sage-grouse may be attracted to areas used by humans for recreational activities and garbage may sustain increased densities of predators in these areas. Pets accompanying humans during recreational activities could act as predators to sage-grouse if not under strict control of their owner. Wildfire threats (Chapter X) may increase in areas with recreational activities if participants start campfires or use cigarettes in dry conditions and do not properly extinguish them (NWCG 1999, p. 1).

Projected Future impacts

Timescale for projecting impacts from recreation

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

Likelihood of future impacts

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

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

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

Anticipated changes from present

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

Threat amelioration

Active Conservation

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 (WGFD year unknown, pp. 1–4). Leks included in the brochure are close to roads and already subject to some level of disturbance (Christiansen 2014, pers. comm.); presumably, focusing attention on these areas reduces pressure on relatively undisturbed leks. Most States discourage viewing of sage-grouse during breeding season and do not provide lek locations to the general public (Budeau 2014, pers. comm.; Robinson 2014, pers. comm.; Schroeder 2014, pers. comm.; Wightman 2014, pers. comm.). Washington and Wyoming have wildlife harassment laws that could apply to disruptions of lek activities from recreational viewing (Christensen 2014, pers. comm.; Schroeder 2014, pers. comm.).

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

Actions and Effectiveness

At present, conservation actions to reduce threats associated with recreational activities have not been implemented range-wide. If winter, brood-rearing, and breeding sage-grouse habitats are closed to OHV use and other recreational activities, threats would be minimized or avoided.

Comment [AB258]: Will depend on amount of active conservation described in section above, which likely depends on the BLM/FS Plans

Threat Amelioration Summary

asdfasdf

Comment [AB259]: Waiting until the above info is complete…

Assessment of Potential Threat

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

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Personal Communications

Email exchange with David Budeau, Upland Game Coordinator, Oregon Dept. of Fish and Wildlife, in Salem, OR (December 3, 2014).

Email exchange with Tom Christiansen, Wyoming Game and Fish Dept., in Green River, WY (December 5, 2014).

Email exchange with Nancy Drilling, Rocky Mountain Bird Observatory, in Rapid City, SD (December 4, 2014).

Email exchange with Shawn P. Espinosa, Upland Game Staff Biologist, Nevada Dept. of Wildlife, in Reno, NV (December 3, 2014).

Email exchange with Scott Gardner, Sage-grouse Program Coordinator, California Department of Fish and Game, in Sacramento, CA. (December 4, 2014).

Email exchange with Don Kremner, Wildlife Program Coordinator, Idaho Department of Fish and Game, in Boise, ID (January 20, 2015).

Email exchange with Aaron Robinson, Upland Game Biologist, North Dakota Game and Fish Department, in Dickinson, ND (December 3, 2014).

Email exchange with Travis Runia, Senior Upland Game Biologist, South Dakota Department of Game, Fish, and Parks , in Huron, SD (December 4, 2014).

Email exchange with Mike Schroeder, Upland Bird Research Scientist, Washington Department of Fish and Wildlife, in Bridgeport, WA (December 3, 2014).

Email exchange with Catherine Wightman, Montana Fish, Wildlife, and Parks, in Helena, MT (December 12, 2014).

Chapter 18: Climate Change

Threat description

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

Our analysis of climate change impacts to sage-grouse relies on several sources of information:

Synthesis documents (e.g., IPCC 2013, entire; Climate Change Impacts in the United States 2014, entire; IPCC 2013, entire; Climate Change Impacts in the United States 2014, entire) that present the consensus view of a large number of experts on climate change from around the world. These synthesis reports and scientific papers used in those reports or resulting from those reports represent the best available scientific information characterizing the processes and trajectory of climate change. 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 we have relied upon them and proved citation within our analysis.

Comment [hf260]: NOTE: The content of this section deviates from the chapter template:
1. HQ has boilerplate language to be used as introductory text in climate change sections of all regulatory documents. Some version of this appears, for example, in the 2010 finding, in the BSSG species report, and in the GUSG final rule.
2. Our 2010 finding, the BSSG species report, and GUSG final rule some include some description of the information sources used in the climate change analysis. Because of the modeling being done and downscaled climate data obtained expressly for this status review, I am including a summary of info. sources here too.
If in the interest of consistency among chapters these draft paragraphs can't stay here, we should still review/revise them, and preserve them somewhere in the event that RDs and/or HQ want this language and information in the final species report (and in the FR notice).

Comment [DMD261]: From 2010 Finding, p. 13954.
HF: I think we have moved on from this fence-sitting perspective. The current boilerplate language from HQ (on which this page and half of the next is based) is more reflective of the majority of the current science: climate change is real, it's strongly influenced by human activities, it's happening now and future conditions can be projected with increasing certainty (see for example IPCC 2013).

Comment [sa262]: Gardali, T., N.E. Seavy, R.T.DiGaudio, and L.A. Comrack. 2012. A climate change vulnerability assessment of California's At-Risk Birds. PLoS ONE 7(3): e29507. Doi:10.1371/journal.pone.0029507.

Comment [JD263]: Good! I like the explicit listing of the information we relied on.

How about information on the species' life history and intrinsic vulnerability to climate change? See the paper out of California that examined the relative vulnerability of sage-grouse to climate change.
HF: I cite that paper farther along, and I have added mention of vulnerability analysis to the second bullet below.

Comment [DMD264]: From 2010 Finding, p. 13954.

Peer-reviewed studies conducted since 2010 of the influence of climate on sagebrush regeneration and distribution, fire frequency, invasive plants, disease incidence, the vulnerability of birds to climate change, and other climate-change literature relevant to the status of sage-grouse.

Comment [sa265]: Both

Comment [DMD266]: On sagebrush? Sagebrush distribution? Or both?
HF: Both

Climate data regionally downscaled for the western United States describing the current and modeled future conditions (USGS [[National Climate Change Viewer data]] 2014). In addition to the published information, we have mapped these downscaled data for several climate variables that influence some important resources for and threats to sage-grouse. In this way we can see the scientific consensus view of climate change on the scale of the sage-grouse's range.

Comment [hf267]: HF: We have these data now. Have requested raster files from USGS (for Rich) of the 30-model means and variance for mapping:
Max annual temp
Max July temp
Annual precip
Annual snow
-- For all four:
Historical (1950-2005) and mid-century (2025-2049), RCP 8.5 only (see lengthy footnote on p. X for RCP rationale).

...So that's eight files/maps to illustrate what we mean by "climate change."

Spatial comparison of modeled future distribution of soil conditions favorable to sagebrush regeneration and current distribution and density of sage-grouse.

Comment [hf268]: Per Kevin, 12 March 15: This is the most likely product (i.e., not a new sagebrush model, so I'm relying on the literature - there are a few very new papers). He's not sure about climate change and R&R, but will be discussing with J. Bradford shortly.

Taken together, these sources informed our assessment of how climate change is likely to affect sage-grouse, both independently and in combination with other threats. We weighed the relevant information, including uncertainty, in our consideration of various aspects of climate change.

Human activities are documented to influence the Earth's climate system, and "climate change poses risks for human and natural systems" (IPCC 2014a, p. 3). Globally, the chief sources of greenhouse gasses (mainly carbon dioxide [CO2]) are anthropogenic (IPCC 2013, p. 14). Greenhouse gas emissions result chiefly from fossil fuel combustion, industrial processes, and forestry and other land uses (IPCC 2014b, p. 7). Roughly half of the cumulative emissions of CO2 in the past 260 years have taken place in the last 40 years, driven by economic and human population growth (IPCC 2014b, pp. 7–8); CO2 emissions increased by approximately 80 percent between 1970 and 2004 due to human activities (IPCC 2007, p. 36), and continue to rise (IPCC 2013, p. 12). Increasing concentrations of CO2 and other greenhouse gasses in the atmosphere since the mid-20th century have resulted in increases in temperature and sea-level and decreases in snow and ice at rates that are unprecedented in the historical record and in paleoclimatic reconstructions (IPCC 2013, p. 4; U.S. Global Change Research Program 2014 p. 14–15). Over the past century, the Earth's troposphere (the layer of the atmosphere adjacent to

Comment [DP269]: can we define? It sounds like the CO2 emissions are the result of the stock market or interest rates.
HF: I think the definition of proximate mechanisms appears in the previous sentence: "Greenhouse gas emissions result chiefly from fossil fuel combustion, industrial processes, and forestry and other land uses (IPCC 2014b, p. 7)."

the surface) has warmed, and the rate of warming has increased in the past 50 years (IPCC 2013, pp. 5–6). Continued greenhouse gas emissions at or above current rates will cause further warming (IPCC 2013, pp. 20–23).

Comment [DP270]: define
HF: Done

Current impacts

Increasing ambient temperature and annual frost-free season, and other indicators of climate change, are occurring within the range of sage-grouse (see for example Mote *et al*. 2005, p. 46; Abatzoglou and Kolden 2011, p. 474; Abatzoglou *et al*. 2014, entire). Documented changes include decreasing snow-pack (Mote *et al*. 2005, p. 46; Mote 2006, p. 6219); increased frequency of heavy precipitation events (U.S. Global Change Research Program 2014, p. 8); increased fire frequency, increased size and duration of fires and longer fire seasons (Westerling *et al*. 2006, p. 941–943; Abatzoglou and Kolden 2011, pp. 474–475); and increasing annual frost-free period and annual precipitation, especially in the spring in the Pacific Northwesst (MZs IV, V, and VI) (Abatzoglou *et al*. 2014, pp. 2132–2133). These and other effects of climate change, e.g., on the incidence and severity of drought and on the timing and amount of precipitation, are anticipated to affect the distribution and quality of sagebrush habitat, seasonal availability of resources, and disease incidence (see below). Sage-grouse vital rates are influenced by climate-mediated resources such as the timing and amount of new vegetation and insect production in the spring (Wenninger and Inouye 2008, p. XX; Blomberg *et al*. 2012, p. 12; Guttery *et al*. 2013 pp. 8–9), and some evidence exists that other grouse species (red grouse [Lagopus lagopus scotica] in Scotland) already are responding to increasing ambient temperature; in the past 20 years, first-egg dates have occurred earlier in relation to increasing spring temperature, clutches are larger, and chick survival is greater (Fletcher *et al*., pp. 460–462). However, current impacts of increasing temperature or other aspects of climate change on sage-grouse vital rates or populations are unknown.

Comment [hf271]: Need to get ahold of this paper.

FUTURE IMPACTS

Timescale for projecting impacts from climate change

Our assessment of climate change impacts to sage-grouse, based on the influence of climate on sage-grouse habitat and on other stressors, is limited to a timeframe of 30 to 50 years from the present. This timeframe is comprehensible from a management and conservation perspective, and one used in many published studies (see for example Abatzoglou and Kolden 2011, p. 473; Schrag *et al*. 2011, p. 5; Dominguez *et al*. 2012, pp. 3–4; Still and Richardson 2015, p. 32). Furthermore, most emissions scenarios diverge by mid-century (IPCC 2013, pp. 19–21), making projections past that time subject to increasingly different assumptions. The overall increase in ambient temperature and the likely northward shift of conditions suitable for sagebrush can be projected to the end of the century (with a high level of agreement among multiple global circulation models [GCMs]; Schlaepfer *et al*. 2015, pp. 6–7). However, the synergistic effects of climate change interactions with threats to sage-grouse habitat such as wildfire and invasive annual grasses are more complex and are projected in the literature as far as mid-century (Abatzoglou and Kolden 2011, p. 473; CITE –new model results??). The even more complex interactions of climate change and political, economic, and social forces that influence use of water use and land uses such as grazing and energy development are difficult to predict at all, and study of these specific interactions and their likely impacts in the western United States is needed (see for example Ford *et al*. 2012, pp. 86–87, 89, 91–92). However, current trends in the climate system—increasing temperature, increasing duration and intensity of drought, decreasing snow-pack, increasing heavy precipitation events and other extreme weather—are likely to continue through the 21st century (IPCC 2013, p. 7).

Likelihood of future impacts

Increases in global and regional ambient temperature are projected out to the end of the 21st century with medium to high confidence (Abatzoglou and Kolden 2011, p. 474; IPCC 2013, p. 19). Under current trends in carbon emissions, global mean surface temperature is likely to increase (relative to 1986–2005) by 0.3°C to 0.7°C (0.54°F to 1.26°F) between 2016 and 2035, and increase by 2.6°C to 4.8°C (4.7°F to 8.6°F) between 2081 and

Comment [hf272]: Provisionally, 30 to 50 years, but depends somewhat on pending model results and USGS data.

Comment [DP273]: The standard language from HQ indicates 30 years. If we are going to differ here we need to explain why (as identified by the model parameters and their level of certainty).
HF: The boilerplate language from HQ says; "The term 'climate' refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or far longer periods also may be used." This sentence refers to measurements of mean values of climate (T, ppt, etc.) and the variability around those means. It doesn't refer to or prescribe timescales for projection.

Comment [sa274]: Sometimes we include non-native in this description – check global and make consistent as appropriate
HF: Conflict here between this comment and other suggested edits, so I'm not sure what convention to use, or which are the most important/informative adjectives...I'd assume "invasive" and "non-native." Non-native appears with the first mention here (and throughout the Invasive Plants chapter... I will leave the executive editing decision to Dawn!

Comment [DP275]: this is the first grazing is mentioned. Suggest it be included under the compounded effects – potential competition source, changes in use as forage availability changes, etc.
HF: Note that the gist of this sentence is that there's no solid information about interactions between these land uses and climate change, so I'm leery of trying to weave an argument without supporting info.

Comment [hf276]: **Comment from Amy:** This seem out of place here in between 2 statements about biological interactions. Maybe put at end of paragraph, saying uncertainty of response to climate change given political, economic, and social considerations.
HF: Hm not sure I follow. this sentence isn't a general disclaimer about unpredictable social and political mediation of climate change impacts. My thought here was to run through the threats to sagebrush habitat, grouped in descending order by the quality of our knowledge about how they'll be affected by climate change, and then say that, irrespective of these specifics, climate change and its interaction with these threats is here to stay, beyo ...

Comment [DP277]: I think the last part is fine here and is key to this discussion.

Comment [hf278]: DELETE?

Comment [JD279]: Warmer, dryer? What exactly are the trends? Spell it out here for the reader.
HF: done, insofar as one can generalize. The story with precipitation is complicated and geographically variable.

Comment [JD280]: I would use this designator sparingly – is there no page number(s) we can point to where they draw this conclusion?
HF: Done

2100 (IPCC 2013, p. 20).6 Despite variable projected changes in precipitation and increases in some areas (Trenberth 2010, p. 15; IPCC 2013, p. 22), moderate to extreme increases in the duration and/or severity of droughts are likely by mid-century (Strezepek *et al*. 2010, pp. 4–6; IPCC 2013, p.7; Ault *et al*. 2014, p. 7540–7545; Touma *et al*. in press, pp. 5–6; Cook *et al*. 2015, pp. 1–2). Regional increases in frequency of heat extremes, and heavy precipitation events and decrease in snow-pack also are likely by mid-century (IPCC 2013, pp. 20, 25, 27; U.S. Global Change Research Program 2014, pp. 7, 8). As annual average temperature increases, increasing hot extremes and decreasing cold extremes, on daily and seasonal timescales, are "virtually certain" (IPCC 2013, p. 20).

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

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

Comment [hf281]: I don't think this is the place to go into detail about why we chose the worst-case emissions scenario, but if (when) that question comes up, there's solid rationale in the literature and our record (see for example See NOAA's final rule for corals in 2014). Short version: the worst-case scenario is the status quo, and to change that would require global-scale changes in policy and regulation of GHGs as well as implementation of carbon capture and storage technologies that are only in R&D infancy now. There's no certainty of implementation or effectiveness of any of this (including for example recent agreements between U.S. and China).

Comment [JD282]: I think at least a footnote to let the reader know which scenario we are referring to and why that was the most reasonable choice.
HF: Done.

Comment [sa283]: Check this pub out as well - this guy may have a few older pubs that may also be useful.
Unprecedented 21st century drought risk in the American Southwest and Central Plains
Benjamin I. Cook, Toby R. Ault, Jason E. Smerdon
+ Author Affiliations
Science Advances 12 Feb 2015: Vol. 1 no. 1 e1400082 DOI: 10.1126/sciadv.1400082
ArticleFigures
HF: Thanks for this - have added.

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

Mechanisms

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

Comment [hf284]: **Amy:** I thought the droughts would happen because of the timing of the precipitation along with temp increase?
HF: Yes - the distinction here is between meteorological drought (low to no precip) vs. hydrological drought (low total water availability; this is the result in part of declining snowpack).

Comment [sa285]: I would briefly define this term – basically your response to Amy in comment bubble above.
HF: done.

Comment [sa286]: Should you put it in terms of increased evapotranspiration???
HF: I don't think evapotranspiration is as widely projected using climate models as drought. Too, I think at this level drought is a more straightforward condition to describe.

Comment [JD287]: This is a good discussion, but need to tie these changes in the climate back to the likelihood of future impacts to sage-grouse and their habitats.
Probably need model results to do an adequate analysis here – suggest putting in a placeholder to that effect.
HF: Agree. Model results will be helpful, but we may not get them. Part of the disconnect here was the partitioning sections in the original chapter template...went on to discuss how the climate conditions described here are likely to affect aspects of sage-grouse habitat and ecology. --- As you note below.

between cheatgrass and wildfire (D'Antonio and Vitousek 1992, pp. 63-87; Westerling *et al*. 2006, entire; Abatzoglou and Kolden 2011, pp. 474–475; Miller *et al*. 2011, p. 183; Balch *et al*. 2013, p. 180–182; Chambers *et al*. 2014, pp. 367–368); and conditions that influence disease incidence (Christiansen and Tate 2011, pp. 119, 126; Schrag *et al*. 2011 pp. 8–9, 12).

Comment [DMD288]: D'Antonio and Vitousek 1992, pp. 63-87; Miller et al. 2011, p. 183.
HF: added.

Anticipated impacts, location, and extent

Western North America is identified as a "hotspot" of regional climate change under a range of future emissions scenarios (Diffenbaugh *et al*. 2008, pp. 3–4; Diffenbaugh and Georgi 2012, p. 819). Some degree of uncertainty is inherent in these and other projections of future change, however, owing to aspects of climate variability, the and complex interrelationships among climate variables, and the potential for unanticipated regional responses of the climate system to increasing greenhouse gasses (Diffenbaugh and Georgi 2012, p. 819; Abatzoglou *et al*. 2014, pp. 2139–2140). Climate change will affect the entire range of sage-grouse, and the severity of impacts and interaction with other limiting factors will vary by Management Zone.

Distribution and quality of sagebrush habitat: By mid-century, conditions suitable for sagebrush will likely be lost in the southernmost parts of the range of sage-grouse (southern portions of MZs III and VII) (Schlaepfer *et al*. 2015, p. 4), with potential adverse impacts to peripheral populations of sage-grouse in those areas. The natural distribution of sagebrush reflects seed germination, seedling survival, and the likelihood of sagebrush regeneration following disturbance such as fire or drought, and these processes are driven by soil-water availability (Schlaepfer *et al*. 2014, p. 74; Schlaepfer *et al*. 2015, pp. 7–8). Soil water conditions are influenced by the amount and seasonality of precipitation and by temperature, with spring precipitation and melting snowpack being the chief influences of peak soil water availability (Bradford *et al*. 2014, p. 595). Decreasing snow-pack and earlier spring melt with increasing ambient temperature is projected to lead to increased evaporation and transpiration in sagebrush habitat and a lengthening summer period of dry soil conditions (Bradford *et al*. 2014, p. 599). These conditions are projected to be most pronounced along the southern edge of the current distribution of sagebrush (MZs III and VII), and particularly at low elevations (Schlaepfer *et al*. 2015,

p. 13; Still and Richardson 2015, p. 33). As climate conditions suitable for sagebrush shift northward, the likely result is low probability of sagebrush regeneration in the south (Nielson *et al.* 2005, p. 155; Schlaepfer *et al.* 2012, p. 377; Schlaepfer *et al.* 2015, pp. 4, 8). In these areas, increasing temperature and an increasing number of frost-free days are likely to favor northward and upslope shifts in frost-sensitive woodland vegetation into areas currently suitable for sagebrush (Nielson *et al.* 2005, pp. 153–155; Comer *et al.* 2012, p. 142; reviewed in Friggens *et al.* 2012, pp. 8–11; Rehfeldt 2012, p. 126) at a projected rate of 12 percent of sagebrush habitat displaced per 1°C (1.8 °F) increase in temperature (Nielson *et al.* 2005, p. 154). Given a projected increase in temperature of several degrees Celsius by mid-century in MZs III and VII [[Fig X - map of USGS max T data]], this could mean the displacement of a substantial proportion of sagebrush by other types of vegetation (Miller *et al.* 2011, p. 179). North of the current extent of sagebrush distribution (along the "leading edge," e.g., north of MZs I and VI), projected changes in temperature and precipitation will alter soil-water storage patterns and likely to produce conditions more suitable for sagebrush than at present, but other factors in those areas, such as extensive agriculture, existing grasslands, and improved conditions for nonnative invasive plants, including cheatgrass, could complicate an actual range-shift to the north in sagebrush (Schlaepfer *et al.* 2012, pp. 379–380; Schlaepfer *et al.* 2015, p. 13). [[PLACEHOLDER: SAGEBRUSH CONDITIONS & SAGE-GROUSE GIS OVERLAYS; Figs. X, Y, and Z]] In addition to these future patterns of trailing-edge loss and leading-edge gain in climate conditions suitable for sagebrush, sagebrush habitat currently faces climate-mediated stressors such as fire and encroachment by nonnative annual grasses and woody species; these stressors in combination could have additive, adverse impacts to sagebrush habitat (Bradford *et al.* 2014, p. 599; Chambers *et al.* 2014, entire). By mid-century sagebrush cover within the Great Basin and Columbia Basin (MZs III, IV, V, and VI) is likely to be fragmented and reduced overall by cheatgrass and pinyon-juniper encroachment (Nielson *et al.* 2005, p. 155–157; Chambers and Pellant 2008, pp. 30–32; Bradley 2010, pp. 203–205; Chambers *et al.* 2014, pp. 365–368; Schlaepfer *et al.* 2015, p. 13; Still and Richardson 2015, p. 33). Low elevation sites within the Great Basin (MZs III, IV, and V) will be susceptible to fragmentation by and conversion to xeric or novel vegetation, such as desert scrub communities (Friggens *et al.* 2012, pp. 9–10). Overall, by mid-century the potential loss and fragmentation of sagebrush habitat caused by climate change, especially in the southern portions of the range (MZs III and VII)

Comment [JD289]: Do they give any confidence intervals around their projections?
HF: Certainty on this point is expressed statistically as a correlation (r2 = 0.62 [where r represents correlation], P < 0.001) between temperature increase and areal decrease in sagebrush (the proximate cause of sagebrush decline being encroachment by frost-sensitive woody species - this also happened during the Holocene). This figure is cited in the Bi-State species report as well, and by Miller et al in the SAB.

Comment [hf290]: This is the simple deduction from Nielson, which is still widely cited (see Bi-State, for example). However, this is the bioclimate envelope approach -- may not square with Bradford's soil suitability data. Maybe you want to just delete this and text highlighted in previous comment if deemed too speculative.

Comment [hf291]: Delete? TMI?
Amy: Don't know how others would feel, but I actually thought this statement is helpful.

Comment [DP292]: I would leave in

and low-elevation portions of the Great Basin (MZs III, IV, and V) could in turn exacerbate impacts to sage-grouse populations of other stressors and sources of fragmentation (e.g., agriculture, infrastructure, wildfire, invasive plants) and increase the risk of population decline and extirpation (Johnson *et al*. 2011, pp. 447–450; Miller *et al*. 2011, pp. 183–184; Wisdom *et al*. 2011, pp. 465–468).

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

Comment [hf293]: Absent new information from modeling efforts, this is what all of the literature points to. It's not quantified or mapped except very broadly, so we can't parse MZs very well, but the theme in the literature is pretty much uniform.

Comment [DP294]: two comments.
1. We need to distinguish between the strongholds referenced here and the strongholds designated in our Oct. 2014 memo.
HF: Have removed the word "stronghold" - not necessary here.
2. We need to cross walk this information with the strongholds in our Oct. 2014, since they were in part identified with a climate change vortex model.
HF: The October 2014 memo says: "Using Data Basin...we verified our analysis is consistent with landscape-level sage-grouse opportunities and needs, as defined by the above criteria as well as addition ...

Comment [sa295]: Are we doing latin first and then common at first mention?
DMD: Per Amy:
For the first occurrence of a plant species, always use the scientific name first, followed by the common name in parentheses.

Comment [JD296]: Does the range shift? Are there areas that are projected to be within the niche that are currently not sagebrush?
Also, need to say where these areas are – most of the changes on the fringes of the range? What are the impacts to the areas of highest sage-grouse densit ...

Comment [sa297]: In addition to clarifying Jesse's comment. This is an amazing statistic – are there others pubs that support refute this number. Can we make a statement like - …of the XX refereed publication addressing this topic between x and x percent of this habitat is projected to be lost ...

Comment [DP298]: agree with both of the above comments. This is a key point that we need to be absolutely clear on.
HF: See response to Jesse's comment above.

Comment [JD299]: Again, need some spatial context – throughout the entire range? Will some portions be more affected than others? - how does that relate to areas of highest sage-grouse density?
HF: These general relationships between temperature, precipitation, and resources that influence vital rates likely occur more or less rang ...

Comment [hf300]: **Comment from Amy:** Dzialak et al 2013 suggest increased variability in snowfall, i.e. more severe winters, could result in population level loss as winter habitat is limiting. Becomes even more so in bad winters.
HF: In looking through the literature, I think in the end we can't make a case that this effect is likely t ...

Comment [DMD301]: But climate change may bring with it changes in seasonality that could impact reproduction. Decreased synchrony between photostimulated events (e.g., mating and nesting) and temperature stimulated events (e.g., habitat greenup, insect availability) could negatively impact reproductive success. For example, see Fletcher e ...

Invasive plants and wildfire:

Version 1: Climate change can exacerbate habitat fragmentation and loss through changing soil-moisture conditions (Schlaepfer *et al*. 2015, pp. 7–8), encroachment by invasive plants such as cheatgrass (Ziska *et al*. 2006, p. 1330; Bradley 2009, p. 204; Abatzoglou and Kolden 2011, p. 475; Zelikova *et al*. 2013 pp. 1383–1384; Chambers *et al*. 2014, p. 367), and larger and more frequent wildfires and longer fire seasons, and the synergistic effects of the annual grass-wildfire cycle (Westerling *et al*. 2006, entire; Bachelet *et al*. 2007, p. 15; Abatzoglou and Kolden 2011, p. 474-475; Balch *et al*. 2013, entire; Chambers *et al*. 2014, entire) resulting ultimately from a combination of increasing temperature, atmospheric CO2, drought severity and duration, and changing patterns in precipitation. Invasion of sagebrush habitat by cheatgrass poses a dual threat to sage-grouse: sagebrush habitat degradation (through loss of native understory species) and increased risk of fire (Brown *et al*. 2004, p. 384; Neilson *et al*. 2005, pp. 150, 156; Chambers and Pellant 2008, pp. 31–32; Balch *et al*. 2013, pp. 180–181; see Invasive Plants and Fire chapters in this report). Increasing ambient temperature and atmospheric CO2 with climate change are conditions favorable for cheatgrass, especially when accompanied by sufficient winter and spring precipitation, as projected by mid-century for the northern part of the Great Basin (MZs II, IV, and V) (Abatzoglou and Kolden 2011, p. 474). Under these conditions, plants mature more quickly, produce more biomass, set more seed, and, when burned, produce significantly more heat per unit of biomass than cheatgrass grown at “pre-industrial” CO2 levels (Blank *et al*. 2006, pp. 231, 234; Ziska *et al*. 2005, pp. 1330–1331; Bradley 2009, p. 203; Zelikova *et al*. 2013, pp. 1383–1384). These responses can increase the invasive capacity of cheatgrass and its displacement of native grasses and forbs (Bradley 2009, p. 203-204; Zelikova *et al*. 2013, pp. 1383–1384), and significantly increase fire risk in sagebrush communities that harbor this invasive plant (Ziska *et al*. 2005, p. 1330; Blank *et al*. 2006, p. 234; Balch *et al*. 2013, pp. 180–182). In addition, although cheatgrass and other nonnative annual grasses typically occur at relatively low elevations and in dry climates (Connelly *et al*. 2004, p. 5-5), climate change may improve conditions for invasion by cheatgrass upslope (Ramakrishnan *et al*. 2006, pp. 61-62; Chambers *et al*. 2014, p. 367). [[PLACEHOLDER: BRADFORD MODEL RESULTS FOR C.C. & R&R MATRIX??]]

Comment [hf302]: This section currently includes several versions of the same story that formerly appeared in separate sections in the original chapter template. I had hoped to get these sorted out and cleaned up before I left, but I ran out of time. Apologies...Which one do you like best...?

Comment [DP303]: SA is correct – for plants the latin is the first descriptor, and the continued descriptor unless otherwise designated in the text.
HF: Addressed above (first mention)

Comment [DMD304]: Also, Blachelet et al. 2007. Wildfires and global climate change. The importance of climate change for future wildfire scenarios in the western U. S.
HF: Added.

Comment [sa305]: Tie back to our projection for change in precip timing.
HF: Done

Comment [JD306]: Need to address this threat in the context of resistant and resilient landscapes – will Bradford’s model look at how the distribution of resistant and resilient landscapes is likely to be affected by climate change?
HF: That's my understanding.

Version 2: Climate change directly affects fire risk, independent of exacerbation by cheatgrass invasion. Since the 1980s, the frequency of wildfires has increased as direct result of increased temperature, earlier spring warming, and diminishing snow-pack, all of which contribute to overall drying of vegetation, especially in arid and semi-arid regions, such as the Great Basin (Westerling *et al*. 2006, entire). Projections for hotter and, in the southern parts of MZ II and VII, drier climate conditions will result in worsening of these trends (Brown *et al*. 2004, pp. 382–383; Neilson *et al*. 2005, p. 150; Westerling *et al*. 2006, p. 943; Chambers and Pellant 2008, p. 31; Climate Change Impacts in the United States 2014, pp. 463–486). Therefore, beyond the potential shifts in sagebrush and other vegetation communities induced by alterations in temperature and precipitation regimes, increases in CO2 concentrations represent a threat to the extant sagebrush biome and an indirect threat to sage-grouse through habitat degradation and loss (Miller *et al*. 2011, p. 179). Climate change also can heighten interactions among existing threats if these are not ameliorated (Chambers *et al*. 2014, p. 368). Increasing temperature coupled with increased winter and spring precipitation, for example, is likely to exacerbate cheatgrass invasion and wildfire in sagebrush habitat—stressors that results in habitat fragmentation, particularly in the Great Basin (MZs III, IV, and V) (Balch *et al*. 2014, p. 182), although wildfire is correlated with decline in sage-grouse populations across their range (Miller and Eddlemen 2000, p. 24; Johnson *et al*. 2011, p. 424; Knick and Hanser 2011, p. 395; see Fire chapter in this report). Warmer winters, earlier spring melt, and increased concentrations of atmospheric carbon dioxide are likely to favor cheatgrass and other invasive grasses, exacerbating the fire-invasives feedback loop, especially in the Great Basin (Chambers *et al*. 2014, pp. 367–368).

Comment [sa307]: By duration and earlier spring are you trying to imply a longer fire season??? Which I think is certainly a recent concern but I do not have a cite for you off the top of my head.

Comment [DMD308]: Or is it more appropriate to limit the discussion to the Great Basin rather than range-wide?
HF: Done.

Comment [DP309]: Its probably worth minimally identifying the difference between the GB and RM portions of the range (and tie to MZs). Cheatgrass is ubiquitous, but it's a more imminent threat in the GB due to precip and soil types.
HF: Done...?

Disease:

The potential for West Nile virus (WNv) outbreaks is likely to increase in the future with increasing temperature (which facilitates mosquito reproduction and virus amplification). The impacts of this disease on small, isolated populations of sage-grouse would increase concomitantly, if conditions for outbreaks of the disease are present (Dohm *et al*. 2002, p. 223; Reisen *et al*. 2006, pp. 312–313; Zou *et al*. 2007, p. 5; Schrag *et al*. 2010, pp. 8; see Disease chapter in this report). In sage-grouse, WNv outbreaks appear to be most severe in years with higher summer temperatures (Walker and Naugle 2011, p. 131) and under drought conditions (Epstein

Comment [DP310]: make the tie as to why – even if just a reference to the disease section and the correlation of increased temps and mosquito persistence
HF: Done

and Defilippo, p. 105). Warm air temperature favors reproduction in of the mosquito Culex tarsalis, the primary vector for WNv in western North America and enhances virus amplification (Reisen 1995, p. 642). Elevated temperature early in the year will extend the disease transmission season (which currently is concentrated in July through September) and speed the incubation of the virus (Reisen *et al*. 2006, pp. 312–313; Zou *et al*. 2007, p. 5; Schrag *et al*. 2011, p. 8). Increased annual temperature is likely to facilitate mosquito dispersal and reproduction, and virus amplification, at high elevations where WNv is not currently known to occur (Schrag *et al*. 2011, p. 10). Drought conditions concentrate sage-grouse adults and broods in mesic habitats in late summer (Schroeder *et al*. 1999, p. 6; Connelly *et al*. 2000, p. 971 and references therein). Because warm standing water that provides breeding habitat for mosquitoes (Doherty 2007, pp. 15–16) is similarly limited during droughts, the likelihood and duration of sage-grouse exposure to mosquitoes is increased under these conditions (Shaman *et al*. 2005, p.135; Reisen *et al*. 2006, p. 313; Walker *et al*. 2007, pp. 694–695). The interactions of climate and local variables, such as precipitation and distribution of suitable breeding habitat for C. lateralis (Brust 1991, entire; Dohm *et al*. 2002, p. 223), make individual outbreaks difficult to predict (Walker and Naugle 2011, p. 131; see the Disease chapter in this report for a complete discussion).

Comment [DP311]: you might want to check out Doherty's 2007 thesis as a citation.

MOSQUITO POPULATIONS IN THE POWDER RIVER BASIN, WYOMING: A COMPARISON OF NATURAL, AGRICULTURAL AND EFFLUENT COAL BED NATURAL GAS AQUATIC HABITATS
HF: Yep - it's cited below.

Large areas of intact sagebrush habitat and connectivity among seasonal habitats are essential for sage-grouse population connectivity and persistence, and loss and fragmentation of this habitat can negatively influence connectivity among sage-grouse populations and population persistence (Aldridge *et al*. 2008, p. 987; Doherty *et al*. 2008, pp. 191, 194; Knick and Hanser 2011, p. 404; Wisdom *et al*. 2011, pp. 465–466). Currently 27 sage-grouse populations are identified as small and isolated (USFWS 2013a, pp. 16–29). Of these, 12 occur along the southern periphery of the species' range, in MZs III, V, and VII (see the "Small Populations" chapter in this report). These populations currently are likely to face risk of extirpation from threats common to small and/or isolated populations: demographic stochasticity and chance environmental occurrences such as severe storms and disease outbreaks (Lande 1998, pp. 357–358; see the Small Populations chapter in this report); climate change could exacerbate these threats.

As described earlier, general trends in climate in the western United States are projected with relative confidence through the middle of the 21st century. However, the effects of these trends on the multiple ecological relationships that govern the persistence of sage-grouse at fine spatial scales are difficult to predict.

Timing

Because climate change involves changes to year-round processes and can result in changes to sage-grouse habitat, the impacts of climate change to sage-grouse are anticipated to be year-round.

Figure X-X. .

Table 18-1: Impacts of Climate Change by Management Zone

Management Zone	Timing of Impacts (Season)	Immediacy of Impacts	Severity of Impacts	Extent of Impacts	Resource or Life stage impacted	Notes
Example	Spring (or all the time, etc.)	Happening right now (or planned)	Direct mortality (or habitat destruction, etc.)	Impacting X% of pops (see Kevin's models)	Lekking adults, broods	This is an example…
1						
2						
3						
4						
5						
6						
7						

Compounded effects

Fire and invasive species (Westerling *et al*. 2006, pp. 942–943 [mountainous areas]; Littel *et al*. 2009, pp. XX [Great Basin]; Bradley 2009 pp. XX; Bradley 2010, pp. XX; Blomberg *et al*. 2012, p. 15; Balch *et al*. 2013 p. 182; Chambers *et al*. 2014, pp. XX)

Comment [JD312]: Seems like it would be year round – especially in areas where sagebrush is likely to be eliminated over time.
HF: Agree.

Comment [hf313]: **Comment from Amy:** Dzialak et al 2013 hypothesis winter could be time of impacts because winter habitat is limiting already. Extreme snowfall and low temps (i.e. extreme variability) could make it even more limiting.
Add red bars to indicate which aspect of this affects them when??
HF: Again, problem is that extreme snowfall events aren't projected to be isn't in the cards in the future. Ratio of snow to rain projected to tip increasingly in favor of rain.

Comment [DP314]: I don't know if we can be so definitive. If climate change affects habitat quality and abundance, even through indirect effects as fire, it could affect the bird year round.
HF: Agree.

Comment [hf315]: Not a lot to say here - really should go in under Anticipated future section.

Comment [hf316]: Again, for climate change, this really belongs in Anticipated changes from present. New Bradford models and mapped USGS data will be key to filling in this table. Will we be able to distinguish impacts between peripheral populations vs. strongholds? Don't know yet.

Comment [JD317]: This seems repetitive with above. Suggest combining this information with the sections above.
HF: Agree - done.

Conifer encroachment (increased CO_2 improves efficiency of water-use in trees [Soulé *et al*. 2003, 2004]; increasing precip. In N part of range favors pinyon-juniper encroachment; increase in frost-free season likely to facilitate invasion of sagebrush habitat by frost-sensitive woodland species from south.

West Nile virus (Schrag *et al*. 2011, Christiansen and Tate 2011)

Threat amelioration

Active Conservation

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

Ameliorate direct impacts to GRSG?

Assessment of Potential Threat

In our 2010 finding, we considered climate change to play a potentially important indirect role in intensifying some of the current significant threats to sage-grouse (USFWS 2010, p. 47). Since then, new climate-change analyses and regionally downscaled climate data have projected future conditions with increased confidence, including range-wide increase in temperature; increasing precipitation in the north, decreasing precipitation in the south, and a shift to more winter and spring precipitation, less precipitation falling as snow,

Comment [JD318]: Do we have anything in the CED that addresses climate change? If not, delete.
HF: Nope. Done.

Comment [JD319]: Could say something to the effect that while direct measures to reduce the threat of climate change are not within the scope, there are many conservation actions that have been implemented to address the those threat factors that are most influenced by climate change – namely …..? And then point the reader to those chapters for specifics.
HF: Done (thanks!)

Comment [DP320]: is there anything we can say about the speed of implementation of these actions and whether or not we can expect them to do anything to ameliorate current impacts?
HF: check out new language below and see if this suits. The speed of implementing actions to address other threats and how well that works to ameliorate them seems like a topic for those chapters. As far as predicting how efforts made now to ameliorate, say, wildfire (e.g., planning efforts under the SO, FIATs, etc.) will affect impacts of climate change later -- I haven't seen any analyses to this effect and I would hesitate to arm-wave on this topic!

Comment [DMD321]: There may be potential to mitigate climate change impacts through conservation actions directed at improving habitat conditions during nesting and brood-rearing.
HF: Should we explore this further? Is there something published on this topic?

Comment [DP322]: I will defer to Steve, but I thought we discussed the value of riparian habitats in the Bi-state relative to maintaining the resilience of the habitat. If so that discussion might be useful here.
HF: I didn't find any discussion of climate change amelioration in Bi-State...

Comment [hf323]: I'm not 100% clear whether we want to repeat all the citations in this section or not...

Comment [hf324]: This is verbatim from 2010.

and increased likelihood of long, severe droughts (e.g., Strzepek *et al*. 2010; Abatzoglou 2011; Abatzoglou and Kolden 2011; IPCC 2013; U.S. Global Change Research Program 2014; Cook *et al*. 2015; [[USGS NCCV data]]). Climate and climate change impacts to conditions suitable for sagebrush have been investigated in greater detail (e.g., Schlaepfer *et al*. 2012, Bradford *et al*. 2014; Schlaepfer *et al*. 2014, 2015; Still and Richardson 2015), as well as climate impacts to wildfire, invasive annual grasses, and West Nile virus in the west (Bradley 2009, 2010; Abatzoglou and Kolden 2011; Chambers *et al*. 2014; Schrag *et al*. 2011; Balch *et al*. 2015). The relationships between climate variables and seasonally important food resources for sage-grouse have been documented in some areas (e.g., Blomberg *et al*. 2012, 2013, 2014; Guttery *et al*. 2014).

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

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

THE FOLLOWING TEXT IS ALL PLACEHOLDER, PASTED VERBATIM FROM (1) GUSG FINAL RULE AND (2) BI-STATE + 2010 FINDING:

The complexity of interactions between climate variables and threats to sage-grouse make it difficult to predict to what extent climate change will affect the species in the future. We recognize that climate change has the potential to negatively affect sage-grouse habitat by facilitating an increase in the distribution of cheatgrass, which in turn can increase the potential for wildfires and displace herbaceous vegetation and insect production in drought years. These changes in habitat would have negative effects on sage-grouse survival and reproduction. We do not consider climate change to be a current threat to sage-grouse because of the uncertainties described above. However, based on the best available information on climate change projections, climate change has the potential to alter the availability of important seasonal habitats and food resources for sage-grouse, the distribution and extent of sagebrush, the occurrence of invasive plants and associated fire frequencies, and the conditions favorable to West Nile virus and its mosquito vector.

Comment [hf325]: Part of summary from GUSG final rule.

Comment [sa326]: I hear you BUT above we discuss potential sagebrush loss (pretty significant percentages), so can we say something more here? HF: these paragraphs were pasted verbatim from GUSG rule, as a place-holder. That said, I think all we could do is arm-wave about how sage-grouse might respond to these habitat changes, and point to the CA vulnerability assessment (Galardi et al. 2012). Not a strong basis for conclusory statements about how climate change will affect sage-grouse populations.

Comment [DP327]: I don't disagree, but don't think we have made the argument in the preceding text. For example – we don't expect sagebrush to disappear immediately (although the understory may be altered, and fire frequencies may increase), et c. HF: Again, this was a placeholder pasted in from Bi-state + 2010. See new draft language above.

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Based on the best available scientific and commercial information, the threat of climate change is not known to currently affect the range of sage-grouse to the degree that the viability of the species is at stake. However, while it is reasonable to assume the Bi-State area will experience vegetation changes into the future (as presented above), we do not know with precision the nature of these changes or ultimately the effect this will have on the Bi-State DPS. However, these same models suggest it is similarly likely that the current extent of suitable shrub habitat will decrease, as the conditions that make the reduction in cheatgrass possible also suggest a less suitable climate condition for sagebrush and improved suitability for woodland and warm-desert vegetation communities, which are not favorable to sage-grouse. In addition, it is reasonable to assume that changes in atmospheric carbon dioxide levels, temperature, precipitation, and timing of snowmelt will act synergistically with other threats such as wildfire and invasive nonnative species to produce yet unknown but likely negative effects to sage-grouse populations. Based on this information it is reasonable to assume that climate change (acting both alone and in concert with impacts of nonnative invasive species and disease) could be pervasive throughout the range of sage-grouse, potentially degrading habitat to such a degree that many populations would be negatively affected. Therefore, given the scope and potential severity of climate change when interacting with other threats to sage-grouse in the future, the overall impact of climate change at this time is considered moderate. Synthesis documents of climate change typically predict changes based on mid- and end of the century timeframes. However, models tend to diverge with longer timeframes (over 50 years). We currently consider the impact of climate change to sage-grouse in the future to remain moderate.

Comment [hf328]: Summary from from Bi-State + 2010

Comment [sa329]: This was bi-statee specific not sure if it holds true in other locations across the range??

Comment [JD330]: Placeholder?
HF: Yup - pasted verbatim from Bi-State.

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Comment [hf331]: List is under construction - this contains a lot of references not cited.

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Chapter 19: Drought

Introduction

Drought, the shortage of precipitation over an extended period of time (NDMC 2015), is a natural, periodic occurrence throughout the range of the greater sage-grouse (Centrocurecus *urophasianus*; hereafter sage-grouse). Impacts from drought to sage-grouse, including habitat loss, may be magnified when the natural event is combined with other habitat impacts and human activities (Braun 1998, p. 148; NDMC 2015). Multiple sage-grouse management zones (MZ) are currently experiencing drought conditions (USDM 2015). The severity, extent, and duration of drought, and therefore associated impacts to sage-grouse, are likely to increase due to climate change (Strzepek *et al*. 2010, p. 1; Ault *et al*. 2014, p. 7545) and increasing demand for water in western United States (EPA 2015).

Based on our review of the currently available scientific and commercial data, we believe drought is impacting individuals and some populations. Because drought has typically not occurred across the entirety of sage-grouse range, it does not appear to be impacting at the management zone level or rangewide. Future drought predictions indicate that impacts will continue and may intensify, particularly in the southern portion of the sage-grouse range, potentially impacting the species at a management zone level.

Threat description

Drought is considered a universal ecological driver across the Great Plains (Knopf 1996, p.147). It can be measured by the imbalance between water supply and water demand, taking duration, intensity, size of the area affected, and impacts into consideration (Peterson *et al*. 2013, p. 827). Large-scale drought lasting a decade, similar to the 1930s Dust Bowl drought, have occurred once or twice per century on average (Woodhouse and Overpeck 1998, p. 2706; Ault *et al*. 2014, p. 7529) and periodic drought regularly influences sagebrush ecosystems (Miller *et al.* 2011, p. 145). Megadroughts (droughts lasting multiple decades) occurred throughout the western United States in the thirteenth and sixteenth centuries according to tree-ring reconstructions (Woodhouse and Overpeck 1998, p. 2699). Throughout the 20th century, drought duration has increased in the interior western United States (Andreadis and Lettenmaier 2006, p. 1; Miller *et al*. 2011, p. 145). Recently, drought has occurred with varying severity in portions of the sage-grouse range (USDM 2015).

Current impacts

Mechanism

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

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

Results of impact

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

Correlational information from the 1930s linked the decline in sage-grouse populations to periods of drought (Patterson 1952, p.33 ; Braun 1998, p. 139). Drought conditions in the late 1980s and early 1990s also coincided with a period when sage-grouse populations were at historically low levels (Connelly and Braun 1997, p. 8). Experimental data found that from 1950 to 2003, the frequency of droughts had a weak negative effect on sage-grouse persistance, with extirpation most likely in areas having three or more severe droughts per decade

(Aldridge *et al*. 2008, pp. 983, 992). Populations on the periphery of a species range may be extripated during periods of severe and prolonged drought (Wisdom *et al*. 2011, p. 468).

Timing

Effects from drought may occur throughout the year, depending on the severity, frequency, and duration of drought conditions (Figure X-1). As discussed above, drought conditions during the spring and winter may lead to reduced chick survival (Aldridge and Bridgham 2003, p. 31; Guttery *et al*. 2013, p. 8).

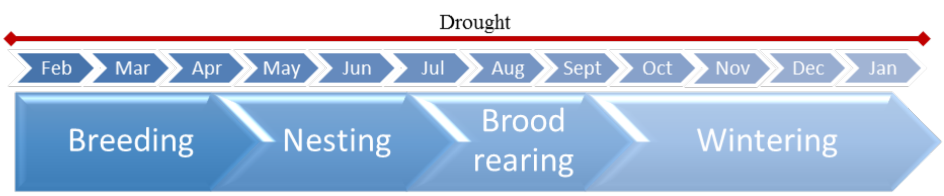

Figure X-1. Annual life cycle of sage-grouse. The timing of drought impacts (year round), when occurring on the landscape in relation this life cycle, is indicated by the red bar.

Location and extent

Drought has been documented through much of the interior western United States in the twentieth century (Miller *et al*. 2011, p. 145). Abnormally dry (when going into drought, defined as short-term dryness slowing planting, growth of crops or pastures; when coming out of drought, defined as the occurance of some lingering water deficits, pastures and crops not fully recovered) to exceptional long-term (defined as exceptional and widespread crop/pasture losses; shortages of water in reservoirs, streams, and wells creating water emergencies) drought conditions currently exist in portions of the sage-grouse range (USDM 2015, Figure X-2). Many portions of the sage-grouse range show drier conditions from 1991-2012 compared to the first half of the 20th century, even though major droughts occurred during the 1930s and 1950s (Walsh *et al*. 2014, p.32; Figure X-3).

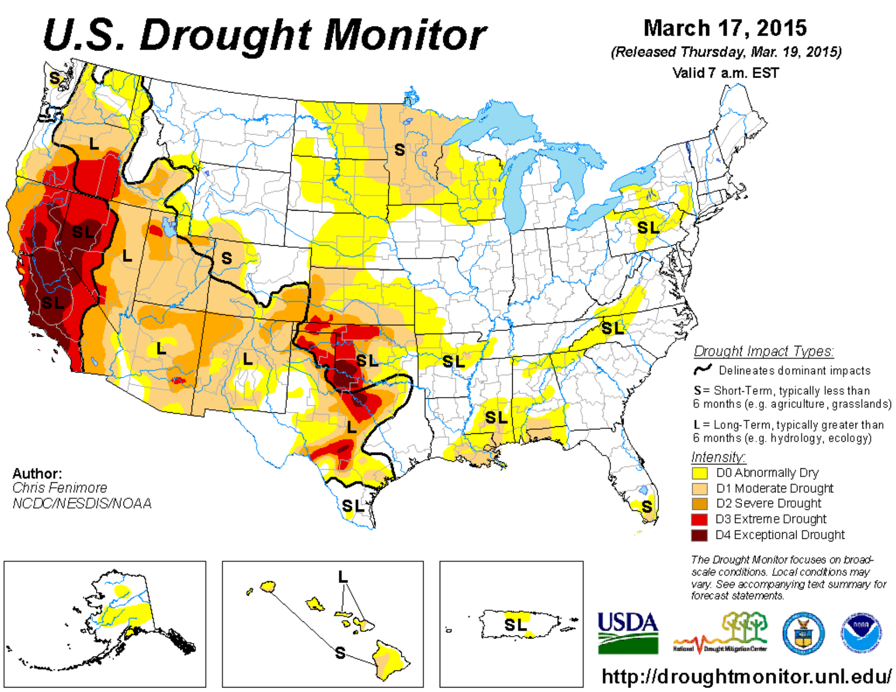

Figure X-2: Drought conditions in United States as of January 27, 2015 (USDM 2015).

Comment [AB332]: Maps/Figures may change – still working with Ed and hoping that we can get a version that includes MZ lines.

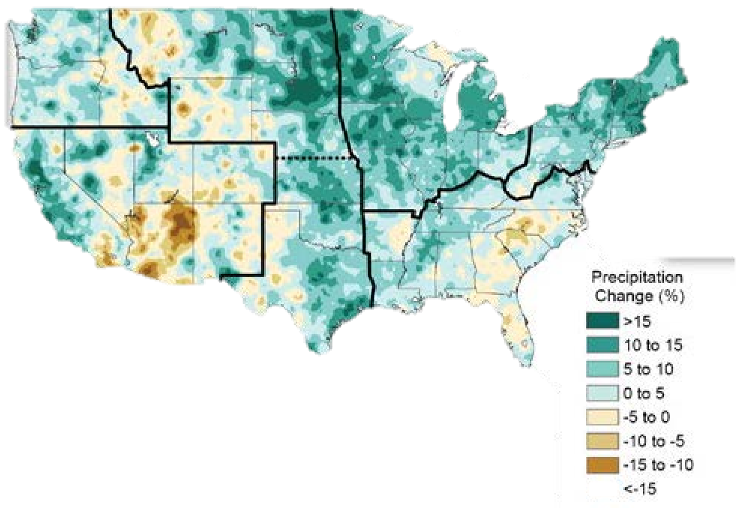

Figure X-3: The colors on the map show annual total precipitation changes for 1991-2012 compared to the 1901-1960 average, and show wetter conditions in most areas. This increase in precipitation reflects the major droughts in the 1930s and 1950s that made the early half of the record drier. (Figure source: Walsh *et al*. 2014, p. 32; adapted from Peterson *et al*. 2013).

Table X-1: Table X-1: List of impacts by management zone.

Management Zone	Timing of Impacts (Season)	Immediacy of Impacts	Severity of Impacts	Extent of Impacts	Resource or Life stage impacted	Notes
1	Current	Drought conditions occurring	Normal conditions, Abnormally dry conditions	Only occurring in very SE portion of MZ; less than 25% of MZ impacted	Potentially all life stages in areas with drought	

Management Zone	Timing of Impacts (Season)	Immediacy of Impacts	Severity of Impacts	Extent of Impacts	Resource or Life stage impacted	Notes
2	Current	Drought conditions occurring	Normal conditions, abnormally dry, moderate drought, and severe drought conditions	Drought conditions occurring only within southern portion of MZ; less than 50% of MZ impacted	Potentially all life stages in areas with drought	
3	Current	Drought conditions occurring	Moderate drought, severe drought, extreme drought, and exceptional drought conditions	Entire MZ currently impacted. Western portions of the MZ have more severe drought conditions.	Potentially all life stages in areas with drought	
4	Current	Drought conditions occurring	Normal conditions, abnormally dry, moderate drought, severe drought, and extreme drought conditions	Over 50% of MZ impacted; Western portions of MZ have more severe drought conditions.	Potentially all life stages in areas with drought	
5	Current	Drought conditions occurring	Moderate drought, severe drought, extreme drought, and exceptional drought conditions	Entire MZ currently impacted. Southern portions of MZ have more severe drought conditions.	Potentially all life stages in areas with drought	
6	Current	Drought conditions occurring	Normal conditions, abnormally dry, and moderate drought	Over 75% of MZ impacted; Southern portions of	Potentially all life stages in areas with drought	

Management Zone	Timing of Impacts (Season)	Immediacy of Impacts	Severity of Impacts	Extent of Impacts	Resource or Life stage impacted	Notes
			conditions	MZ have more severe drought conditions		
7	Current	Drought conditions occurring	Normal conditions, abnormally dry, moderate drought, and severe drought conditions	Over 75% of MZ impacted; Southern and western portions of MZ have more severe drought conditions.	Potentially all life stages in areas with drought	

Compounded effects

The compounding effects will be discussed in greater detail in the Compounded Effects chapter. In brief, the following impacts are likely to interact with the threat described in this chapter.

- West Nile Virus - In sage-grouse, WNv outbreaks appear to be most severe in years with higher summer temperatures (Walker and Naugle 2011, p. 131) and under drought conditions (Epstein and Defilippo 2001, p. 105). This relationship is due to the breeding cycle of the WNv vector, Culex tarsalis being highly dependent on warm water temperature for mosquito activity and virus amplification (Walker and Naugle 2011, p. 131). Therefore, 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. Additionally, loss of mesic vegetation and reduced surface water sources from drought also serves to concentrate sage-grouse around what water is left, facilitating spread of the disease.

- Climate Change - Arid regions where greater sage-grouse occurs are likely to become hotter and drier due to climate change (Brown *et al*. 2004, pp. 382–383; Neilson *et al*. 2005, p. 150; Chambers and Pellant 2008, p. 31; Global Climate Change Impacts in the United States 2009, p. 83; Strzepek *et al*. 2010, p. 1; Ault *et al*. 2014, p. 7541–7542; Cook *et al*. 2015, p. 6).
- Invasive Species – Drought impacts to native sagebrush vegetation may allow the encroachment of invasive species (Connelly *et al*. 2004, p. 5-11; Chambers *et al*. 2007, p. 141).
- Ranch management/grazing/free-roaming equids – 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).
- Fire – Drought may increase fire risk and severity of wildfires that occur.
- Ex-Urban Development – expanding human populations are likely to use higher amounts of water, reducing the amount of water in reservoirs, rivers, and streams, increasing impacts of drought in the surrounding areas (EPA 2015).
- Agricultural Conversion – agricultural fields may require irrigation and higher water use, increasing impacts of drought within the watershed to native species.
- Non-renewable Energy Development – water usage required for drilling and production of oil and gas may increase impacts of drought.

Projected Future impacts

Timescale for Projecting impacts from Drought

Drought is a natural occurance that has been documented across the range of the sage-grouse since precipitation records have been maintained and has been documented in the paleoclimatic record. Therefore, we believe that impacts from drought will continue indefinitely.

Likelihood of future impacts

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

Anticipated changes from present

Arid regions where sage-grouse occur are likely to become hotter and drier by the end of the 21st century due to climate change (Brown *et al*. 2004, pp. 382-383; Neilson *et al*. 2005, p. 150; Chambers and Pellant 2008, p. 31; Global Climate Change Impacts in the United States 2009, p. 83; Walsh *et al*. 2014, p. 34; Cook *et al*. 2015, p. 6). The southern portions of the range (MZ I,VI, and portions of MZ II and IV) are likely to have increased risk and higher severity of drought, though the entire range will likely be impacted by drought (Cook *et al*. 2015, p. 6). Drought models for late 21st century indicate that drought and changes in precipitation may be seasonal, with higher than normal amounts of precipitation occurring in the northern portion of the range during the spring, fall, and winter, with reduced precipitation occurring over the southern portion of the range in the spring and the majority of the range in summer (Figure X-4) (Walsh *et al*. 2014, p. 34). Additionally, despite projected increases in precipitation in much of the range of the sage-grouse, rising temperatures associated with climate change are projected to lead to a high likelihood of increases in hydrological drought (i.e., drought defined by low water supply, rather than by low precipitation) across the west by the middle of the 21st century (Strzepeck *et al*. 2010, pp. 4–6).

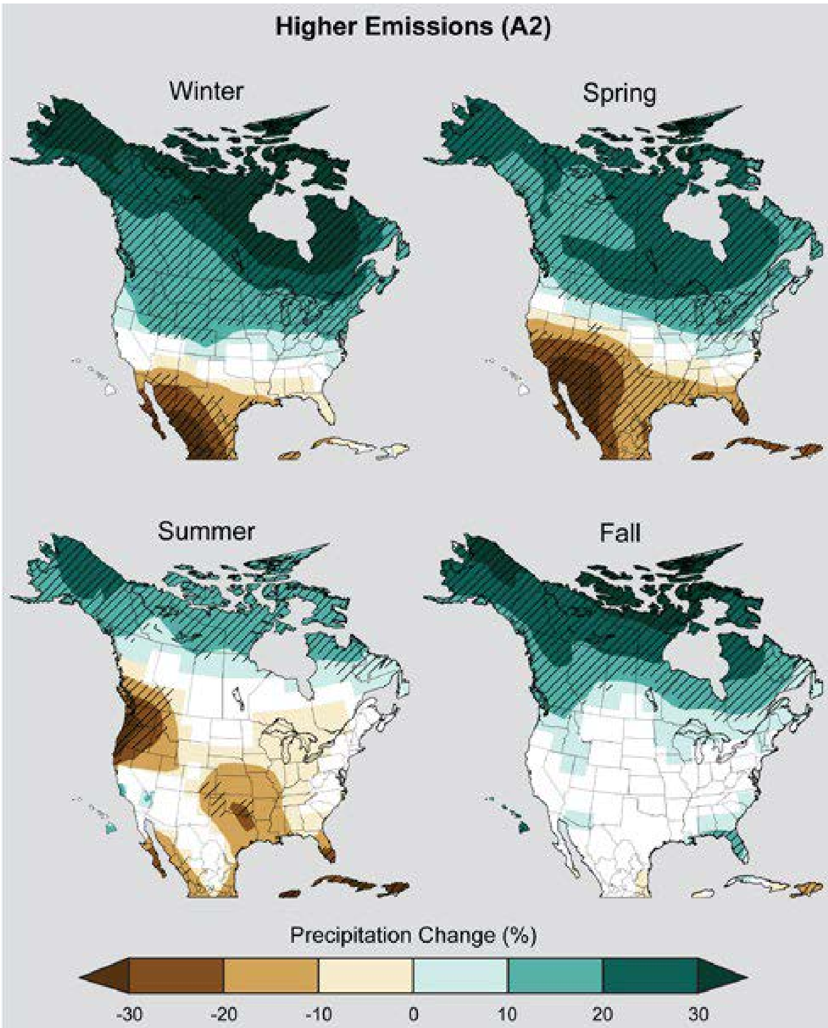

Figure X-4: Projected change in seasonal precipitation for 2071-2099 (compared to 1970-1999) under an emissions scenario that assumes continued increases in emissions (A2). Hatched areas indicate that the projected changes are significant and consistent among models. White areas indicate that the changes are not projected to be larger than could be expected from natural variability. (Figure source: Walsh *et al*. 2014, p. 34/ NOAA NCDC / CICS-NC).

Table 19-1: Projected change in seasonal precipitation for 2071-2099 (compared to 1970-1999) under an emissions scenario that assumes continued increases in emissions (Figure source: Walsh et al. 2014, p. 34/ NOAA NCDC / CICS-NC).

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

Threat amelioration

Active Conservation

Through the Conservation Efforts Database (CED), the Service collected information relating to conservation actions that were completed, in progress, or planned. Active conservation is occurring related to compounding factors that may be associated with drought, such as implementation of proper grazing practices, but no conservation measures directly influence the potential risk or impacts associated with drought. Threat Amelioration Summary

Conservation efforts underway do not currently ameliorate the impacts of drought to any measurable extent. Best management practices designed to use less water may exist, but are difficult to quantify.

Assessment of Potential Threat

Drought has been a periodic and natural part of the sagebrush-steppe ecosystem and therefore it is unlikely that drought was a major factor of persistent population declines of sage-grouse under historical conditions. Sage-grouse population numbers have been shown to fluctuate in correlation to drought conditions, but data is lacking to indicate that drought contributes to overall long-term declines in sage-grouse populations. Presently, drought is impacting individuals and some populations. Drought impacts on the greater sage-grouse may be exacerbated when combined with other habitat impacts (for example, habitat modification from grazing and development) that reduce cover and food and may increase in frequency and duration due to climate change. Future drought predictions indicate that impacts will continue and may intensify, particularly for the southern portion of the sage-grouse range, potentially resulting in management zone level impacts.

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Overutilization

Chapter 20: Recreational Hunting

Introduction

Comment [acn333]: Significant revision still in the works. I am expecting maps from jdinkins that are important for extent/impact discussion.

Recreational hunting of greater sage-grouse (*Centrocercus urophasianus*; hereafter sage-grouse) takes place across the range of the species in the United States. In Canada, hunting of sage-grouse is prohibited. In 2014, 8 of the 11 States where sage-grouse occur allowed some level of recreational sage-grouse hunting. Three States, Washington, North Dakota, and South Dakota, have suspended sage-grouse hunts. Current harvest levels are undoubtedly lower than in the past. States have adopted more conservative management approaches in response to and increased knowledge of sage-grouse biology and ongoing rangewide population declines. Recreational hunting is not universal across the range but varies geographically; not all populations experience the same degree of hunting pressure and some areas receive little to no hunting pressure at all. The Service does not believe that recreational hunting as a singular factor poses a threat to the species across its range, though negative impacts to local populations have been demonstrated. Continued close attention will be needed by States to carefully manage hunting mortality, including adjusting seasons and allowable harvest levels, and imposing emergency closures if needed.

Threat description

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

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

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

Comment [acn334]: NOTE: Is the Draft Resource Management Plan EIS-Nevada and Northeastern California

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

Since the resumption of recreational hunting in the 1950s, sage-grouse hunting mortality has varied considerably and at times likely exceeded levels considered sustainable under current management recommendations (i.e., harvest of no more than 10 percent of the estimated fall population (Connelly *et al*. 2000a, p. 976) See Threat Amelioration). It is important to note however, that historical population and hunting mortality estimates are very coarse, given the techniques used at the time to collect such information. Thus, it is impossible to accurately estimate how often annual recreational hunting mortality exceeded 10 percent of the fall population.

In the 1960s, hunting mortality across the range is estimated to have exceeded 120,000 individuals annually for 7 of 10 years. Hunting mortality reached a peak in the 1970s, with estimates being above 200,000 individuals in 9 of 10 years (Table 1). During the 1980s, hunting mortality is estimated to have exceeded 130,000 individuals in 9 of 10 years. The hunting mortality was estimated above 100,000 annually during the early 1990s but in 1994 dropped below 100,000 for the first time in decades. Hunting mortality decreased significantly in the 2000s with an average annual mortality estimate of 31, 373 (Table 1). From 1968 to 2013, the time period with the most complete records, the majority of estimated sage-grouse hunting mortality has occurred in Wyoming (32 percent), Idaho (28 percent), and Montana (16 percent), accounting for at least 76 percent of the annual hunting mortality (Service 2015).

Comment [acn335]: Decided I should change this to 1965 to 2013. 1968 is first year we have hunting estimates for CO, WY, MT, ID, OR and..NV

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

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

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

Current impacts

Mechanism

Direct mortality is the primary mechanism for impacts to sage-grouse from recreational hunting. Poor shot placement also results in an undetermined amount of delayed mortality (crippling loss) either as a direct result of the injury or because injuries make individuals more susceptible to predation. Birds injured by hunters are seldom retrieved or reported, making estimates on these types of crippling losses difficult to obtain or monitor (Watson 2007, p.3; Caudill 2011, p. 10). Estimates of crippling loss for sage-grouse are rare. However, one recent radio-telemetry study estimated crippling losses from sage-grouse hunting on Parker Mountain in south-central Utah at 0 and 6.8 percent in 2008 and 2009, respectively (Caudill *et al*. 2014, p. 814). These estimates, however, are based on a very small sample size (n=11) and Caudill *et al.* (2014, p. 815) note that more research on crippling loss is needed. Potentially high and variable mortality from crippling loss could limit the ability of States to effectively maintain hunting mortality below levels considered sustainable under current management recommendations (i.e., harvest of no more than 10 percent of the estimated fall population, Connelly *et al*. 2000a, p. 976).

In addition to direct mortality and injury, levels of disturbance increase with the increased human activity (e.g., vehicles, dogs, gunshot noise) in areas open to hunting. Hunters often target areas of high resource value to sage-grouse (e.g., wet meadows). Targeting of such areas has the potential to bias hunting mortality more towards females and young, which tend to aggregate in moist areas. Potential impacts from targeting females is discussed in more detail below. The presence of hunters could also potentially result in avoidance of these areas during the hunting season (Connelly *et al*. 2000b, p. 230; Wik 2002, p. 34; Reese and Connelly 2011, p. 109). However, this type of disturbance currently only impacts some populations of sage-grouse annually from 2 to 30 days depending on the State. It is unknown if disturbance of this type and relatively short duration has any measurable negative impacts on sage-grouse.

Hunting also can subject populations to exploitation-induced selection that can have unintended and long-term negative consequences, such as earlier maturation times, loss of genetic variation, reduced production, etc. (Harris *et al*. 2002, p. 634; Allendorf *et al*. 2008, p. 327; Allendorf and Hard 2009, p. 9987; Bunnefeld *et al.* 2011, p. 1258). Exploitation-induced selection, however, has never been examined in sage-grouse, and it is not known whether hunting mortality is at a level that could or has caused any measurable changes in traits.

Results of impact

Sage-grouse hunting is regulated by State wildlife agencies and managed with the goal of maintaining a sustainable harvest. Managing for sustainable harvest is traditionally based on the concept of compensatory and additive mortality (Connelly 2005, p. 7). The compensatory mortality hypothesis asserts that because sage-grouse produce many more offspring than can survive to sexual maturity, individuals lost to hunting represent losses that would have occurred anyways from some other source (e.g., starvation, predation, disease). Hunting mortality becomes additive if it exceeds natural mortality, ultimately resulting in a decline of the breeding population. A sustainable (compensatory) harvest occurs when hunting mortality is at a level that does not exceed natural mortality.

The validity of the idea that hunting is a form of compensatory mortality for upland game birds, including sage-grouse, has been questioned in recent years (Connelly 2005, p. 7; Gibson *et al*. 2011, p. 313; Reese and Connelly 2011, p. 101). Sage-grouse possess several life history characteristics which violate the assumptions of compensatory hunting hypothesis, making the potential for additive hunting mortality high. First, although high mortality during notably severe winters has been reported (Moynahan *et al*. 2006, p. 1536; Anthony and Willis 2008, p. 544), sage-grouse typically experience low overwintering mortality (Connelly *et al*. 2000b, p. 22; Wik 2002, p. 40; Sika 2006, p. 80; Caudill *et al*. 2014, p. 812). Thus, in a typical year, the majority of individuals should theoretically successfully overwinter and join the breeding population in the spring (Wik 2002, p. 36). This suggests there is little potential for compensatory hunting mortality as birds lost to hunting likely would have otherwise survived to breed (Gibson *et al*. 2011, p. 309). Second, harvest management levels based on the concept of compensatory mortality assume the species under considerations is short-lived with high rates of reproduction resulting in a large surplus of individuals available for compensatory hunting. Sage-grouse, however, are relatively long-lived with relatively limited reproduction (i.e., small clutch sizes and infrequent renesting attempts) (Schroeder *et al*. 1999, pp. 12–14; Taylor *et al*. 2012, p. 342.) Thus, there is little evidence that populations of sage-grouse produce large annual surpluses that would be available for compensatory hunting mortality (Connelly *et al*. 2011a, pp. 66–67).

Additionally, as is the case for many other long-lived species, female survival has been shown to be a key element driving sage-grouse population growth (Taylor *et al*. 2012, p. 336). Females (adults and juveniles) on average comprise the majority of reported hunting mortalities. For example, of 151 radio-marked sage-grouse in southwest Idaho from 1999-2001, the overall average hunting mortality was 7.4 percent. However, the mortality was not distributed equally among sex and age classes. No adult males, 5.3 percent of juvenile males, 5.9 percent of adult females, and 18.1 percent of juvenile females experienced hunting mortality (Wik 2002, p. 42). Hunting was determined responsible for 42 percent of adult female mortality and for only 15 percent of adult male mortality in Idaho (Connelly *et al*. 2000b, p. 228). In 6 of the 15 years examined, female hunting mortality was estimated to have been above the currently recommended maximum hunting mortality rate of no more than 10 percent (Connelly *et al*. 2000b, p. 229). Male mortality exceeded 10 percent in only 2 of the 13 years examined. Results from these studies suggest that females may be experiencing impacts from recreational hunting disproportionately.

The potential for negative population-level impacts due to increased mortality of reproductive females has long been recognized in wildlife management. Results from wing collection barrels (sites where hunters are asked to deposit a wing from each hunted bird) and hunter surveys indicate that females continue to experience the majority of hunting mortality (Service 2015). A recent examination of 60,132 wings collected in Colorado and Oregon over the periods, 1973–1998, and 1993–2013, respectively (Braun *et al*. 2015, p. 2) also showed the harvest was on average female-biased. However, because it is not clear how well these data correlate with actual population structure, this information alone cannot be used to definitively determine the percentage of the female population that experiences annual hunting mortality.

Comment [acn336]: Add more discussion about results in Braun here…

The higher proportion of females experiencing hunting mortality likely reflects to some degree the typically female-skewed sex ratio frequently reported for sage-grouse (Connelly *et al*. 2011a, p. 66). However, results from the hunting mortality studies mentioned above, from information gathered at wing-barrel collection sites, and from hunter surveys suggest that hunting may affect female and male sage-grouse differently (Christiansen 2014, pers. comm.; Service 2014, unpublished data). Specifically, females may be more susceptible to hunting mortality. Females may be selected intentionally (e.g., thought to taste better) or unintentionally due to their typically more clumped distribution on the landscape (Connelly *et al*. 2000b, p. 230; Caudill *et al*. 2014, p. 815; Christiansen 2014, pers. comm.). Selective hunting that alters the population structure of a species can result in a variety of unintended impacts (e.g., decreased population growth, increased extinction risk, changes in population cycles) (Bunnefeld *et al*. 2011, pp 1265–1266). The degree and impact of potentially selective hunting of females has not been examined in sage-grouse, but could have measureable and likely negative impacts on the populations.

Various studies have attempted to determine whether hunting mortality in sage-grouse is compensatory or additive (Crawford 1982; Crawford and Lutz 1985; Braun 1987; Zunino 1987; Gibson 1998; Johnson and Braun 1999; Connelly *et al*. 2003; Sedinger *et al*. 2010; Gibson *et al*. 2011; Reese and Connelly 2011). Results have been contradictory. For example, Braun (1987, p. 139) found that harvest levels of 7 to 11 percent had no effect on subsequent spring breeding populations, 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. In Montana, Moynahan *et al*. (2006, p. 1536) found that survival was lower in an area that allowed hunting compared to another area where hunting was closed, but noted that the effect could not be definitely attributed only to hunting. Sedinger *et al*.(2011, p. 324–325) examined variation in survival of sage-grouse in Nevada and California and concluded that even if harvest was an additive source of mortality, other sources of mortality were more important in determining annual survival. The contradictions and weak support both for and against compensatory hunting mortality are likely a result of differing methods, a reliance on correlation, an almost total absence of experimental data, and differing effects of hunting mortality due to a relationship between hunting mortality and habitat quality.

In recent years, the levels of hunting mortality (expressed as a percent of the estimated fall population) suggested as compensatory (sustainable) for sage-grouse have varied widely (30 percent (Autenreith 1981, p. 77), 20 to 25 percent (Braun1987, p.139), 10 percent (Connelly *et al*. 2000a, p. 976), 11 percent (Sedinger *et al*. 2010, p. 331)). State wildlife agencies currently attempt to keep hunting mortality below 10 percent of the estimated fall population, based on recommendations by Connelly *et al*. (2000a, p. 976). Similar to other suggested rates of hunting mortality, this level has not been experimentally tested with regard to its impacts on sage-grouse populations.

There is a growing body of evidence that suggests sage-grouse populations in relatively poor habitats (i.e., isolated, fragmented, closer to urban centers) have a limited ability to withstand levels of hunting mortality that would have little or no impacts on populations in higher quality habitats (i.e., contiguous, relatively mesic (wet) habitats) (Gibson 1998, p. 15; Connelly *et al*. 2003, pp. 256–257; Reese and Connelly 2011, p. 109). In other words, the threshold value for a sustainable harvest could be lower or more variable for such populations, regardless of population size. For example, research conducted in Idaho showed that sage-grouse populations experiencing relatively higher levels of hunting mortality had slower population growth rates than populations experiencing light or no hunting mortality (Connelly *et al*. 2003, pp. 256–257). The effect was particularly pronounced in xeric (dry) habitats near human populations, which suggests that the impact of hunting on sage-grouse to some extent depends on habitat quality.

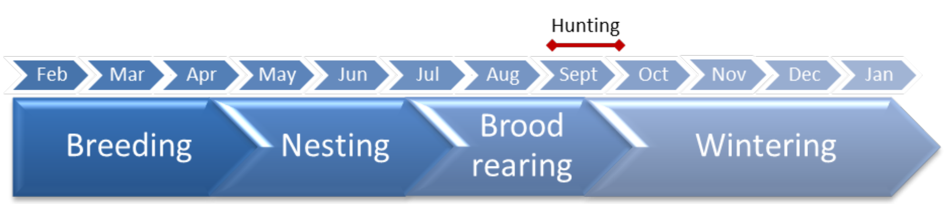
Hunting mortality was also shown to have a negative impact on the population dynamics of an isolated population of sage-grouse in Long Valley, California, where data indicated that hunting suppressed the population size of the isolated population well below the apparent carrying capacity (Gibson 1998, p. 15; Gardner 2008, pers. comm., Gibson *et al*. 2011, p. 307). Over the period examined (1960-1998), hunting seasons were 2 days with a bag and possession limit of 2 birds each (Gibson *et al*. 2011, p. 310). After 1986 permit numbers were restricted (50-250 annually). It must be noted, however, that despite what appears to be relatively restricted seasons over the time period, for several years hunting mortality may have substantially exceeded the 10 percent currently considered compensatory in sage-grouse (Sedinger *et al*. 2011, p. 325). In contrast to the Long Valley population, hunting appeared to have no effect on sage-grouse in Bodie Hills, California, a nearby population that is contiguous with adjacent occupied areas of Nevada (Gibson 1998, p. 15). These results suggest isolated populations may not be able to withstand hunting mortality levels that would be negligible for populations that are not isolated.

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

Timing

The hunting season start dates currently range from September 1 to October 4 with the majority of States open in mid- to late September (Figure X-1). Montana opens earliest on September 1. All States with hunting seasons have changed limits and season dates to more evenly distribute hunting mortality across the entire population structure of sage-grouse, harvesting birds after females have left their broods (Bohne 2003, p. 5). Females and broods congregate in mesic (wet) areas late in the summer potentially making them more vulnerable to hunting (Connelly *et al*. 2000b, p. 230; Caudill *et al*. 2014, p. 815). However, despite increasingly later hunting seasons, females continue to comprise the majority of the hunting mortality in all years (Service 2015).

Figure X-1-Annual life cycle of sage-grouse. The timing of hunting mortality in relation this life cycle is indicated by the red bar.



Sage-grouse hunting seasons currently range from 2 to 30 days. Daily bag limits range from one to two birds. Possession limits range from one to four birds. Direct hunting mortality occurs in the fall during the late brood rearing, early wintering season (Figure X-1). Indirect impacts (e.g., reduced reproductive potential from female mortality) may be long term.

Location and extent

Comment [acn337]: Add info using maps below… on variation in hunting pressure, hunting occurs closer to urban centers, no or little on private lands, x percent of occupied range is private land, hunting pressures is reduced for all pop under state management,e tc……

In 2014, recreational hunting of greater sage-grouse took place in 8 of the 11 States where sage-grouse occur. States with the largest sage-grouse populations historically and currently have the highest average percentage of hunting mortality (Table 2). From 2010 to 2013, the overwhelming majority (93 percent) of reported hunting mortality occurred in Wyoming, Idaho, Montana, and Nevada (in portions of Management Zones I, II, III, and IV). Hunting is prohibited in Washington (Management Zone VI). Mortality is not distributed uniformly throughout any of the MZs, but is dependent on accessibility of the area given State management designations or private landowner permission. Areas closer to urban centers tend to receive greater hunting pressure than more remote areas.

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

Decade	WY	ID	MT	NV	UT	CO	OR	CA	ND	SD	WA	Total Mortality
1960s	35	23	27*	4	5	2*	3	**	**	**	1	1,514,811
1970s	27	30	19	8	8	5	1	**	**	0.01*	0.44	2,322,581
1980s	40	23	14	6	9	8	0.08	0.08*	0.02	closed	0.18	1,646,610
1990s	28	32	12	10	10	7	1	0.33	0.02	closed	closed	909,674
2000s	36	23	15	15	4	3	3	0.46	0.05	0.05	closed	313,731
2010-2013	44	13	14	21	3	2	3	0.09*	closed	0.04	closed	82,899

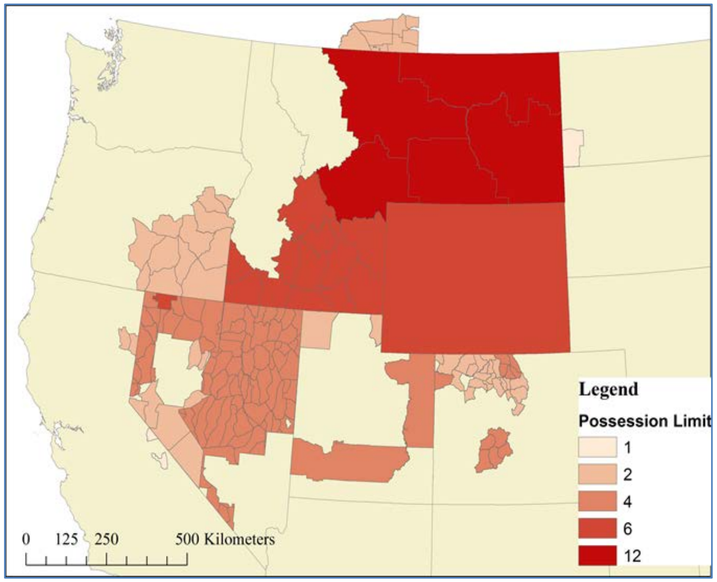
*Limited data available
** No data available

Table 20-3: List of impacts by management zone.

Management Zone	Timing of Impacts (Season)	Immediacy of Impacts	Severity of Impacts	Extent of Impacts	Resource or Life stage impacted	Notes
Example	Spring (or all the time, etc.)	Happening right now (or planned)	Direct mortality (or habitat destruction, etc.)	Impacting X% of occupied range by MZ(see Kevin's models)	Lekking adults, broods	This is an example…
1						
2						

Management Zone	Timing of Impacts (Season)	Immediacy of Impacts	Severity of Impacts	Extent of Impacts	Resource or Life stage impacted	Notes
3						
4						
5						
6						
7						

Placeholder maps (J Dinkins is adding MZ boundaries and current range to maps below, I also asked color palette to be changed to blue or black)


Legend
Possession Limit
1
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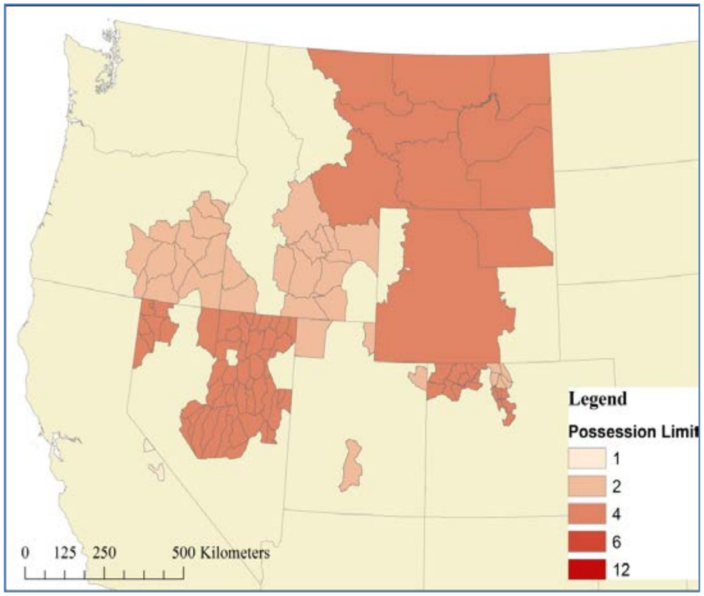
12
0 125 250 500 Kilometers



Possession limits1995

Possession limits 2013

Compounded effects

The compounding effects will be discussed in greater detail in the Compounded Effects chapter. In brief, all threats that result in sage-grouse mortality or decreased habitat quality increase the probability that recreational hunting mortality will be additive. Significant habitat loss, degradation, and fragmentation have occurred during the past several decades, and there is evidence that the sustainability of harvest levels depends to some degree upon the quality and quantity of habitat and the health of the population. Threats that reduce habitat quantity or quality include agricultural conversion, urbanization, wildfire, invasive plants, pinyon-juniper encroachment, overgrazing, energy development and infrastructure, drought, climate change, predation, and disease. These same threats can and do result in direct mortality, which again increases the probability that recreational hunting will be additive.

Projected Future impacts

Timescale for Projecting impacts from Hunting

Sage-grouse hunting is regulated by State wildlife agencies. Hunting seasons are reviewed annually at which time States can adjust harvest management or implement emergency closures based on estimates for spring production and population size or other concerns (e.g., projected wildfire probability, West Nile virus) (e.g., Bohne 2003, pp.1¬10). Because States make adjustments annually, it is difficult to make accurate predictions about specific levels of hunting mortality into the future. In other words, current levels of hunting are only certain for 2 years into the future. However, given the downward trend in hunting mortality reported over the last several decades, we anticipate mortality rates will continue at levels similar to or potentially lower than current levels. For reasons discussed below, we assume that recreational hunting will continue at some level indefinitely.

Likelihood of future impacts

The likelihood of recreational hunting continuing at some level in the future is high. States are unlikely to end sage-grouse hunting for several reasons: 1) States have a long cultural tradition of recreational hunting of sage-grouse, 2) States are confident that current adaptive management strategies are adequate to avoid additive hunting mortality that can result in population level declines in sage-grouse, 3) States recognize the value of population information gained through hunter surveys and wing collection barrels and contend that the information would be more difficult and expensive to obtain by any other methods, 4) License fees provide revenue for State management and conservation of sage-grouse.

Despite strong State support, however, there is a degree of political uncertainty about the continuation of recreational hunting. Currently there is public pressure both to maintain sage-grouse hunting and to completely prohibit sage-grouse hunting (e.g. Christiansen 2010, p. 14; Frost 2010; Brean 2014; Darling 2014; Moore 2014; Smith 2014; South Dakota Game, Fish, and Parks 2014) .

Comment [acn338]: Add more citation about bill introduced in Montan, other states saying they wont, or perhapts add below some crawfor 1982 citations for historical hunting. us interest in consideration of sustainablity.to comments by States. Discuss

Anticipated changes from present

We anticipate that recreational hunting will likely continue at present or potentially reduced levels throughout the range of sage-grouse. States have been responsive to concerns about the status of sage-grouse and the potential impacts of recreational hunting. As knowledge of the potential impacts of recreational hunting has increased, States have adopted more conservative hunting seasons and an adaptive management approach at the population level.

Threat amelioration

Active Conservation

All States with sage-grouse hunting seasons have adopted an adaptive management approach to sage-grouse hunting. This approach incorporates the recommendations, or somewhat modified versions of them, made by Connelly *et al*. (2000a; p. 976) to manage hunting seasons (Budeau 2014, pers. comm.; Christiansen 2014, pers. comm.; Espinosa 2014, pers. comm.;Griffin 2014, pers. comm.; Moser 2014b, pers. comm.; Robinson 2014, pers. comm.;Wightman 2014, pers. comm.). Connelly *et al*. (2000a, p. 976) make the following recommendations for sage-grouse hunting:

1) Hunting seasons should be based on knowledge of population size and trends,
2) Liberal seasons should only occur for populations that are stable or increasing and occur over relatively large geographic areas,
3) If populations are declining (for 3 or more consecutive years) or trends are unknown, seasons and bag limits should be generally conservative or suspended,
4) Hunting mortality should be no more than 10 percent of the estimated fall population size,
5) Populations should not be hunted where less than 300 birds comprise the breeding population (i.e., less than 100 males are counted on leks).

Sage-grouse hunting seasons are set based on population information gathered through leks counts, hunter surveys, and wing collection barrels. Information on population size, trends, and structure along with knowledge of current local habitat conditions is then used to make any adjustments to the hunting season necessary to reduce the potential for additive mortality. Seasonal adjustments take the form of changes to the number of permits issued (in UT, OR, CA, and one site in NV), changes to the season length or bag limit, or total closure of the hunting season.

Actions and Effectiveness

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

In 2014, management actions taken by the States include closures (or permits not offered) in limited portions of California, Colorado, Idaho, Montana, and Oregon because data suggested the populations under consideration were in decline or too small to support a hunting season. That same year, hunting in North and South Dakota remained closed due to continued low lek count numbers. Oregon, California, and Nevada also had limited or closed hunting in targeted areas due to concerns over impacts from wildfire.

Earlier in this decade, States closed or limited hunting in targeted areas for several reasons, including inadequate population information, small or declining population size, ongoing research, and negative impacts from wildfire and drought. Prior to 2010, areas in Idaho, Nevada, and Wyoming were also closed due to impacts from West nile virus which does not appear to be currently as active as in the past (See Disease) (Gossett 2008, pers. comm; Dick 2009, pers. comm.; Moser 2014b, pers.comm.).

The current management strategy employed by the States is more conservative and risk-averse than management approaches taken in past decades. States now recognize the relatively high potential for additive hunting mortality in sage-grouse, a long-lived species with low reproduction, and have responded appropriately. Rangewide, hunting seasons are more conservative than in the past which has resulted in a significant reduction in sage-grouse hunting mortality across all sex and age classes (Service 2014, unpublished data). States have taken an adaptive management approach to sage grouse hunting management and have incorporated the risk adverse recommendations made by Connelly *et al*. (2000a; p. 976). Many States have reported estimated hunting mortality to be lower than the 10 percent mortality cap recommended by Connelly *et al*. (2000a; p. 976) (Christiansen 2010, p. 12; Budeau 2014, pers. comm.). Oregon has an explicit self-imposed policy to keep hunting mortality below 5 percent of the estimated fall through their permitted hunting season, but in reality hunting mortality is estimated to be closer to 2.5 percent (Budeau 2014, pers. comm.). Wyoming estimates that hunting mortality likely has been below 5 percent in recent years, but note this estimate is based on crude population estimates (Christiansen 2010, p.12). Nevada estimates since 2004 hunting mortality has been between 2 and 6 percent of the estimated fall population (Nevada Department of Wildlife 20XX, p. 1)

This adaptive conservative approach undoubtedly has ameliorated the impacts of hunting on sage-grouse. There remains uncertainty, however, because the approach requires States have detailed and specific knowledge of sage-grouse population sizes and dynamics which is notably difficult to obtain for sage-grouse. States adjust hunting seasons largely on estimates for spring production and population size (e.g., Bohne 2003, pp.1¬10). However, hunting mortality 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; Reese and Connelly 2011, p. 110). Instead, lek counts conducted in the spring and production estimates taken from harvest data gathered the previous year are used as the basis for estimating fall population size. 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, female 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.

Threat Amelioration Summary

States have adopted an adaptive management approach that is structured to allow for a timely reduction or cessation of hunting pressure on populations in decline. Adaptive management requires that States maintain detailed knowledge of population size and dynamics. Such information for sage-grouse is difficult to obtain with precision given current knowledge and techniques. To date, changes in the management of sage-grouse hunting have resulted in a significant reduction in sage-grouse hunting mortality rangewide.

Assessment of Potential Threat

Comment [acn339]: Will reword to include info based on Kate’s comments below.

In the United States, sage-grouse hunting is regulated by State wildlife agencies and hunting regulations are re-evaluated annually. Negative impacts on local populations have been demonstrated. Further, uncertainty regarding the impacts of hunting mortality exists because of a lack of experimental evidence and weakly supported and conflicting studies. Significant habitat loss and fragmentation have occurred during the past several decades, and there is evidence that sustainable harvest thresholds could vary with the quality of habitat and 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 hunting mortality will not have an effect on population stability or recovery. In light of present and threatened habitat loss and other considerations (e.g., disease), continued vigilance will be needed by States to carefully manage hunting mortality, including continued adjustment to seasons and allowable harvest levels, and imposing emergency closures if needed.

The best available information indicates that current sage-grouse hunting management will continue, with most States making annual adjustments in harvest levels and seasons. Recreational hunting does not appear to have been a primary cause of rangewide declines of the greater sage-grouse in the recent past. In addition, current levels of recreational hunting likely do not pose a significant threat to the species. asdfasdf

Comment [KNorman340]: Per conversations on 2/26/2015- this should now include the following pieces:

- Quote 2010 conclusion (e.g. "We find that the threat of disease is not significant to the point that the greater sage-grouse warrants listing at this time.")
- What are the impacts at various scales:
  - Individuals
  - Populations
  - Management Zone
  - "Range"
- Regulatory mechanisms may be ameliorating these impacts including x, y z. See cumulative effects and/or regulatory mechanisms chapter for further explanation.
- Based on the new science, we conclude that THIS STRESSOR is affecting the species in X way.

Language

- Avoid the terms "threatened or threatening" as a verb or adverb and "threat" as noun; may consider using:
  - Impact
  - Stressor
  - Negatively affecting
  - Negligible impact (on its own), but could have cumulative impacts

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Chapter 21: Scientific and Educational Purposes-PLACEHOLDER

Disease and Predation

Chapter 22: Disease

Introduction

Greater sage-grouse (*Centrocercus urophasianus*; hereafter “sage-grouse”) have been affected by several diseases including coccidiosis, tularemia, and West Nile virus (WNv; *Flavivirus* spp.). WNv has been found in sage-grouse in 10 states and one Canadian province (Walker and Naugle 2011, p. 133), and currently is the only disease known to cause population-level impacts to the species (Christiansen and Tate 2011, p. 122). The impacts of the disease have been greatest in small, isolated populations (Walker *et al.* 2004, p. 4). Little new information on WNv and its impacts on the greater sage-grouse has emerged since we completed our findings in 2010, and as we concluded then, West Nile virus currently is not a threat to sage-grouse rangewide, although it is likely to continue to occur episodically in the species (USFWS 2010). Owing to the high susceptibility of sage-grouse to the disease and the low projected rate of acquired resistance, WNv is likely to remain a threat to sage-grouse, and especially to small, isolated populations (Naugle *et al.* 2004, p. 705; Walker and Naugle 2011, pp. 139–140), which currently number about 27 (USFWS 2013a, pp. 16–29). Climate change is likely to enhance conditions for mosquito reproduction and virus amplification in the future (Dohm *et al.* 2002, entire; Reisen *et al.* 2006, pp. 312–313; Zou *et al.* 2007, p. 5); if habitat fragmentation and other key threats to sage-grouse continue unabated, they will exacerbate the threat of WNv range-wide (Walker and Naugle 2011, p. 139).

Threat description

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

We only know of one disease, West Nile virus (WNv; *Flavivirus* spp.) that currently causes population-level impacts to the species (Christiansen and Tate 2011, p. 122), albeit on a localized scale.

West Nile virus is a mosquito-borne pathogen that was introduced to the Americas (probably from the Middle East). The disease, which is transmitted principally by mosquitoes, infects multiple systems and tissues, and in sage-grouse results in weakness, loss of balance, difficulty breathing, profuse oral and nasal secretions, and, typically, death in a matter of days (Clark *et al.* 2006, p. 17).

Historical source(s)

In the early-to-mid 20th century, two diseases caused by native parasites had documented, population-level effects on sage-grouse: coccidiosis caused by protozoans in the genus *Eimeria*, and tularemia transmitted by ticks in genus *Haemaphysalis*. We do not consider coccidiosis or tularemia to be current threats to sage-grouse. Both of these diseases have been limited to geographically isolated, localized incidents; moreover, no coccidiosis-related mortality in sage-grouse has been recorded since the early 1960s, and the single outbreak of tularemia occurred in Montana in 1932 (Parker *et al.* 1932, p. 480; Scott 1940, entire; Honess and Post 1968, p. 20; Connelly *et al.* 2004, p. 10-4; Christiansen and Tate, 2011, pp. 119, 120. In 1999, WNv was discovered in humans in New York City (Sejvar 2003, pp. 7–8). The first sage-grouse mortalities from WNv were documented in 2003 (Naugle *et al.* 2004, p. 705).

Current source(s)

West Nile virus spread across North America within five years (from 1999-2004), and is now found in all 48 contiguous states and the District of Columbia in the United States (CDC 2014) and six provinces in Canada (PHAC 2014). Elsewhere in the Americas, WNv also occurs in parts of Mexico, Central America, and the island Caribbean (reviewed in McLean 2006, pp. 51–52). The virus occurs in at least 225 wild and captive bird species in North American (USGS NWHC 2014), and many native North American birds are susceptible (Marra *et al.* 2004, pp. 393–394). In the United States, at least 47,000 avian mortalities caused by WNv had been confirmed by 2005 (McLean 2006, p. 52), but the majority of mortalities likely go undetected or unreported (McLean 2006, p. 55; Ward *et al.* 2006, p. 101). Millions of North American birds likely have succumbed to the disease since 1999 (Marra *et al.* 2004, p. 398).

The WNv strain first identified in New York in 1999, NY99, has mutated extensively and multiple strains now occur in North America (McMullen *et al.* 2011, entire). One strain, WN02, has a shorter incubation period and infects *C. tarsalis* more rapidly and efficiently than NY99 (Moudy *et al.* 2007, p. 367). An infected mosquito is thus able to transmit the disease to more individual host animals (such as sage-grouse) in its lifetime (Moudy *et al.* 2007, p. 369).

WNv currently is the only disease known to cause mortality in sage-grouse that has population-level impacts (Naugle *et al.* 2004, p. 711; Walker *et al.* 2004, p. 4 Walker and Naugle 2011, p. 139). Similar to some other North American bird species (Komar *et al.* 2003, pp. 314–315; McLean 2006, p. 54), sage-grouse are highly susceptible to WNv (Clark *et al.* 2006, p. 18), and outbreaks probably result in mortality rates nearing 100 percent of infected birds (Naugle *et al.* 2004, p. 711; Walker *et al.* 2004, p. 4; McLean 2006, pp. 53–54).

West Nile virus is transmitted among birds mainly through a mosquito-bird-mosquito infection cycle that relies on optimal climate conditions and movement of birds (McLean 2006, p. 52). Sage-grouse have transmitted WNv to each other without an intermediary vector in laboratory conditions as well, however (Cornish 2014, pers. comm). Direct transmission between sage-grouse is likely to occur in the wild, and this has been observed in other species (Komar *et al.* 2003, p. 320; Marra *et al.* 2004, p. 396), but its frequency and importance are unknown (McLean 2006, p. 54–55).

The importance of other species as competent hosts or reservoirs for WNv in sage-grouse habitat remains unknown (Naugle *et al*. 2005, p. 621), and transmission between host species depends on a complex set of variables (Marra *et al.* 2004, pp. 394–396). For example, horses are notably susceptible to WNv, but they are not thought to be a competent reservoir for the disease because they do not sufficiently amplify the virus (Bunning *et al*. 2002, p. 385; but see discussion below about nonviremic transmission and McGee *et al*. 2005, p. 8873). Other bird species that occur in sage-grouse habitat, notably American crows, are competent reservoirs for WNv (Komar *et al*. 2003, p. 320), but transmission between crows and sage-grouse has not been studied. The role of these and other vertebrate reservoirs in WNv prevalence in sage-grouse and the mechanics of WNv transmission between host species and between vertebrates classes in the range of sage-grouse are not known.

Several native mosquito species that carry WNv feed on both birds and mammals and occur in western North America (Marra *et al*. 2004, p. 394). One of these, *Culex tarsalis* is the primary vector of WNv in in sage-grouse, and in western birds generally (Goddard *et al.* 2002, p. 1390; Marra *et al.* 2004, p. 394; Naugle *et al.* 2004, p. 711; Naugle *et al.* 2005, p. 617). Individuals of *C. tarsalis* can disperse as far as 18 km (11.2 mi) (Doherty 2007, p. 17; Walker and Naugle 2011, p. 129 and references therein). This species is capable of overwinter survival and adults can emerge infected with WNv in the spring (Nasci *et al.* 2001, entire; Goddard *et al.* 2003, p. 745; Reisen *et al.* 2006a, entire; Doherty 2007, pp. 19–20) as well as transmit the virus between females and their offspring (Goddard *et al* 2003, p. 744), thereby abbreviating the disease cycle (Miller 2009, pers. comm.).

Environmental variables such as ambient temperature and availability of surface water where *C. tarsalis* breeds are important components of the WNv transmission cycle in sage-grouse (Walker and Naugle 2011, p. 129). These variables influence seasonal, inter-annual, and spatial patterns in WNv occurrence in the species (Walker and Naugle 2011, p. 131). The positive correlation between ambient temperature, mosquito reproduction, and the replication of WNv and similar viruses is well documented (Dohm *et al.* 2002, entire; Reisen *et al* 2006b, entire). Low ambient temperature inhibits mosquito activity and virus replication (Naugle *et al.* 2005, p. 621; Reisen *et al.* 2006b, p. 313), thus limiting potential transmission to and among sage-grouse to summer months (mid-May to mid-September), when the warmest temperatures support both rapid development of mosquito larvae and rapid replication of the virus in mosquitoes (Dohm *et al.* 2002, entire; Ciota *et al.* 2014, pp. 56–57). West Nile virus detections and mortalities in sage-grouse typically peak along with temperature in July and August (Walker *et al.* 2004, p. 5; Naugle *et al.* 2005, p. 620; Walker *et al.* 2007b, p. 693). Reduced and delayed WNv transmission in sage-grouse has occurred in years with lower than average summer temperatures (Naugle *et al.* 2005, pp. 620–621; Walker *et al.* 2007b, pp. 694-695).

Similarly, because summer temperatures tend to decrease with increasing elevation, mosquito abundance, including that of *C. tarsalis*, also decreases with increasing elevation (Barker *et al.* 2009, p. 288–289). Sage-grouse are not known to have been infected with WNv at elevations higher than approximately 2,300 meters (7,546 feet) above sea level (Walker and Naugle 2011, p. 130); birds using summer habitat at elevations inhospitable to mosquitoes are less likely to contract WNv than birds downslope (Walker and Naugle 2011, p. 131). The sage-grouse populations in northwestern Colorado and western Wyoming, for example, may currently face relatively low risk of exposure to WNv owing to their occurrence at high elevations (Walker and Naugle 2011, p. 140).

Dry summers are typical across the range of sage-grouse (Miller *et al.* 2011, pp. 172–173). As the grass-forb understory of the shrub-steppe dries, the birds move from sagebrush to mesic habitats that continue to produce succulent forbs and abundant insects during mid and late summer (Schroeder *et al.* 1999, p. 6; Connelly *et al.* 2000, p. 971 and references therein), thereby increasing the likelihood of the birds' exposure to *C. tarsalis*, which uses such habitats for breeding (Doherty 2007, pp. 15–16).

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

Current impacts

Mechanism

Sage-grouse infected with WNv are affected rapidly and are likely to die in as few as six days, but nevertheless are competent hosts for the disease and can infect others before they die (Clark *et al.* 2006, p. 18). Mortality is not inevitable: a very small proportion of infected birds survive, as evidenced by the presence of WNv-specific antibodies in live birds (Walker *et al.* 2007b; Dusek *et al.* 2014; but see Clark *et al.* 2006, p. 17). In addition, resistance to the disease apparently is present in sage-grouse albeit at an extremely low rate (Clark *et al.* 2006, p. 17). Overall, however, rates of WNv infection and the occurrence of outbreaks in sage-grouse are likely to be governed by climate and other conditions that limit mosquito reproduction and virus replication rather than by increasing disease resistance in the birds (Walker *et al.* 2007b, p. 694; Zou *et al.* 2007, p. 417; Walker and Naugle 2011, p. 139).

West Nile virus-specific antibodies in live sage-grouse have been found at very low rates in samples from northeastern Wyoming (Walker *et al.* 2007b, p.693–694), Montana, South Dakota, and Alberta (Cornish 2009 pers. comm.), and southeastern Oregon (Dusek *et al.* 2014, pp. 4–5). The presence of antibodies likely indicates that a bird has survived infection, but antibodies may also be heritable (Walker *et al.* 2007b, p. 694). Because the mortality rate in experimentally infected birds has been very high and most birds die (Clark *et al.* 2006, pp. 17–18), the presence of WNv-specific antibodies in live birds likely underrepresents the rate of infection (Walker *et al.* 2007b, p. 694). Indeed, the very low proportion of WNv antibodies found in blood sample from thousands of free-living sage-grouse suggests that the survival rate among infected birds in the wild is extremely low (Walker *et al.* 2007b, p. 694; Dusek *et al.* 2014, p. 6). Based on this information, the rate of increasing resistance to WNv in sage-grouse is likely to be very low (projected over a 20-year period; Walker and Naugle 2011, pp. 137–139).

The duration of immunity in birds that survive WNv infection is unknown (Marra *et al.* 2004, p. 397), as is the rate of sub-lethal or residual effects in sage-grouse. Birds of some other species that survive WNv infection were found to suffer from chronic symptoms, including reduced mobility, weakness, disorientation, and lack of vigilance (Marra *et al.* 2004, p. 397; Nemeth *et al.* 2006, p. 254), all of which can affect survival, reproduction, or both (Walker and Naugle 2011, p. 136). Sage-grouse that survive WNv infection may thus experience low survival subsequently, but reduced productivity or overwinter survival resulting from WNv have not been documented (Walker *et al.* 2007b, p. 694).

Results of impact

West Nile virus causes mortality in infected sage-grouse and can have wider impacts when multiple birds are infected and outbreaks occur. Mortality in adult sage-grouse in late summer is typically low, therefore mortality pulses caused by WNv during this season (WNv is most prevalent in late summer) are unusual (Naugle *et al.* 2004, p. 711; Walker *et al.* 2004, p. 3; Naugle *et al.* 2005, p. 620). High mortality rates from WNv deaths thus are additive and can reduce average annual adult survival, a limiting factor in sage-grouse population growth (Johnson and Braun 1999, p. 81; Taylor *et al.* 2012, p. 343). For example, survival in several populations in Alberta, eastern Montana, and northeast Wyoming declined 25 percent in July and August of 2003 as a result of WNv infection (Naugle *et al.* 2004, p. 711). Population-level impacts also can result from WNv mortality in juvenile sage-grouse by decreasing recruitment of young birds into the breeding population the following year (Kaczor 2008, p. 65; Taylor *et al.* 2012, p. 343). This occurred in South Dakota, where mortality rates among radio-marked juvenile sage-grouse attributed to WNv ranged between 6.5 and 71 percent in 2006 (Kaczor 2008, p. 63) and between 20.8 and 62.5 percent in 2007 (Kaczor 2008, p. 63), reducing recruitment the subsequent spring by 2 to 4 percent (Kaczor 2008, p. 65).

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

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

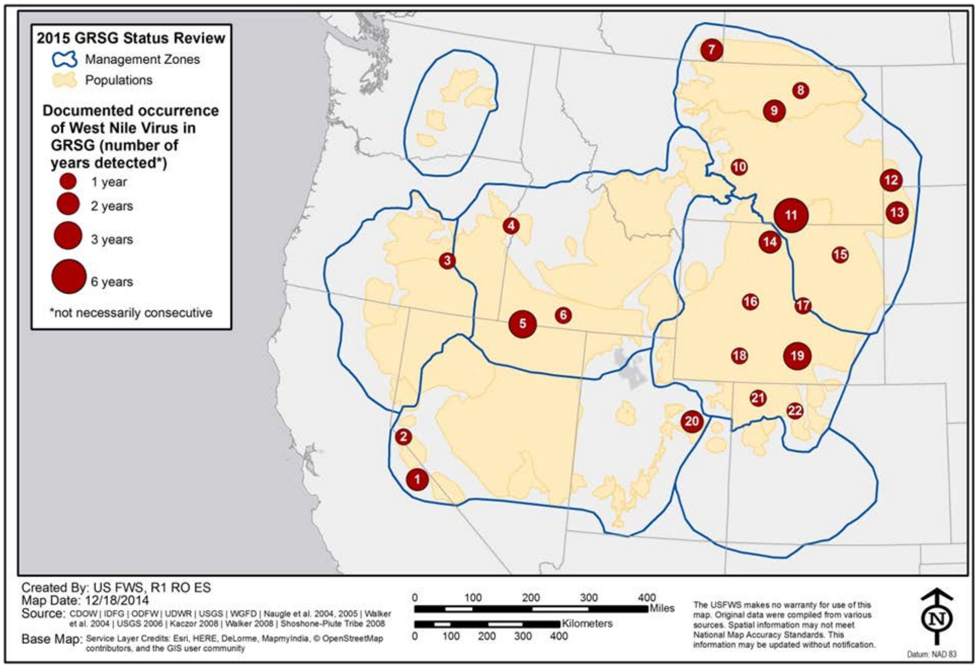


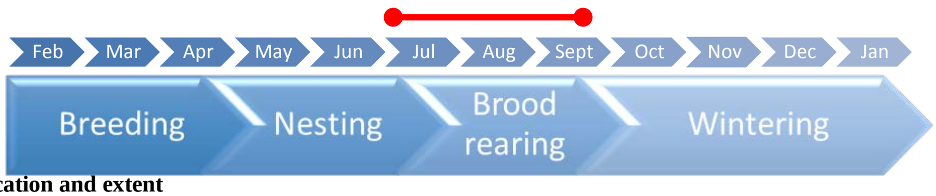
Figure X-1. Distribution incidence of West Nile virus in sage-grouse (confirmed by WNv-positive carcasses, 2003-2012).

Numbered locations are as follows: (1) Mono Co., CA; (2) Douglas Co., NV; (3) Harney Co., OR; (4) Washington Co., ID; (5) Owyhee Co., ID and Duck Valley IR, ID and NV; (6) Twin Falls Co., ID; (7) SE Alberta; (8) Valley Co., MT; (9) Phillips Co., MT; (10) Golden Valley Co., MT; (11) Big Horn Co., MT and Sheridan Co., WY; (12) Bowman Co., ND; (13) Harding Co. and Butte Co., SD; (14) Big Horn Co., WY; (15) Campbell Co., WY: (16) Fremont Co., WY; (17) Natrona Co., WY; (18) Sweetwater Co., WY; (19) Carbon Co., WY; (20) Duchesne Co., UT; (21) Moffat Co., CO; (22) Routt Co., CO. Data from Naugle *et al.* 2004, Walker *et al*. 2004, Naugle *et al*. 2005; Walker *et al*. 2007b; USGS 2006, Dick 2008, Kaczor 2008, Walker 2008, Moser 2009 pers comm., Swanson 2009, Walker and Naugle 2011, WGFD 2013.

Timing

Comment [hf341]: This is addressed above - this topic is difficult to separate from discussion of "Source."

Figure X-2. Annual life cycle of sage-grouse. The peak period of West Nile virus transmission (and likely seasonality of outbreaks) in relation to this cycle is indicated by the red bar.



Location and extent

Specific climatic and habitat conditions are necessary for WNv to occur in sage-grouse. Although WNv is present throughout the range of sage-grouse, on a finer scale the presence of natural and artificial water sources that provide aquatic breeding habitat for *C. tarsalis* influence WNv distribution in the range of sage-grouse (Zou *et al*. 2006, p. 1035; Dohery 2007, pp. 60–61). In addition, local, seasonal, and inter-annual variation in prevalence and transmission of WNv are mediated by abiotic factors such as temperature and precipitation, as described above. Information characterizing WNv occurrence in sage-grouse is not uniform across the species' range. No rangewide WNv surveillance program exists, and dedicated studies have been few (e.g., Naugle *et al.* 2005, entire; Walker *et al.* 2007b, entire; Dusek *et al.* 2014, entire); detailed documentation of WNv in sage-grouse comes principally from sites (distributed in Alberta, Montana, Wyoming, Colorado, California, and Washington; Naugle *et al.* 2005, p. 16) where radio-tracking studies and chance have yielded carcasses fresh enough for testing, and from the studies cited above. In some cases, WNv mortality rates have been associated with decreased survival probability and estimated declines in annual survival at the population level (e.g., based on telemetry studies; Connelly *et al.* 2004, p. 10-9; Naugle *et al.* 2004, p. 711; Kaczor 2008, pp. 62–63, 65). In other cases, decreases in lek attendance have been ascribed to WNv impacts (e.g., in northeastern Wyoming; Walker *et al.* 2004, p. 4). In some instances, mortality events of unmarked birds have been discovered (e.g., in Oregon, Idaho, Nevada, Colorado, Montana/Wyoming, and the Dakotas in 2006; USGS 2006), and individual carcasses of have tested positive for WNv, but no further inferences about infections rates or mortalities can be made. The presence of WNv antibodies in small numbers of live birds in the eastern portion of the range and in southeastern Oregon (described above) indicate only that WNv has occurred in those locations, but again provides no information about infection rates, mortality rates, or when infections took place (Walker *et al.* 2007b, p. 694). In sum, many WNv-related mortalities in sage-grouse likely go undocumented, as is thought to be the case generally with respect to the disease in birds, and our knowledge of the locations and extent of WNv occurrence in sage-grouse, described below, is probably incomplete.

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

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

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

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

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

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

West Nile virus was first detected in 2003 as a cause of greater sage-grouse mortalities in Wyoming (Naugle *et al.* 2004, p. 705). Between 2004 and 2009, annual sage-grouse mortalities confirmed as cases of WNv have been localized and patchily distributed across the range and among years (Fig. 1, Table 1). Some of these confirmed cases have been associated with significant mortality events; for detailed descriptions, see our 2010 findings [USFWS 2010, pp. 57–58] and Walker and Naugle 2011, pp. 133–135). Based on available information, no sage-grouse mortality caused by WNv occurred anywhere throughout the species' range in 2010–

2013, with the exception of two confirmed cases in Wyoming in 2012 (Colorado Parks and Wildlife 2013; Idaho Department of Fish and Game 2013; Montana Fish, Wildlife and Parks 2013; Nevada Division of Wildlife 2012; North Dakota Game and Fish 2013; Oregon Department of Fish and Wildlife 2013; South Dakota Fish, Wildlife and Parks 2013; USFWS 2013a, p. 80; USFWS 2013b, pp. 79–81; Utah Division of Wildlife Resources 2013; Washington Department of Fish and Wildlife 2012, 2013; Wyoming Game and Fish Department 2013). The two confirmed cases of WNv in Wyoming in 2012 were found in Carbon County and Big Horn County (Wyoming Game and Fish Department 2013). While record-breaking high temperatures were favorable for WNv replication and outbreak, the concurrent record-breaking lack of precipitation (NOAA 2012) likely inhibited the life cycle of *C. tarsalis*. However, we caution again that no rangewide disease surveillance program exists, and the distribution of documented WNv mortalities in sage-grouse may better reflect monitoring than disease incidence.

Compounded effects

The incidence of WNv in sage-grouse and its impacts to the species can be exacerbated by other threats across the range, including aspects of habitat loss and degradation, sources of direct mortality, and climate change. Climate change has the potential to increase the incidence and distribution of WNv in the range of sage-grouse; this is discussed below in Projected Future Impacts. Human activities can affect the availability and distribution of mosquito breeding habitat, a key limiting factor in the WNv transmission cycle (Zou *et al.* 2006, p. 1035). Anthropogenic water sources, such as ponds and ditches filled by irrigated agriculture, stock tanks and ponds, and discharge ponds from coal-bed natural gas extraction, provide mosquito habitat that would not otherwise exist in the arid sagebrush-steppe habitat that comprises most of the range of sage-grouse (Naugle *et al.* 2004, p. 711; Doherty 2007, pp. 36–37; Zou *et al.* 2006, p. 1039). This expansion of persistent surface water and mosquito breeding habitat can facilitate WNv persistence and its spread across the landscape (Friend *et al.*, 2001, p. 298; Zou *et al.* 2006, p.1040; Walker and Naugle 2011, p. 139). The growing number of discharge ponds associated with coal-bed natural gas development is a particular problem; this artificial source of surface water increased potential mosquito habitats in the Powder River Basin of Wyoming and Montana by 75 percent (619 hectares (ha) to 1084.5 ha; 1259 acres (ac) to 2680 ac) between 1999 and 2005 (Zou *et al.* 2006, p. 1034; Walker *et al.* 2007a, p. 2645). Coal-bed natural gas development is ongoing; the proliferation of discharge ponds contributes to maintaining, and possibly increasing, WNv occurrence in Wyoming and Montana (Zou *et al.* 2006, p. 1040). However, growing industry awareness of WNv concerns has prompted the implementation of practices to minimize mosquito presence through pond design and the use of mosquito larvicide in discharge ponds on a relatively modest scale in some areas, notably in Wyoming (Big Horn Environmental 2011, p. 3; Chesapeake Energy Corporation 2014, p. 2-6).

Diseases that have only density-dependent, regulatory effects on highly connected populations of abundant species can cause the extirpation of small, isolated populations that do not have the numbers or resilience to rebuild themselves following a mortality event (Peterson 2004, p. 38 and references therein). Isolated, small, and/or genetically depauperate populations of sage-grouse, such as those at the periphery of the species' range or that result from habitat fragmentation likely face the greatest risk from WNv (Walker and Naugle 2011, p. 140). More than 25 such populations are identified (USFWS 2013a, pp. 16–29; "Small Populations" chapter in this report). For example, the Columbia Basin populations in Washington State may be at high risk of extirpation by WNv because a disease outbreak that has population-level impacts can exacerbate the impacts of other threats and stressors, such as demographic stochasticity and inbreeding depression (Naugle *et al.* 2004, p. 711; Christiansen and Tate 2011, pp. 125–126). Conversely, larger populations, such as those in the center of the species' range, probably are better able to sustain and recover from WNv outbreaks simply owing to their size and connectivity (Walker and Naugle 2011, p. 140). However, if human impacts to sage-grouse habitat increase in these areas, and connectivity within or among populations is reduced, sage-grouse strongholds (e.g., in southwestern Wyoming and the northern Great Basin) will become fragmented into small, isolated populations that are more vulnerable to extirpation (Knick and Hanser 2011, pp. 404–405).

Mortality from WNv combined with other anthropogenic sources of direct mortality of sage-grouse can raise mortality to levels that result in local, population-level impacts. Recreational hunting, or predation by synanthropic predators, can have localized, population-level impacts when combined with other sources of anthropogenic mortality such as WNv (Stiver *et al.* 2006, p. 2-13; also see Hunting chaper, this report, for a detailed discussion). For example, in 2006 and 2007, sage-grouse mortality to WNv in South Dakota was estimated to be between 21 and 63 percent of the monitored population (Kaczor 2008, p.72), compounded by mortality from hunting when regulations were not adjusted accordingly in those years (see Hunting chapter).

Projected Future impacts

Timescale for projecting this threat

We consider a reasonable period for evaluating the impacts of WNv on sage-grouse to be XX years from the present. Currently available future projections of WNv impacts to sage-grouse use a 20-year timeframe and project effects out to the year 2030 (Schrag *et al.* 2010, p. 5; Walker and Naugle 2011, pp. 136–140). This limited timeframe was not chosen based on measures of certainty associated with the results of model outputs, but rather in order to encompass a meaningful period for implementing and adapting management actions (Schrag *et al*. 2010, p. 5). Therefore, given fairly well-understood relationships between ambient temperature, mosquito reproduction, and virus replication and transmission potential (Reisen *et al.* 1995, p. 311; Dohm *et al.* 2002, p. 222; Zou *et al.* 2007, p. 5; Ciota *et al.* 2014, p. 59), and the relative certainty attached to future increase in ambient temperature across the range of sage-grouse over a period beyond 20 years from the present (CITE – MACA and USGS data, other climate models and/or refer to Chapter X, Climate Change), we have elected to extend our assessment XX years farther into the future, with the caveat that this evaluation is broad and qualitative.

Comment [hf342]: Depends on climate change projections and how those shake out.

Likelihood of future impacts

Comment [hf343]: I think this section and the next one should be combined under one heading reather than trying to surgically separate likelihood of future impacts from the mechanisms and possible patterns of future impacts. These concepts are closely interrelated and separating them is counter-intuitive...I haven't done a good job of it here, and there redundancies between this section and the next.

WNv will remain present in sage-grouse habitat and will continue to affect the species because sage-grouse are highly susceptible to WNv, the capacity for the species to develop resistance is thought to be very low (Walker *et al*. 2007b, p.694; Walker and Naugle 2011, p. 139), and options for controlling mosquitoes on a landscape-scale are limited. Characterizing population-level effects of WNv-related mortality (such as changes in population growth-rates) in sage-grouse in the future is complicated by vital rates that vary widely among populations, such as nest success and juvenile survival (Walker and Naugle 2011, pp. 137–140). However, population modeling experiments using a 20-year timeframe suggest that chronic WNv mortality will lead cumulatively to a decrease in population growth rates and only slight increases in the rate of resistance to the disease throughout the sage-grouse's range (Walker and Naugle 2011, pp. 136–139).

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

Owing to the conjunction of localized circumstances (climate conditions, presence of mosquitoes and the virus, and sage-grouse distribution) necessary to generate an outbreak of WNv in sage-grouse, the impacts of these landscape-scale variables on WNv occurrence in the species are currently limited to one or several individual populations in a given year (Fig. 1). However, if climate and other conditions across the range become more conducive to the reproduction of mosquitoes and amplification of the virus, including at elevations higher than these conditions occur today, and sage-grouse populations continue to decline and more populations become small and isolated, the likelihood of outbreaks affecting population vital rates on a local and, ultimately, regional scale will incerase (Schrag *et al.* 2011, pp. 11–12; Walker and Naugle 2011, p. 140). Thus the cumulative effects of this disease on sage-grouse will likely be greater in the future than they have been to date if other threats continue unabated.

Climate change could also result in increased incidence of other diseases that are rare or absent in sage-grouse today (Christiansen and Tate 2011, p. 126). In the early and mid-20th century, when the abundance and density of sage-grouse were much higher than they are today, sage-grouse mortalities from bacterial and coccidial infections were documented when large groups of sage-grouse congregated, for example in limited mesic habitats (Honess and Post 1968, pp. 6, 8–9). If these habitats become restricted by habitat loss and degradation or climate change, these easily transmissible diseases may become more prevalent.

Anticipated changes from present

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

The ongoing proliferation of artificial surface water (and mosquito breeding habitat) in otherwise arid sagebrush-steppe can facilitate the spread of WNv in the range of sage-grouse (Schrag *et al.* 2010, p. 13; Walker and Naugle 2011, p. 132). Small, persistent water sources such as discharge ponds from coal-bed natural gas development, watering infrastructure for livestock, and irrigated agriculture often harbor vegetation conducive to mosquito breeding (Zou *et al.* 2006; Doherty 2007, pp. 60–61, 80–81). Such artificial water sources, notably discharge ponds, have increased significantly in the range of sage-grouse in recent years, resulting in a concomitant increase in persistent breeding habitat for *C. tarsalis* (see for example Doherty 2007, pp. 58–59). As energy development and agricultural conversion continue to expand, artificial surface water and the potential for WNv occurrence will expand as well.

Climate change is projected to affect seasonal and geographic patterns in temperature and precipitation across the range of sage-grouse (see Climate Change chapter in this report). In general, ambient temperature is projected to increase (Abatzoglou and Kolden 2011, p. 474; IPCC 2013, pp. 5–6, 20). Because both mosquito reproduction and WNv replication are enhanced by increasing temperature (Dohm *et al.* 2002, entire), rangewide increase in temperature likely will result in:

1) increased summer temperatures that improve breeding conditions for *C. lateralis* and replication conditions for WNv (Reisen *et al*. 2006, pp. 312–313; Zou *et al.* 2007, p. 5);
2) a longer mosquito and disease-transmission season that begins earlier in the year (Schrag *et al.* 2010, p. 8); and
3) conditions favorable for mosquitoes and WNv transmission in high elevation habitats that currently act as refugia from WNv for sage-grouse (Schrag *et al.* 2010, p. 10).

The effects of temperature on disease incidence are complicated by variables such as precipitation and distribution of suitable breeding habitat for *C. lateralis* (Brust 1991, entire; Dohm *et al.* 2002, p. 223). Like ambient temperature, precipitation across the range of sage-grouse also will be affected by global climate change, but changes in the distribution, timing, and amount of precipitation are projected to be more variable (CITE maps/data from MACA and USGS). The distribution of natural breeding habitat for mosquitoes is likely to be altered by rangewide changes in precipitation patterns**.** In areas where climate change is likely to result in decreased precipitation, such as [[– CITE climate-change maps]], the distribution and areal extent of natural surface water are likely to decrease as well. This scenario would reduce the availability of breeding habitat for mosquitoes. However, chronic drought would also result in the shrinking or disappearance of natural mesic habitats on which sage-grouse hens and broods rely in mid-to-late summer (Connelly *et al.* 2000a, p. 971), thus increasing concentrations of birds at fewer water sources (Connelly *et al.* 2004, p. 10-10)). These circumstances are documented to improve conditions for transmission of other parasite-borne diseases as well, including coccidiosis, which is known to have affected dense congregations of sage-grouse in the early-to-mid 20th century (Honess and Post 1968, entire; Thorne *et al*. 1982, pp. 108, 112). Such conditions also favor bacterial and fungal infections that are potentially serious but that have only rarely been documented in sage-grouse to date (such as *Clostridium perfringens, Salmonella* spp., *Mycoplasma* spp., *Mycobacterium avium* (avian tuberculosis), *Pasteurella multocida* (avian cholera), and *Aspergillus fumigatus*; Christensen and Tate 2011, pp. 123–124). The incidence of some or all of these infections could increase under conditions of climate change (Christiansen and Tate 2011, pp. 119, 126).

The synergistic interactions of increasing temperature, changing precipitation patterns, and other threats to sage-grouse (e.g., continued increase in artificial surface water; habitat fragmentation and associated synanthropic predation) are certain to be complex and vary unpredictably across the sage-grouse range. Disease surveillance and further study of infectious diseases, particularly WNv, in sage-grouse is warranted (Connelly *et al*. 2004, p. 10-3; Christiansen and Tate 2011, p. 126). We cannot project in detail the outcomes of these interactions for individual sage-grouse management zones or populations, or assess with certainty the degree or extent to which they will affect the future occurrence of WNv and other infectious diseases in the species as a whole**.**

Threat amelioration

Active Conservation

Recommendations for reducing the risk of WNv to sage-grouse across the range principally involve conservation of large populations at elevations currently higher than mosquitoes and WNv can survive and reproduce (Walker and Naugle 2011, p. 140), and controlling mosquitos and their breeding habitat (Walker and Naugle 2011, pp. 140–141). For example, water produced during coal-bed natural gas development could be re-injected rather than discharged to surface ponds; these ponds and other anthropogenic surface water such as stock tanks and guzzlers can be constructed or managed to reduce their suitability as mosquito breeding habitat (Doherty 2007, pp. 81–84). Water sources known to host breeding *C. tarsalis* can be stocked with *Gambusia* spp. or other fish that feed on mosquito larvae (Doherty 2007, p. 85) or treated with widely used mosquito larvicide (e.g., *Bacillus thuringiensis* v. *israelensis*), which is known to be highly effective in controlling larvae of *Culex* and other mosquitoes (Russell *et al.* 2003, pp. 1788–1789; Doherty 2007, p. 84; reviewed in Lacey 2007, entire) and has been applied experimentally in the Powder River Basin in Wyoming to control *C. tarsalis* (Big Horn Environmental 2009, pp. 4–8; Big Horn Environmental 2011, pp. 22–24; see below). The extent to which irrigated agriculture contributes to mosquito breeding habitat and WNv risk to sage-grouse is not well known (Stiver *et al.* 2006, p. 9-12). In areas where agriculture is deemed to be an important contribution to mosquito breeding habitat, this could be mitigated by employing sprinklers instead of flooding systems and controlling water overflow and persistence in ditches and other depressions (Davis 2014 pers comm.). All of these measures would require monitoring to ascertain their effectiveness. The benefits of widespread pesticide spraying for control of adult mosquitoes must be weighed against the potential adverse impacts to other species (Marra *et al.* 2004, p. 401; Walker and Naugle 2011, p. 141). Evaluation of disease impacts can be incorporated into permitting and other regulatory compliance associated with energy development, agriculture, livestock grazing, and other land uses that influence the prevalence of WNv (Marra *et al*. 2004, p. 401). Finally, intensive monitoring is necessary to shed light on long-term, population-level impacts of WNv (Walker and Naugle 2011, p.140), and centralized database housing the results of monitoring and research would improve rangewide information-sharing about WNv incidence (Stiver *et al.* 2006, p. 9-21).

Actions and Effectiveness

Surveillance, including intensive monitoring using radio-marked birds, is necessary to ascertain the occurrence of WNv in sage-grouse rangewide and its impact on individual populations (Walker *et al.* 2007b, p. 692; Walker and Naugle 2011, p. 140), but limited resources have rendered such efforts patchy and intermittent. Proactive measures to reduce the impact of WNv on greater sage-grouse have been limited and are typically economically prohibitive to implement on a landscape scale. To date, management or conservation actions have not been implemented at a scale that would reduce disease incidence or the risk of disease rangewide. Experimental treatments of ponds with mosquito larvicide resulted in greatly reduced numbers of *C. tarsalis* larvae (Big Horn Environmental Consultants 2009, pp. 5–7; Big Horn Environmental Consultants 2011, p. 23) and thus are promising, but no statistical analyses or feasibility assessment of broad-scale implementation are available. Similarly, in 2014 Chesapeake Energy Corporation instituted a program to test and treat standing water created by oil and gas development within the Douglas Core Area in eastern Wyoming, and to aid landowners within a 3-mile radius of leks in this area to do the same (Chesapeake Energy Corporation 2014, p. 2-6).

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

Threat Amelioration Summary

Little specific action has been taken rangewide to ameliorate the threat of WNv to sage-grouse.

Assessment of Potential Threat

With the exception of WNv, we could find no evidence that disease poses a threat to sage-grouse across the species' range. Although greater sage-grouse are host to a wide variety of diseases and parasites, only WNv has resulted in recent, recurrent population-level effects. Variable environmental conditions such as climate change and anthropogenic alteration of sage-grouse habitat are likely to cause changes in the incidence of WNv and perhaps in other of the numerous parasites and pathogens that occur in sage-grouse and in their effects on individual birds or populations. Sub-lethal effects of these diseases and parasitic infections on sage-grouse have never been studied, and, therefore, are unknown. The lack of information about recent incidence or adverse effects of most sage-grouse parasites prevents us from predicting with any confidence what conditions might give rise to changes in their occurrence. Therefore, although we do not currently consider the majority of sage-grouse parasites to be threats to the species, we cannot evaluate their potential to become significant threats within the timeframe of our analysis.

Sage-grouse are highly susceptible to WNv, rates of resistance are very low, and the virus is distributed throughout the species' range. These conditions are unlikely to change in the next several decades. When outbreaks occur, the affected sage-grouse populations experience high rates of mortality that can result in reduction in survival and recruitment rates; these impacts are especially significant for small, isolated populations (which currently number more than 25). The incidence of WNv in northeastern Wyoming, southeastern Montana, and the Dakotas seems to be the most persistent, with mortalities recorded in that region every year between 2003 and 2009, but these areas also have been the sites of the most consistent study and monitoring of the disease in sage-grouse. Without a comprehensive surveillance program to monitor the re-emergence and spread of WNv, the extent and effects of this disease on greater sage-grouse range-wide cannot be assessed. The low number of confirmed mortalities in the past several years may reflect climate conditions that have not favored mosquito reproduction and virus transmission, the lack of a rangewide surveillance program, or both.

The incidence of WNv is likely to increase across the species' range in the future. The most significant factors likely to affect future occurrence are climate change and the abundance and the distribution of anthropogenic surface water. Increase in ambient temperature likely will exacerbate the incidence of WNv and its impacts on greater sage-grouse by potentially lengthening the transmission season and increasing the elevation at which virus and *C. tarsalis*, its mosquito vector, can survive and reproduce. Increases in anthropogenic surface water will increase the availability of breeding habitat for mosquitoes in arid environments where such habitat is not common naturally. The influence of these environmental factors (and, possibly, changes in the virulence of WNv through evolution) on WNv incidence, and on the risk of disease outbreak, is likely to outstrip the very slow projected development of genetic resistance to the disease in sage-grouse.

WNv currently is a localized threat that has had significant impacts on small, isolated sage-grouse populations. The effects of an outbreak can be locally exacerbated by other anthropogenic sources of mortality. Currently, about 27 sage-grouse populations are thought to be small and isolated; most of these occur on the periphery of the species' range. Ongoing habitat loss that results in continued fragmentation and isolation of populations has the potential to multiply these local effects of WNv across the species' range. In contrast, as long as source populations in areas surrounding a WNv outbreak are intact, suitable habitat that supports sage-grouse would likely be reoccupied.

In sum, factors exist that are likely to increase habitat suitability for the disease and its vector on a landscape scale, and others exist that decrease the resilience of individual sage-grouse populations and their capacity to recovery from disease outbreaks. These mechanisms, in combination, have the potential to magnify the impacts of WNv across the range of sage-grouse in the future. However, based on the suite of biotic and abiotic conditions necessary for an outbreak to occur, and the history of mainly localized WNv incidence in sage-grouse, the likelihood of synchronous, rangewide, population-level impacts is low within the timeframe of our analysis.

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Chapter 23: Predation-(LARA DRIZD)

Introduction

Greater sage-grouse have evolved among a suite of avian and mammalian predators (Schroeder et al. 1999, p. 10; Coates et al. 2008, p. 69; Coates and Delehanty 2008, p. 635; Hagen 2011, p. 96). With exception for a few areas of Wyoming and Nevada and several other locations, predation is not currently believed to be a widespread factor limiting sage-grouse population growth (Connelly et al. 2000b, p. 975; Connelly et al. 2004, p. 10-1). However, the effects of predation can be compounded by threats that cause habitat fragmentation, changes to the vegetative communities, or artificially inflate predator populations; thus, have the potential to increase the incidences of sage-grouse mortality due to predation. The relatively high levels of predation observed in some areas are thought to be caused by an overall increase in predator species (Coates and Delehanty 2010, p. 246; Coates et al. 2014, p. 350) and an increase in predator effectiveness in poor quality habitat, particularly as altered by fragmentation (Burger et al. 1994, p. 252; Braun 1998, p. 6; Connelly et al. 2004, p. 7-23) and loss of cover (Gregg et al. 1994, p. 164; Ritchie et al. 1994, p. 128; Braun 1995, pp. 1–2; DeLong et al. 1995, p. 90; Coggins 1998, p. 30; Connelly et al. 2000a, p. 975; Schroeder and Baydack 2001, p. 25; Coates et al. 2008, p. 636; Wing 2014, p. 21).

Trash, landfills, and road-kill have the potential to subsidize predators by providing additional food resources (Kristan III et al. 2004, p. 250). Furthermore, anthropogenic structures in the environment including oil and gas infrastructure, residential houses, communication towers, powerlines, fences, and trees provide perching and nesting habitat for avian predators, especially raptors and ravens (*Corvus corvax*) (Braun 1998, pp. 145–146; Coates 2007, p. 155; Bui 2009, p. 2; Dinkins et al. 2012, p. 320; Coates et al. 2014, p. 352). Because of these changes in the environment, the abundance of red foxes (*Vulpes vulpes*), raccoons, and corvids, which historically were rare in the sagebrush landscape, has increased in association with human-altered landscapes (Sovada et al. 1995, p. 5; Luginbuhl et al. 2001, p. 570).

Comment [JD344]: I am not finding these introduction sections helpful (nothing against this one in particular). I would suggest getting rid of them for all chapters. They are really summaries – which are more suited for the end of the chapter than the beginning.

Alternatively, rename these sections: "Abstract" or "Executive Summary"

Comment [DMD345]: Such as?

Comment [JD346]: I think we should be explicit here regarding what areas/populations we are talking about. If it is only a few we should list them.

Comment [LD347]: I don't think we have enough current information to be very specific. There is some evidence of low nest success and other indicators but information is generally lacking. I edited the Location and Extent section to be more specific on this topic.

Comment [DP348]: and provide the citations

Comment [JD349]: Do we really mean an increase in the richness of predators? If not, just say "the number of predators."

Comment [LD350]: I meant both species richness and abundance, though I thought it best to avoid going into so much detail in the first paragraph.

Comment [LD351]: It is primarily (or most-researched to be) nesting habitat, but not exclusively. I removed the word nesting since I don't think it's necessary to be so specific here anyway.

Comment [DMD352]: Scientific name?

Comment [LD353]: I will let you guys work out issues like these in the final version. I have a feeling ravens will be mentioned more than once throughout the document.

Comment [DMD354]: Scientific names?

Comment [LD355]: Rejected change of *has* to *have*. In my mind, it's that the abundance *has* increased, rather than the foxes *have* increased.

Maintaining large areas of intact sagebrush is widely recognized as being critical to ensuring the long-term viability of sage-grouse populations (Aldridge et al. 2008, p. 990-92; Connelly et al. 2011b, p. 560; Taylor et al. 2012, p. 344). The impacts of predation on sage-grouse can increase where habitat quality has been compromised by anthropogenic activities (e.g., Coates 2007, pp. 154–155; Bui 2009, p. 16; Hagen 2011, p. 100).

Threat description

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. 2000a, p. 228; Connelly et al. 2011a, p. 66; Blomberg et al. 2013b, p. 347; Caudill et al. 2014, p. 808). Because sage-grouse have co-evolved with a variety of predators, their cryptic plumage and behavioral adaptations have allowed them to persist despite this mortality factor (Schroeder et al. 1999, p. 10; Coates et al. 2008, p. 69; Coates and Delehanty 2008, p. 635; Hagen 2011, p. 96). Although many generalist predators consume sage-grouse, most depend predominantly on rodents and lagomorphs and none specialize on the species (Hagen 2011, p. 97). In healthy landscapes, sage-grouse nest success and adult survival rates are generally high (Hagen 2011, p. 95); however, predation can become a factor limiting population sustainability in places where the habitat quality has been compromised (Gregg et al. 1994, p. 165; Coates and Delehanty 2010, p. 246; Lockyer et al. 2013, p. 242).

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

Sage-grouse mortality rates due to predation vary widely by location and year, and short-term studies are often not representative of population dynamics for the species across the range (Taylor et al. 2012, p. 337). Researchers have found predation to cause between 52 and 90 percent of adult and subadult deaths (Connelly et al. 2000a, p. 228; Blomberg et al. 2013a, p. 152; Blomberg et al. 2013b, p. 347; Caudill et al. 2014, p. 811). Predation of adult sage-grouse is low outside the lekking, nesting, and brood-rearing season (Connelly et al. 2000a, p. 230; Naugle et al. 2004, p. 711; Moynahan et al. 2006, p. 1536; Hagen 2011, p. 97). Adult male sage-grouse are susceptible to predation while on the lek, presumably because male sage-grouse are very conspicuous while performing their mating displays (Schroeder et al. 1999, p. 10; Schroeder and Baydack 2001, p. 25; Aspbury and Gibson 2004, p. 1127-1128; Hagen 2011, p. 97). Because leks are attended daily by numerous sage-grouse, predators also may be attracted to these areas during the breeding season. Adult female sage-grouse are susceptible to predators while on the nest but mortality rates due to predation are substantially lower than males during the same time period (Connelly et al. 2000a, p. 227; Hagen 2011, p. 97). Hens will abandon their nest when disturbed by predators (Patterson 1952, p. 110), likely reducing this mortality (Hagen 2011, p. 97). However, hens that nest successfully appear to be more susceptible to predation than hens that are unsuccessful (Blomberg et al. 2013a, p. 154; Davis et al. 2014, p. 1350). Causes for the increased levels of predation on

Comment [DMD356]: But see Davis et al. (2014) who found that that female sage-grouse were exposed to greater mortality risk during the incubation and brood-rearing periods. And Blomberg et al. 2013 who found successful reproduction was associated with reduced female survival during summer and autumn.

Davis et al. 2014. Demography, reproductive ecology, and variation in survivial of GRSG in NE Californial. JWM DOI: 10.1002/jwmg.797

Blomberg, E. J., J. S. Sedinger, D. V. Nonne, and M. T. Atamian. 2013. Seasonal reproductive costs contribute to reduced survival of female greater sage-grouse. Journal of Avian Biology 44:149–158.

Comment [LD357]: See added sentences. I can be more specific if neccessary but I didn't think it was warranted in this case. The Blomberg article summarizes the speculations. Instead of listing all of the citations, we could just say "Blomber et al. 2013, p. 155 and references therein."

successful nesters are widely speculated (Schroeder et al. 1999, p. 10; Dawson et al. 2000, p. 2097; Hanssen et al. 2005, p. 1044; Davis et al. 2014, p. 1350).

Estimates of predation rates of juvenile sage-grouse are limited due to the difficulties in studying this age class (Aldridge and Boyce 2007, p. 509; Hagen 2011, p. 98); but, similar to adults, appear to be variable. At several sites in Oregon, chick mortality from predation ranged from 27 to 51 percent in 2002 and 10 to 43 percent in 2003 (Gregg et al. 2003, pp. 15–17). Mortality due to predation during the first few weeks after hatching has been estimated to be 82 percent (Gregg et al. 2007, p. 648), but juvenile sage-grouse greater than 10 weeks of age experience comparatively low mortality (14 to 36 percent) (Beck et al. 2006, p. 1075; Caudill et al. 2014, p. 808). Juveniles that migrate greater distances to winter habitat may experience lower survival due to increased exposure to predators (Beck et al. 2006, p. 1076). Based on partial estimates from three studies, Crawford *et al*. (2004, p. 4 and references therein) reported survival of juveniles to their first breeding season was low, approximately 10 percent, and predation was one of several factors they cited as affecting juvenile survival. However, Connelly *et al*. (2011a, p. 64) 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 also subject to varying levels of predation. Because nest success is regulated by predator effectiveness in poor quality habitat as well as predator densities (Coates and Delehanty 2010, p. 246; Doherty et al. 2014, pp. 322–323), nest success can vary by as much as 30 percent at the same site over consecutive years (Taylor et al. 2012, p. 342). Most sage-grouse nest success rates are greater than 40 percent (Connelly et al. 2004, p. 10-1; Connelly et al. 2011a, p. 63), and depredations represent only a portion of nest failures (Patterson 1952, p. 104; Holloran and Anderson 2003, p. 309; Moynahan et al. 2007, p. 1777). However, inflated levels of predation due to poor nesting habitat have been shown to be detrimental to sage-grouse nesting success rates (Gregg 1991, p. 30; Gregg et al. 1994, p. 165; Connelly et al. 2011b, pp. 63-64). In two recent studies in northwestern Nevada (Lockyer et al. 2013, p. 252) and central Wyoming (Webb et al. 2012, p. 7), where habitat alterations have boosted predator populations, researchers found that at least 64 and 68 percent of

Comment [JD358]: We don't know the exact number?

Comment [LD359]: Connelly also states that they aren't sure. The 4 studies referenced took place in Washington, Wyoming, Utah, and Alberta. We know that the studies in Washington and Utah were in fragmented/marginal habitat. Wyoming and Alberta are more questionable… The Alberta paper does not describe the habitat quality of the specific area studied. I'm still trying to get the Wyoming reference. It's a thesis.

Comment [DP360]: can we quantify? Providing an estimate of how much nest predation increases relative to habitat quality would be informative.

Comment [LD361]: Nest failures include nests deserted as well as those destroyed by predators. Before camera traps, I don't think we could determine the cause of nest failures with great accuracy. Those cases where the fates were known are described below.

Comment [DP362]: define

Comment [LD363]: Poor nesting habitat can mean many different things. There are MANY factors and these are described in the Mechanisms section. Suggest linking to that section (or wherever that information ends up) when the you, the species leads, make your structural changes.

nests, respectively, failed due to predation. Nest predation can be total (all eggs destroyed) or partial (one or more eggs destroyed), but hens usually abandon their nests in both cases (Coates 2007, p. 26; Lockyer et al. 2013, pp. 246–248). Renesting efforts may compensate for some of the nest failures due to predation (Schroeder 1997, p. 938), but renesting rates are highly variable (Connelly et al. 2011a, p. 64; Lockyer et al. 2013, Table S1) ranging between 9 and 43 percent (Connelly et al. 2011a, p. 56 and references therein; Taylor et al. 2012, p. 340; Davis et al. 2014, p. 1351). Therefore, renesting is unlikely to completely offset losses from initial nest failure.

Predation has historically been the primary source of sage-grouse mortality (Schroeder et al. 1999, p. 9; Connelly et al. 2000, p. 228; Connelly et al. 2011, p. 66), but the increased habitat fragmentation and development that began across the sagebrush-steppe in the late nineteenth century (West 1996, p. 334) has caused predator dynamics to change (Fichter and Williams 1967, p. 225; Baxter et al. 2007, p. 266; Coates and Delehanty 2010, p. 240 and references therein). For this landscape species, decreasing habitat quality and quantity has created a situation in which the sage-grouse is more vulnerable to predation (Connelly et al. 1991, p. 524; Coates 2007, p. 38–39; Hagen 2011, p. 96). Threats including agricultural development, landscape fragmentation, and encroaching human populations have the potential to increase predation pressure on sage-grouse by forcing sage-grouse to nest in less suitable or marginal habitats, increasing travel time through habitats where they are vulnerable to predation, and increasing the diversity and density of predators (Ritchie et al. 1994, p. 125; Schroeder and Baydack 2001, p. 25; Connelly et al. 2004, p. 7-23; Summers et al. 2004, p. 523; Coates and Delehanty 2010, p. 246; Dinkins et al. 2014a, p. 639). Degraded and fragmented landscapes can benefit predators by increasing their kill efficiency, as well as subsidizing their food and nest or den substrate (Hagen 2011, p. 100). These habitats also provide limited concealment cover for sage-grouse nests and young, and result in a greater likelihood of predation, especially by visual predators such as ravens (Coates and Delehanty 2010, p. 245; Webb et al. 2012, p. 11) whose abundance in fragmented habitats has increased substantially (Coates and Delehanty 2010, p. 244 and references therein; Coates et al. 2014, p. 350; Sauer et al. 2014, Common Raven).Where sage-grouse habitat has been altered, the influx of predators can decrease annual recruitment into a population (Gregg

Comment [DP364]: This is different than the information presented above. Here you focus on habitat alterations increasing predator populations, and then predation, but above you describe how poor quality habitat makes nests more vulnerable to predation. So is the problem habitat, or increased predators or both? If both that interaction should be clarified.

Comment [LD365]: I altered the second sentence in this paragraph (and see changes made to the Mechanisms section below). If an Abstract or new Intro section is added, I suggest highlighting that increased predation is caused by an increase in predators and an increase in predator effectiveness, similar to what is included in the first paragraph of the Intro section. I've also added information to the following paragraph.

Comment [DP366]: This is unclear as to whether or not the predator dynamics affect interspecies predator interactions, or the effects of predators on sage-grouse.

Also, if predation has always been the primary cause of mortality, why is the change in predator dynamics so important? There needs to be some clarification that it is a shift in the balance of the predator pry dynamic.

Comment [DP367]: explain why this is a problem – its not been presented yet.

Comment [DP368]: While correct I'm still not certain we've made the clear connection between habitat quality and sage-grouse predation. While an influx of predators can increase predation, it's the synergistic play of new predator types, increased abundance of predators, and habitat fragmentation that is the concern.

Comment [LD369]: I've made some changes to this paragraph.

et al. 1994, p. 164; Braun 1995; DeLong et al. 1995, p. 91; Schroeder and Baydack 2001, p. 28; Coates 2007, p. 2; Hagen 2011, p. 98).

Current impacts

Mechanism

Sage-grouse hen mortality, chick mortality, and nest failure are the primary mechanisms impacting sage-grouse population growth directly (Aldridge and Brigham 2001, p. 542; Beck et al. 2006, p. 1076; Baxter et al. 2008, p. 185; Taylor et al. 2012, p. 343; Dinkins et al. 2014b, p. 319). It is widely recognized that nest success and chick survival are essential to population recruitment, and failure in either stage can greatly impact annual productivity (Crawford and Lutz 1985, p. 73; Schroeder and Baydack 2001, p. 26; Beck et al. 2006, p, 1076; Dinkins et al. 2012, p. 600; Lockyer et al. 2013, p. 242). Juvenile mortality due to predation may be limiting population growth in some locations as well (Caudill et al. 2014, p. 808). Compared to other upland game birds, adult sage-grouse are expected to have higher survival rates and lower productivity, and therefore long-lived individuals can have a great influence on population dynamics (Connelly et al. 2011a, p. 66; Taylor et al. 2012, p. 337). Because sage-grouse are highly polygynous with only a few males breeding per year, populations are likely more sensitive to predation upon females (Moynahan et al. 2006, p. 1529).

Although increased predator densities are associated with increased predation rates (Coates and Delehanty 2010, p. 244; Coates et al. 2014, p. 350; Dinkins et al. 2014a, p. 640), the relatively high levels of predation observed in some areas are thought to be caused by an increase in predator diversity (Baxter et al. 2007, p. 259; Coates et al. 2014, p. 241). Abundance of red foxes, raccoons, and corvids, which historically were rare in the sagebrush landscape, has increased in association with human-altered landscapes (Sovada et al. 1995, p. 5; Luginbuhl et al. 2001, p. 570). Raven occupancy can be particularly harmful to sage-grouse nest success (Bui et al. 2010, p.74) because raven are visual predators that are most successful in degraded habitat with reduced canopy cover (Coates and Delehanty 2010, p. 245). Ranches, farms, and housing developments have resulted in the introduction of nonnative predators including domestic dogs (*Canis domesticus*) and cats (*Felis domesticus*)

Comment [JD370]: Not sure what this means. Are we saying that changes to adult mortality rates can have a large impact on population dynamics? Compared to what? Males and females – or only females?

Comment [LD371]: Yes, that adult mortality rates are important. Because of the expectation that sage-grouse have high annual survival, we shouldn't ONLY focus on chick survival and nest success.

Comment [DP372]: explain why these predators are important – the way they hunt, lack of co-evolution with grouse, loss of habitat quality, etc.

Comment [LD373]: I've made some changes to this paragraph and the next one.

into sage-grouse habitats as well (Connelly et al. 2000b, p. 975; Connelly et al. 2004, p. 7-24). The addition of these predators to the landscape is an important change because generalist predators can have an additive effect on sage-grouse mortality due to the shared-predation hypothesis (Hagen 2011, p. 98) in which the combined effort of indiscriminant predators results in higher than average predation rates (Norrdahl and Korpimäki 2000, p. 529). While the presence or density of predators does not necessarily lead to increased mortality rates (Abrams 1993, p. 726), it is the synergistic relationship between new predator species, increased abundance of predators, and habitat degradation that is influencing sage-grouse populations.

Comment [JD374]: Need to acknowledge that predation rate is not necessarily proportional to predator density. See Abrams 1993. Why predation rate should not be proportional to predator density. Ecology 74:726-733.

Comment [LD375]: See last sentence added to this paragraph.

Raven abundance has increased as much as 1,500 percent in some areas of western North America since the 1960s (Coates and Delehanty 2010, p. 244 and references therein; Sauer et al. 2014, Common Raven). 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 is negatively associated with sage-grouse nest and brood fate (Bui 2009, p. 27; Coates and Delehanty 2010, p. 244; Lockyer et al. 2013, p. 250). Anthropogenic structures in the environment increase the abundance of avian predation, particularly in low canopy cover areas, by providing ravens and raptors with hunting perches (Coates 2007, p. 155; Bui 2009, p. 2; Coates et al. 2014, p. 352). Development, including oil and gas infrastructure, residential houses, communication towers, power lines, fences, and trees, provide perching and nesting habitat for predatory birds (Dinkins et al. 2012, p. 320). Trash, landfills, and road-kill have the potential to subsidize predator food sources, especially ravens (Kristan III et al. 2004, p. 250). In southern Wyoming, lower survival rates of female sage-grouse were associated with greater power-line density (Dinkins et al. 2014b, p. 323). Reduction in patch size and diversity of sagebrush habitat are also likely to encourage the presence of the common raven (Coates et al. 2008, p. 426; Bui 2009, p. 4; Coates et al. 2014, p. 352). As more suitable sage-grouse habitat is converted to and impacted by oil fields, agriculture, and other exurban development, sage-grouse nesting and brood-rearing become increasingly spatially restricted (Bui 2009, p. 32). High sage-grouse nest densities which result from habitat fragmentation or disturbance associated with the presence of edges, fencerows, or trails may increase predation rates because predators can more efficiently locate prey in these environments

(Holloran 2005, p. C37; Holloran and Anderson 2005, p. 748). Pairs of territorial breeding ravens have been observed to predate two to three sage-grouse nests in a single nesting season, though this observation is likely to be lower than the actual total due to the opportunistic nature of the study (Howe and Coates 2014, pp. 2–3). The majority of depredations by ravens are likely caused by territorial breeding pairs rather than nonbreeding transient individuals (Bui et al. 2010, p. 74; Howe and Coates 2014, pp. 2–3).

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

Comment [DP376]: This is key information that should be presented earlier.

Comment [LD377]: I added a couple sentences on page 6.

Results of impact

Sage-grouse mortality due to predation has likely had major population level effects in fragmented habitats and areas with human-subsidized predator populations (Hagen 2011, p. 95). Decreased sagebrush abundance and distribution, which is known to lead to low nest success (see above), is a associated with extirpation of the species (Wisdom et al. 2011, p. 465). At several sites in Oregon, researchers found that 16

Comment [JD378]: Agree with Dawn. This is a strong statement and need to make sure we are clear which populations or groups of pouplations we are talking about. Which MZs is this threat most significant?

Comment [LD379]: See section on "Anticipated Changes from Present" about the 27 small and isolated popualtions. Should that information be presented here instead?

Comment [DMD380]: Can we put this in a geographic context? Do we know which populations are being referred to here?

percent of nests observed were successful during the 3-year study (Gregg et al. 1994, p. 164). Continually low productivity levels can lead to reduced annual recruitment and prevent population sustainability (Allen 1962). Sage-grouse populations with apparent nest success rates lower than 30 percent and female annual survival rates lower than 45 percent are considered sink populations that could become extirpated if conservation measures are not implemented (Hagen 2011, p. 100).

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

Timing

Figure 23-1: Annual life cycle of sage-grouse. The timing of the greatest levels of predation mortality in relation to this cycle is indicated by the red bar.

The greatest seasonal mortality to adult sage-grouse caused by predation occurs in the spring, summer and fall seasons, during lekking, nesting, and brood-rearing (Connelly et al. 2000a, p. 230) (Fig. X). High winter survival is commonly observed for both adults and juvenile sage-grouse, ranging between 82 and 100 percent

(Hausleitner 2003, p. 115; Beck et al. 2006, p. 1076; Blomberg et al. 2013a, p. 149). Due to increased exposure to predators, survival of juvenile sage-grouse that migrate greater distances in the fall may be relatively lower than juveniles that migrate shorter distances or not at all (Beck et al. 2006, p. 1076). Blomberg *et al.* (2013b, entire) conducted a study in Nevada in which they observed adult mortalities in April through May (nesting) and August through October (fall) and found that predation by mammals and raptors was relatively the same during nesting season and predation by mammals was proportionally higher in the fall.

Comment [DMD381]: Also Zablan et al. 2003.

Zablan, M. A., C. E. Braun, and G. C. White. 2003. Estimation of greater sage-grouse survival in North Park, Colorado. Journal of Wildlife Management 67:144–154.

Comment [LD382]: Zablan discusses annual survival. She includes the seasons as covariates and simulates survival rates given winter precipitation but does not calculate observed winter survival rates.

Comment [LD383]: The Anthony & Willis article talks about survival without discussing predation. Since I've removed the second half of this sentence, I'm not including/citing it here.

Location and extent

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

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

In the Strawberry Valley of northwestern Utah where major habitat losses have occurred, low survival of sage-grouse may have been due to an unusually high density of red foxes, which apparently were attracted to the area by human-subsidized food sources (Bunnell 2000, p. 45). Red foxes are suspected to be the primary cause of almost complete reproductive failure observed in the late 1990s (Bunnell 2000, pp. 36–37), and a predator-management program was put in place in 1999 through at least 2012 to reduce red fox, coyote, and raven populations (Bunnell 2000, p. 41; Baxter et al. 2009, p. 481; USDA 2013). More recent studies have shown that nest success rates may have improved and it is unclear if predation is currently limiting population growth (Baxter et al. 2008, p. 185; Baxter et al. 2013, p. 424).

Comment [DP384]: independent of habitat condition?

Comment [JD385]: Add a paragraph on Washington. See http://wdfw.wa.gov/publications/00388/wdfw00388.pdf

And other reports from WDFW that have several citations on predation not included here.

Comment [LD386]: Gap alert… I am still working on my Washington paragraph. This will be done asap.

Compounded effects

The compounding effects will be discussed in greater detail in the Compounded Effects chapter. In brief, the following impacts are likely to interact with predation:

- Activities/Stressors that cause habitat fragmentation
  - Agriculture
  - Energy development and transmission lines
  - Ex-urban development (roads and residential areas)
  - Fences
  - Invasive/Nonnative plant species
- Activities/Stressors that cause changes to the vegetative communities or reduce nest cover
  - Climate change and drought
  - Conifer encroachment
  - Fire
  - Grazing by livestock and free-roaming equids
  - Invasive/Nonnative plant species
- Activities/Stressors that support predators by providing perches or food subsidies
  - Conifer encroachment
  - Energy development and transmission lines
  - Ex-urban development (roads and residential areas)
  - Fences
  - Recreation

Projected Future impacts

Timescale for Projecting this Threat

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

Comment [DP387]: clarify how this could affect the timescale for predation. You also might want to add how timing of recovery of the habitat is affected by active restoration efforts – where that happens the time-frame is reduced.

Likelihood of future impacts

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

Comment [DMD388]: Has effectiveness of these measures been demonstrated?

Anticipated changes from present

Comment [LD389]: Gap alert… I need to add information regarding the rise of raven-killing permits for Idaho and Utah from the data call. Also waiting on information from Mig. Birds on most recent national data.

Sage-grouse may be subject to increasing levels of predation that would not normally occur in the historically contiguous unaltered sagebrush habitats. The impacts of predation on sage-grouse can increase where habitat quality has been compromised by anthropogenic activities (such as exurban development, road development) (e.g., Coates 2007, pp. 154–155; Bui 2009, p. 16; Hagen 2011, p. 100), and we expect these indirect threats to continue to become more widespread issues in sagebrush habitats across the western states (see chapters on Infrastructure and Exurban Development within this document). 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). As avian predators become more abundant, high-quality nesting and brood-rearing habitat for sage-grouse will likely become more limited (Bui et al. 2010, p. 74; Dinkins et al. 2012, p. 607).

Comment [DP390]: the type of predator is also important. There has been a shift in the predator type that grouse are exposed to.

Comment [LD391]: May want to reformat this reference. What's the standard for doing this in this document?

Comment [DP392]: is it only avian, or do we anticipate novel mammalian predators will also be a concern?

Comment [LD393]: Total predation is a concern. Avian predator abundance has a greater impact on nesting success. Mammalian predators have not been studied to as great of a degree.

We have insufficient information to project the extent and intensity of the increase of predation in all areas; however small and isolated populations are at the greatest risk of extirpation (Soulé 1987; Shaffer and Stein

2000). Currently, about 27 sage-grouse populations are considered to be small and isolated (U.S. Fish and Wildlife Service 2013). Most of these occur on the periphery of the species' range with many occurring in Management Zones III, IV, and VII. Ongoing habitat loss that results in continued fragmentation and isolation of populations has the potential to multiply these local effects of predation across the species' range.

Comment [LD394]: These were identified in the COT report. Need to revisit this information following our current analysis, especially the Small/Isolated Pops chapter.

Threat amelioration

Comment [JD395]: Will also need to include some reference to regulatory mechansims and the role they will play in limiting future development in sage-grouse habitats – which will limit future fragmentation and therefore ameliorate some of the projected future impacts of predation.

Active Conservation

Maintaining large areas of intact sagebrush is widely recognized as being critical to ensuring the long-term viability of sage-grouse populations (Aldridge et al. 2008, p. 990-92; Connelly et al. 2011b, p. 560; Taylor et al. 2012, p. 344). In their review of literature regarding predation, Connelly *et al*. (2004, p. 10-1) noted that only two of nine studies examining survival and nest success indicated that predation had limited a sage-grouse population by decreasing nest success, and both studies indicated low nest success due to predation was ultimately related to poor nesting habitat. Conservation measures can limit the effects of predation by preventing habitat fragmentation caused by transmission lines, roads, and nonnative vegetation (Howe et al. 2014, p. 46). Elevated predation rates can also be prevented by restoring vegetative cover and reducing perches and food subsidies for predators (Bui 2009, pp. 36–37; Coates and Delehanty 2010, p. 246; Leu and Hanser 2011, p. 27; Taylor et al. 2012, p. 344; Lockyer et al. 2013, p. 252). Restoring connectivity to fragmented landscapes to reduce the amount of edge associated with patchy habitat may reduce the effects of avian predators, such as ravens (Howe et al. 2014, p. 46).

Predator removal programs are often suggested in response to inflated predation rates (Coates and Delehanty 2010, p. 246; Connelly et al. 2000b, p. 976). The majority of studies on the effectiveness of predator control have failed to demonstrate an inverse relationship between predator numbers and sage-grouse nesting success or breeding population numbers (Slater 2003, p. 132; Orning 2013, p. 40). Predator removal programs can have short-term gains that may benefit fall populations (Lawrence and Silvy 1995, p. 275; Coates and Delehanty 2004, p, 19), but not breeding population sizes (Cote and Sutherland 1997, p. 402; Hagen 2011, p. 99; Leu and

Hanser 2011, p. 270). Predator removal may have greater benefits in areas with low habitat quality, but predator numbers quickly rebound without continual control (Hagen 2011, p. 99); thus, there is limited opportunity for useful application (Hagen et al. 2004, p. 77). Red fox removal in Utah appeared to increase adult sage-grouse survival and productivity, but the study did not compare these rates against other non-removal areas, so inferences are limited (Hagen 2011, p. 99). Two studies in Wyoming (Slater 2003, p. 133; Orning 2013, p. 18) demonstrated that coyote control failed to have an positive? effect on sage-grouse nesting success. 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 negative consequences for sage-grouse by potentially causing indirect effects: mesopredator release, in which mammalian nest predators like the red fox become more abundant; apparent competition, in which other top predators like the golden eagle become more abundant; and exploitative competition, in which other prey species such as jackrabbits become more abundant and compete for sage-grouse food sources (Mezquida et al. 2006, p. 755). Removal of ravens from an area in northeastern Nevada caused only short-term reductions in raven populations (less than 1 year) as 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).

Comment [LD396]: My preference is to leave this word out. Coyote removal could have a positive effect on the population by not being there to kill grouse, but it could also have a negative effect by allowing mesopredator populations to increase.

Comment [DP397]: Bui also discusses this at length in her thesis. I would suggest including.

Bui 2009 -
The Effects of Nest and Brood Predation by Common Ravens (*Corvus corax*) on Greater Sage-grouse (*Centrocercus urophasianus*) in Relation to Land Use in Western Wyoming

Through the Conservation Efforts Database (CED), the Service collected information relating to conservation actions that were completed, in progress, or planned. Based on a summary report of that information created on XXXXXX, the following table indicates the number of actions and approximate areas for threat amelioration. These numbers are self-reported; the Service will further review and certify these actions if they are pivotal to any determination. *<Insert information from the CED regarding increased connectivity and habitat restoration.>*

Table 23-1: List of Conservation Efforts (ameliorating threat described in this chapter) by management zone

Management Zone	Type of Conservation Effort	Sum of Acres or Miles	Number of Actions	Notes
1				
2				
3				
4				
5				
6				
7				

Threat Amelioration Summary

To be completed after CED information is added.

Assessment of Potential Threat

In 2010, the Service determined that the effects of predation did not significantly threaten the sage-grouse such that the species across its range should require listing under the Act as endangered or threatened (75 FR 13910, p. 13973). Since 2010, many studies have been published regarding the increase of predation in various locations across the species' range. Those studies have elucidated the intricacies of the situation and provided managers with useful knowledge that will help them implement effective conservation strategies to help ameliorate the effects of predation. There is no new scientific information indicating that the effects of predation have changed significantly in the past five years.

Where habitat is not limited and is of good quality, predation is not a significant stressor acting upon to the species. Continued landscape fragmentation is likely to increase the effects of predation on this species resulting in a reduction in sage-grouse productivity and abundance, especially in management zones III, IV, and VII where the sage-grouse populations are particularly small and isolated. However, there is very limited

Comment [JD398]: Recommend following our new outline for the conclusion section:

1. State what we said in 2010
2. Indicate major new science
3. Indicate new regulatory mechanisms and conservation actions.
4. Then draw conclusion.

Comment [JD399]: What about where habitat is limited or not of good quality?

Comment [JD400]: In some areas? What MZs/populations are particularly affected.

Comment [LD401]: These were identified in the COT report. Need to revisit this information following our current analysis, especially the Small/Isolated Pops chapter.

scientific 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.

Comment [DP402]: Critics will be very quick to point to Strawberry Valley research which conflicts with this statement. Also, a study in NW WY is making such a claim although I don't know the status of peer review or publication. Will try to track that down (and please remind me to do so if I forget!).

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Other Threat Factors

Chapter 24: Small population and life history traits affecting population viability = PLACEHOLDER FOR LIEF

Chapter 25: Contaminants

Introduction

Contaminants, when accidentally or deliberately introduced into the environment, have the potential to pollute water, air, or other resources used by greater sage-grouse (Centrocurecus *urophasianus*; hereafter sage-grouse). Since 2010, sources of contaminants have continued to occur and expand across portions of the sage-grouse range, including oil and gas development, infrastructure, and agriculture. However, while contaminants impact sage-grouse individuals sporadically at a local scale rangewide, it is unlikely that contaminants lead to widespread mortality or declines in sage-grouse populations across management zones (MZ).

Threat description

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

Current impacts

Mechanism

Direct exposure to contaminants may impact health and survival of sage-grouse. Mortality of sage-grouse can occur if they enter oil and gas wastewater pits. Exposure to spills or leaks of contaminats associated with the numerous gas and oil pipelines occurring within the occupied range of the species may lead to mortalities or morbidity to sage-grouse. Similarly, given the extensive network of highways and railroad lines that occur throughout the range of the sage-grouse (see Chapter X for more information on infrastructure), there is some potential for direct exposure of sage-grouse to contaminants resulting from spills or leaks of hazardous materials being conveyed along these transportation corridors. Radionuclides (radioactive atoms) from nuclear research facilities, oil and gas activities, or mining, if intercepted by wildlife, can cause internal damage from radioactive decay (Kennedy *et al*. 1990, p. 10). Exposure of sage-grouse to radionuclides has been documented at the Department of Energy Idaho National Engineering Laboratory in eastern Idaho. Mining may directly expose sage-grouse to elevated levels of metals, other minerals, and/or contaminated fluids used in the extraction. Toxic concentrations of metals or chemicals used in mining have been found in birds occurring near mining operations (Pristos and Ma 1997, p. 203; Beyer *et al*. 2004, p. 116; Hansen *et al*. 2011, p. 593). Direct exposure to pesticides may have lethal or sublethal effects to sage-grouse, depending on the pesticide, level of exposure, and area sprayed. Sage-grouse may use areas sprayed with various pesticides, including agricultural areas (hay meadows and alfalfa fields) and rangelands used for livestock grazing (Peterson 1970, p. 154; Wallestad and Eng 1975, pp. 629–630; Klebenow 1982, p. 113; Beck and Mitchell 2000, p. 997). Insecticides have been documented to cause mortality (Ward *et al*. 1942, p. 57; Post 1951, p. 383; Blus *et al*. 1989, p. 1142; Blus and Connelly 1998, p. 23; Christiansen and Tate 2011, p. 20), abnormal behavior (Dahlen and Haugen 1954, p. 477; McEwen and

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

Sage-grouse may be indirectly affected when contaminants are introduced into their habitat. Spills, leaks, or purposeful application of hazardous substances can result in vegetation die-off, reduction of insects important in the diet of sage-grouse, and loss of suitable water sources. Herbicide applications can kill sagebrush and forbs important as food sources for sage-grouse (Carr 1968 as cited in Call and Maser 1985, p. 14). Loss of vegetation cover can also result in increased soil erosion and subsequent reduced soil depths, decreased water infiltration, and reduced water storage capacity (Miller *et al*. 2011, p. 174), further degrading vegetation and riparian areas used by sage-grouse. Use of insecticides, including neonicitinoids, may reduce insect populations and indirectly expose insect-eating birds to insecticides (Mineau and Palmer 2013, p. 20; Gibbons *et al*. 2015, p. 105) in agriculture or rangelands used by sage-grouse or in close proximity to areas occupied by sage-grouse. Pesticide treatment for grasshopper control appeared to affect nestling development and resulted in mortality for 50–100 percent of songbird and corvid nestlings, depending on the chemical used (Eng 1952; pp. 332, 334). Partridge chicks (Perdix perdix) had high starvation rates resulting from reduced food supply when of pesticides were applied (Rands 1985, p. 56). Wildlife may be indirectly exposed to pesticidal proteins occurring in genetically-modified organism (GMOs) through bioaccumulation, if diets include insects that consume GMOs (Wolfenbarger *et al*.2000, p. 2089). Human development potentially exposes sage-grouse to pathogens introduced from septic systems and waste disposal (Moore and Mills 1977, pp. 114–116, 135) that could negatively affect their health. Mining operations can contribute contamination to water sources in sage-grouse habitat as a result of blasting chemicals (ammonium nitrate, fuel oil) or metal leachate from waste rock or overburden (Moore and Mills 1977, pp. 115, 133; Adams and Picket 1998, p. 486; Ramirez and Rogers 2002, p. 434–435). Chemicals used to control wildland fires within sagebrush ecosystems may reduce species richness of vegetation for short time periods (Larson *et al*. 1999, p. 115) thereby potentially impacting vegetation important for sage-grouse nesting and brood rearing. Air pollution can impact plant and insect health and abundance (Alstad and Edmonds, Jr. 1982, p. 369, University of Illinois 2002, pp. 1–2), both of which are necessary for sage-grouse diets. Sage-grouse are a landscape scale species, requiring large expanses of sagebrush to me *et al*l 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). Contamination of sage-grouse habitat may increase habitat fragmination or displace sage-grouse to less optimal habitat.

Results of impact

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

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

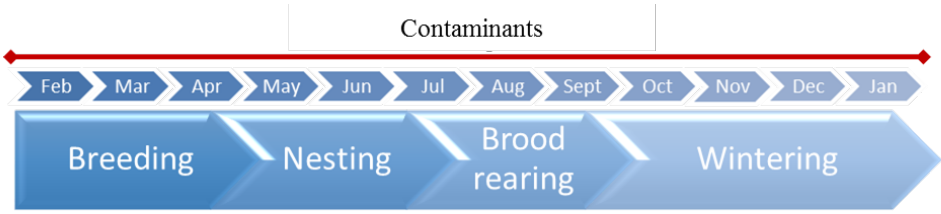
Although radionuclides were present in greater sage-grouse at DOE's Idaho National Engineery Laboratory in eastern Idaho, there were no apparent harmful effects to the population (Connelly and Markham 1983, pp. 175–176). With current provisions regulating nuclear energy development, it is unlikely that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

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

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

Timing

Impacts to sage-grouse from contaminants may occur throughout the year. Chemical spills are sporadic and typically unpredictable. Pesticide use primarily occurs during the summer months, though depending on the target species and specific pesticide, they may be used in or near sage-grouse habitat year around and throughout the lifespan of the sage-grouse.



Location and extent

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

Table 25-1:.

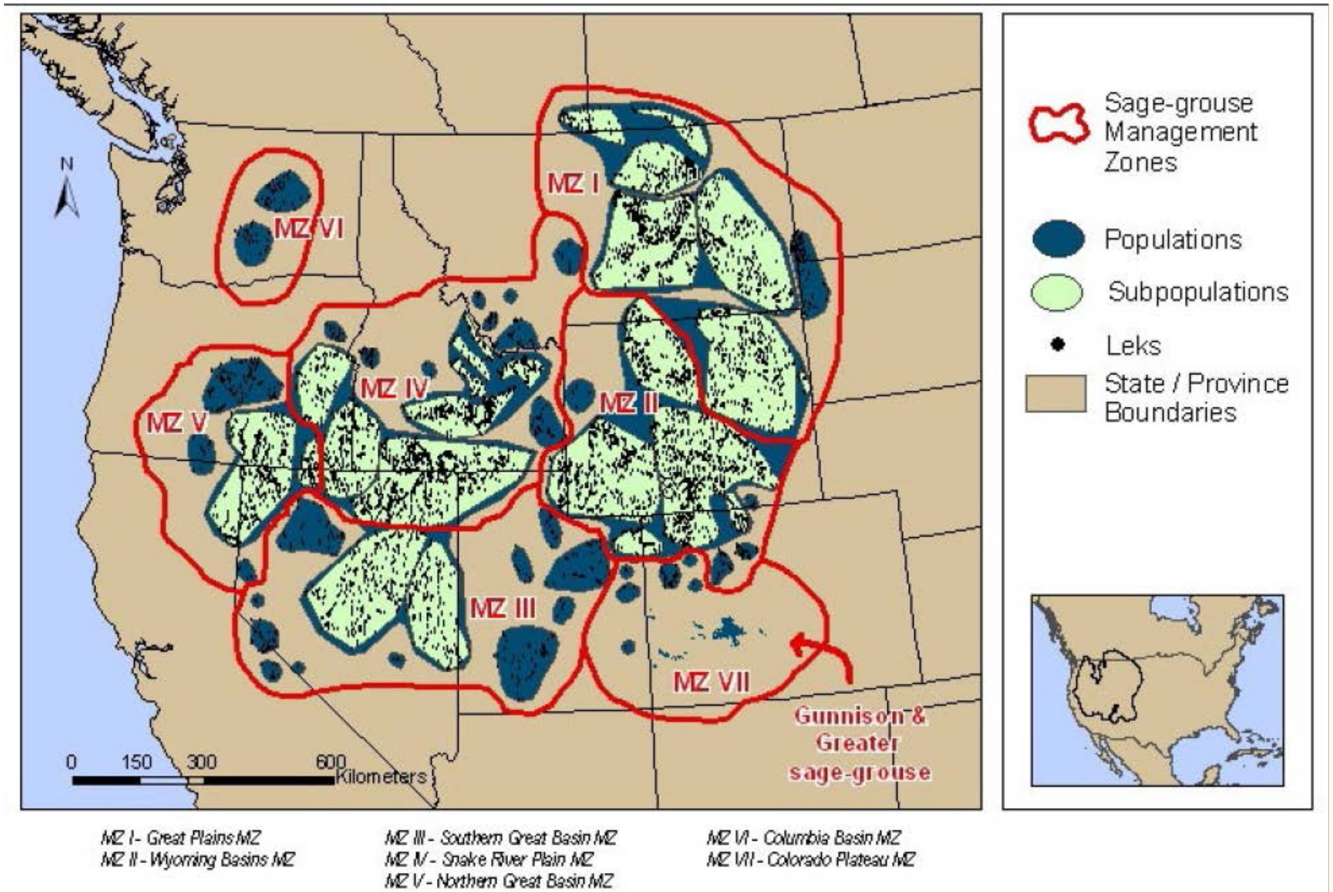
Comment [AB403]: This table is still being worked on/discussed, but because of a lack of complete data for contaminants, it will likely be difficult to delineate by management zone, other than discuss what types of activities are occurring that may lead to contamination…

Table 25-2: List of impacts by management zone

Management Zone	Timing of Impacts (Season)	Immediacy of Impacts	Severity of Impacts	Extent of Impacts	Resource or Life stage impacted	Notes

Management Zone	Timing of Impacts (Season)	Immediacy of Impacts	Severity of Impacts	Extent of Impacts	Resource or Life stage impacted	Notes
Example	Spring (or all the time, etc.)	Happening right now (or planned)	Direct mortality (or habitat destruction, etc.)	Impacting X% of occupied range by MZ	Lekking adults, broods	This is an example…
1						
2						
3						
4						
5						
6						
7						

Map Showing Current Threats (this is “Map 2” that the GIS team is working on; we will not have this map for all chapters)



Comment [AB404]: Still working with Ed for potential GIS maps, but for this chapter, I’m guessing that it will be more reliant on other chapters about things that could be sources for contaminants (oil and gas, ag, human development, infrastructure…)

Compounded effects

The compounding effects will be discussed in greater detail in the Compounded Effects chapter. In brief, the following impacts are likely to interact with the threat described in this chapter.

- Infrastructure (pipelines, roadways, railroads) – Failures in infrastructure such as pipelines may increase threats of exposure of contaminants to sage grouse. Roadways and railways may be used to transport chemicals. Invasive plants may become established during the construction of various infrastructure projects, which may require use of pesticides for control. Additionally, pipeline and electric transmission line ROWs frequently require vegetation management, which may be done through use of pesticides.
- Mining – mined substances and chemicals used in mining may lead to contamination.
- Nonrenewable Energy Development – oil, gas, and other chemicals associated with the production and development of nonrenewable energy may be toxic to sage-grouse and negatively impact sage-grouse habitat.
- Renewable Energy Development – Renewable energy development (wind turbines, solar panels) frequently require vegetation management, which also may require the use of pesticides.
- Rangeland Management – Management of livestock and ranching activities could expose sage-grouse to chemicals. Pesticides are frequently used in agricultural and rangeland activities to reduce unwanted species. The Rangeland Grasshopper and Mormon Cricket Suppression Control Program (APHIS 2002, entire) may include the use of three approved insecticides (carbaryl, diflubenzuron, and malathion).
- Invasive Plants – Control of invasive plants by land managers may require use of pesticides. This management action may be done to benefit sage-grouse within occupied habitat.
- Recreation – Areas used by humans for recreational activities (hiking trails, OHV trails, camping areas) may have increased use of pesticides for weed control.

- Fire – use and dispersal of fire retardants in sage-grouse habitat may impact vegetation composition.
- Agricultural conversion – Areas converted to cropland likely have increased use of pesticides for weed and insect control.
- Disease – Areas at risk for West Nile Virus outbreaks may have increased used of insecticides in an attempt to decrease mosquitoes.
- Ex-Urban Development – Areas developed for human use may have an increase in garbage and use of pesticides.

Projected Future impacts

Timescale for Projecting this Threat

Comment [AB405]: Somewhat of an issue figuring out what to say for this…as it's based on the activities that are associated with contaminants. Because we have such a wide variety of answers/timescales, it looks a bit strange all put next to each other.

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

Likelihood of future impacts

Given the level of activities associated with contaminants sources across the range of the sage-grouse, it is highly likely that future impacts will continue across the range.

Anticipated changes from present

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

Threat amelioration

Comment [AB406]: Waiting to see what conservation actions may be associated with reducing contaminants.

Active Conservation

Through the Conservation Efforts Database (CED), the Service collected information relating to conservation actions that were completed, in progress, or planned. Based on a summary report of that information created on XXXXXX, the following table indicate the number of actions and approximate areas for threat amelioration. These numbers are self-reported; the Service will further review and certify these actions if they are pivotal to any determination.

The Service addresses regulatory actions in a separate chapter????

Table 25-3: List of Conservation Efforts (ameliorating threat described in this chapter) by management zone

Management Zone	Type of Conservation Effort	Sum of Acres or Miles	Number of Actions	Notes
1				
2				
3				
4				
5				
6				
7				

Threat Amelioration Summary

asdfasdf

Assessment of Potential Threat

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

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Chapter 26: Military Activity-PLACEHOLDER

Synergist Impacts

Chapter 27: Threat Interaction - PLACEHOLDER

Regulatory Mechanisms and Conservation Efforts

Chapter 28: Federal PLACEHOLDER (Jesse D'Elia)

Chapter 29: State PLACEHOLDER (Jesse D'Elia)

Chapter 30: **Private PLACEHOLDER(Jesse D'Elia**

Chapter 31: Conservation Efforts PLACEHOLDER

Conservation Measures

CED Summaries

CUMULATIVE EFFECTS

Chapter 32: Cumulative Threats and Amelioration by Management Zone PLACEHOLDER (Steve Abele, with assistance from MZ Leads)

This chapter is the discussion of cumulative threats and plans/action to ameliorate **by MZ,** as well as the status of sage-grouse in the MZ.

This chapter will identify all threats by MZ, relying on threat interactions described in previous chapter and spatial threat concentration information of primary threats. This allows an examination of primary threats that we have quantitative/spatial information for, and a concomitant examination of other threats tied to the primary threat by MZ.

Additionally, this chapter will describe the efforts implemented and planned to reduce or remove threats and risks on the landscape. Summaries of conservation actions would be summarized from CED, as well as evaluation of plans, policies, and regulatory mechanisms, broken down by MZ.

Lastly, this chapter will describe overall status of sage-grouse in each management zone, based on the cumulative threats and the plans/action aimed at ameliorating them.

Comment [LW 407]: *Relative to the evaluation of conservation plans, each MZ subsection would include information from the following list (as appropriate):*

- Laws, regulations, Polices and Management Plans
  - Federal Plans
    - BLM/FS LUP Amendments / Planning efforts
      - Disturbance Monitoring
      - Adaptive Management
      - Mitigation
      - FIAT
    - FWS (Refuges)
    - NPS
    - DOD/DOE
  - State Planning Effort
  - Private Lands
    - FWS CCAA
    - NRCS SGI
  - Tribal Lands
  - Canadian Federal and Provincial Laws and Regulations

Comment [LW 408]:
--- MZ 1 (Montana – Jeff Berglund / North Dakota Kevin Shelley [support from Wyoming and South Dakota)
--- MZ 2 (Wyoming – Lisa Solberg Schwab [Support from Montana, Colorado, Utah])
--- MZ 3 (Nevada – TBD / Utah – TBD) (potentially Jay Martini, Ron Baxter)
--- MZ 4 (Idaho – TBD [Support from Oregon, Nevada, Utah, Montana])
--- MZ 5 (Oregon – TBD [Support from Nevada, California])
--- MZ 6 (Washington – TBD) (potentially Jessi Gonzales, Heather)
--- MZ 7 (Colorado – TBD)

OVERALL SUMMARY OF SPECIES STATUS

Chapter 33: **Summary PLACEHOLDER**

SUPPORT SECTIONS

- REFERENCES CITED (Lara Drizd)
- APPENDIX A — DEFINITIONS
- APPENDIX B — ACRONYMS USED
- APPENDIX C — OCCURRENCE TABLE (if too large to include in that section)
- APPENDIX D — THREATS SUMMARY TABLE (if too large to include in that section)
- APPENDIX E — CHANGES OVER TIME SUMMARY TABLE (if too large to include in that section)
- APPENDIX F — MANAGEMENT ZONE (and POPULATION) MAPS
- APPENDIX G — NON-REGULATORY MECHANISMS EVALUATED