From: Skora, Genevieve
To: Freifeld, Holly
Subject: Re: Fire?
Date: Wednesday, March 04, 2015 8:43:21 AM
Attachments: 20150228_FireChapter_PMExp_Rv1.docx

Hi Holly,

Yes, attached is the draft that I submitted for the second round of reviews. If there are items that would better fit into your chapter (although I believe I have more overlap with invasives and conifers), let me know!

Good luck,

- Gen

On Wed, Mar 4, 2015 at 8:31 AM, Freifeld, Holly <holly_freifeld@fws.gov> wrote:

> Hi Gen,
>
> I'm working away on the Climate Change chapter, and wondering if you have a draft of Fire you can share...I want to make sure I'm on the same page with you -- AND not excessively redundant -- on a variety of fire-related points. (I'm teleworking today, so no access to the sharepoint...)
>
> Thanks,
> Holly

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Chapter 1: FIRE

INTRODUCTION

Fire is the principle natural disturbance in the sagebrush ecosystem, causing loss and fragmentation of *Artemisia* spp. (sagebrush) 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 threats of wildfire and invasive species to compound and increase the severity of impacts to sage-grouse from the threat 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. 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 of sagebrush habitats (xx acres over the past decade). Therefore, management actions to help prevent mega-fires and improvements in restoration activities are the best means to continue to lessen the impact of fires on sagebrush ecosystems and sage-grouse.

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. Lightning ignitions were the primary source of fires in the arid 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 (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 Survey (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). GLO 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. 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.

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. 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 (vital rate/population level effects (direct, indirect)

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 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, both natural and anthropogenic, can occur at any time throughout the year. Within the range of the sage-grouse, fire danger is highest June to September with parts of the range having a heightened fire danger March to November (NICC 2014, entire). Fire danger is more extreme within the Great Basin region of the sage-grouse's range. 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). From 2005 through 2014, there were 8,028 fires that burned in priority and general sage-grouse habitats (BLM and USFS delineation of areas essential/important and of moderate importance to sage-grouse, respectively), 72 percent (5,760) were lightning caused and 28 percent (2,268) were human caused (Havlina *et al.* 2014, pp. 12, 23). 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, p. 12, 23).

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 (NIFC 2015, p. 1).

From 1980 to 2007, wildfires have burned approximately 8.7 million ha (21.5 million ac) of sagebrush, or approximately 18 percent of the estimated 47.5 million ha (117.4 million ac) of sagebrush habitat occurring within the delineated MZs (Baker 2011, p. 193). Additionally, the trend in total acreage burned from 1980 to 2007 has primarily increased (Miller *et al.* 2011, pp. 169–171). Although fire alters sagebrush habitats throughout the sage-grouse's range, fire disproportionately affects the Great Basin (Baker *et al*. 2011, p. 20; Miller *et al.* 2011, pp. 170–171) (MZs III, IV, and V) and will likely influence the persistence of sage-grouse populations in the area. In these three MZs combined, nearly 27 percent of sagebrush habitat has burned between 1980 and 2007 (Baker 2011, pp. 193, 197–199). A primary reason for this disproportionate influence in this region is due to the moderate to low resistance to invasive annual grasses and low resilience of these areas to disturbance (Chambers *et al.* 2014, entire).

The USGS analyzed data from the National Interagency Fire Center (NIFC) on fires within designated sage-grouse habitat (PPH (Preliminary Priority Habitat) and PGH (Preliminary General Habitat)) from 2000 through 2012. Fires occurring during this time frame and within the range of sage-

grouse, disproportionately affected the western MZs (MZ III, IV, and V; data from MZ VI was not included). In the Snake River Plain (MZ IV) from 2000 through 2012, 14.2 percent of PPH and 17.1 percent of PGH burned. 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 one 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) (Signe Sather-Blair, BLM, *in* Healy 2001). This amount included about 202,000 ha (500,000 ac), which burned between 1999 and 2001, significantly altering the largest remaining contiguous patch of sagebrush in the State (Signe Sather-Blair, BLM, *in* Healy 2001). Between 2003 and 2007, Idaho lost an additional 267,000 ha (660,000 ac) of sage-grouse habitat, or approximately 7 percent of the total estimated remaining habitat in the State. Over nine fire seasons in Nevada (1999 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).

Management Zone	Timing of Impacts (Season)	Immediacy of Impacts	Severity of Impacts	Extent of Impacts	Resource or Life stage impacted	Notes
1						
2						
3						
4						
5						
6						
7						
8						

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 threat 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 re-establish. 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 threat. 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.

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 threat 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 over the 21st 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

a. Timescale for projecting this threat; likelihood of future impacts

It is not currently possible to predict the 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.

c. Anticipated changes from present (direct, indirect; same amount of range? Populations?)

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.

Management Zone	PPH SG Habitat (acres)	PPH High Burn Probability (acres)	High Burn Probability (%)		PGH SG 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 threat 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 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				
8				

a. Known management/conservation actions and regulatory mechanisms

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 threats to sage-grouse and include conifer removal, seedings, chemical treatments of invasive species, strategically placed fuel breaks, and other measures to change fire behavior, augment suppression effectiveness, or maintain and restore sage-grouse habitat. In 2014, the BLM treated approximately 96,720 ha (239,000 ac) to reduce wildfire related impacts to sage-grouse habitat (Havlina *et al.* 2014, pp. 20–21).

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

<u>BMPs</u>

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.

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 of appropriate methods, invasive plant species, and abiotic factors, such as weather, that are largely outside the control of land managers (Hemstrom *et al*. 2002, pp. 1250–1251; Pyke 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. This successful suppression and resulting homogenization of the vegetation, has marginalized almost all escaped fires to becoming relatively extreme events. The three percent of wildfires that escape usually occur under the most extreme environmental conditions. This, coupled with vegetation changes over time, has caused these fires to grow larger and become more environmentally destructive than historical fires that occurred under more moderate conditions without suppression. While we do not know the extent to which these regulatory mechanisms alleviated the wildfire threat to sage-grouse, we believe that this strategic approach to ameliorating the threat of fire is appropriate and significant. Targeting the protection of important sage-grouse habitats during fire suppression and fuels management activities could help reduce loss of key habitat due to fire if directed through a long-term, regulatory mechanism. We describe the threat of wildfire as likely to continue indefinitely. This foreseeable future requires a regulatory approach that addresses the threat over the long term. The use of IMs to increase protection

of sage-grouse habitat during wildfire is not adequate to protect the species because IMs are both short-term and have discretionary renewal (decisions made on a case-by-case basis).

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 ever 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. ?). 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.

Threat Amelioration Summary

ASSESSMENT OF POTENTIAL THREAT

Fire has been identified as a primary factor associated with sage-grouse population declines. The threat of fire to sage-grouse and their habitats is compounded by its interactions with the dual threats of

invasive species 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.

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