Synergist Impacts

Chapter 1: Threat Interaction

Sage-grouse population persistence is influenced by a combination of factors acting in synergy. Cumulative impacts result from the incremental or synergistic impact of an action when added to other past, present, and reasonable foreseeable future actions. Many of the impacts described in this report may cumulatively or synergistically affect the species beyond the scope of each individual stressor. For example, across the range of sage-grouse, improper livestock grazing alone may only affect a portion of sage-grouse habitat. However, improper grazing combined with invasive plants, drought, and wildfire may collectively result in substantial habitat loss, degradation, or fragmentation across large portions of the species' range. The effects of free-roaming equids on sagebrush ecosystems may also interact synergistically with livestock grazing or simply be additive (Beever and Aldridge 2011, p. 286). Other stressors, such as ex-urban development and increasing human populations result in increased roads, power lines, 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; FWS 2013, p. 50). Fences are another type of infrastructure which can cause direct sage-grouse mortality from collision, indirect mortality by providing perches for avian predators and potential creation of predator corridors along fences, and habitat degradation through fragmentation and the spread of invasives (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). Thus, numerous threats are likely acting in concert, both synergistically and cumulatively to further contribute to the challenges faced by sage-grouse in the future.

Comment [DP1]: we may want to drop this if CE is not combined with synergistic. I would suggest deleting this sentence entirely if we don't combine synergism and CE simply because we use the word cumulatively here, which is confusing…

Synergistic feedbacks between invasive plants and increased fire frequency and size has reduced sagebrush shrub cover and plant diversity and resulted in type conversions from sagebrush communities to non-native grassland landscapes (Miller *et al.* 2011, p. 183). We anticipate the loss of sage-grouse habitat from wildfire to increase due to the intensifying synergistic interactions among fire, people, invasives, 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 invasives 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 wildfire will likely further interact with people and infrastructure. Human-caused fires have reportedly increased and been shown to be correlated with roads (Miller *et al.* 2011, p. 171). The most common human-caused fire starts were from power lines, 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 -OHVs 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.

We anticipate the increased amount of land use activities will also 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). Invasives are 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 land use 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.

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; Zohar *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. 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).

Other land uses, including threats associated with recreation activities are often tied with other impacts described in this report. 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 may increase recreation activities near those urban centers and expand the areas where recreation activities are likely to occur. Recreationalists, such as OHV users, using roads and corridors through sage-grouse habitat may increase disturbance to lekking and nesting activities as well as lead to frequent flushing (Patterson 1952, p. vi). Increased hunting and recreation may also be facilitated by infrastructure such as roads and trails. Hunting of sage-grouse 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 (e.g., noise, garbage, and/or habitat impacts). Other infrastructure, such as camping areas, restrooms, and visitor centers, would likely increase recreational activities. Contaminants to sage-grouse, such as fuel for OHVs, pet waste, and garbage, are associated with recreational activities. Pesticide 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

Comment [DP2]: don't we have information that recreation/OHV also help spreads invasives? I can't remember the source, but if so it might be worth A sentence here…

recreational activities and garbage may sustain increased densities of predators in these areas (Bui 2009, p. ?). Pets accompanying humans during recreational activities could act as predators to sage-grouse if not under strict control of their owner. Wildfire threats 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).

Comment [DP3]: in reference to garbage and densities of ravens

Abundance of red foxes, raccoons, and corvids, which historically were rare in the sagebrush landscape, has increased in association with human-altered landscapes (Johnson and Cassidy 1997, p. 222; Sovada *et al.* 1995, p. 5; Luginbuhl *et al.* 2001, p. 570). Ranches, farms, and housing developments have resulted in the introduction of nonnative predators including domestic dogs (and cats into sage-grouse habitats (Connelly *et al.* 2000b, p. 975; Connelly *et al.* 2004, p. 7-24). The addition of these nonnative predators have increased predation on sage-grouse (Hagen 2011, p. 98). Raven abundance has increased as much as 1,500 percent in some areas of western North America since the 1960s, thriving on human-altered landscapes (Coates and Delehanty 2010, p. 244 and references therein; Sauer *et al.* 2014, p. ?). Local attraction of ravens to nesting females may be facilitated by loss and fragmentation of native shrublands (e.g., infrastructure to support urbanization and energy development; Aldridge and Boyce 2007, p. 522; Bui 2009, p. 32). 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; Coates and Delehanty 2010, p. 244). 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).

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 through increasing temperatures and precipitation. 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).

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). Twenty-seven ~~More than~~ ~~25 such~~ populations are identified (FWS 2013a, pp. 16–29). 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

Comment [DP4]: in predation we talk about 27 populations so changed this here just for consistency.

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). 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 . However, it is important to recognize that although hunting, disease, and predation may have direct effects on some sage-grouse populations, the effects of these factors on rangewide population persistence are relatively small compared to indirect effects on populations by habitat loss and degradation. (Manier *et al.* 2013, p. 23).

The impacts described in this report may vary in relative importance among MZs but are inclusive and representative of the suite of threats across the species range. Human land use and both natural and anthropogenic disturbance will continue to be the dominant stressors on sagebrush communities and we anticipate their individual and cumulative effects will challenge long-term conservation of sage-grouse populations (Knick *et al.* 2011, pp. 203–204). Although we address cumulative impacts separately, we acknowledge that the synergistic effects of land use changes described in this report may result in landscape-scale changes across the range of the species or may influence population persistence in some regions within the sage-grouse range. Ultimately, the cumulative impact of these potential stressors, rather than a single factor, will have the most significant influence on the trajectory of sagebrush-steppe ecosystems into the foreseeable future (Knick *et al.* 2011, p. 249).