PRESCRIBED FIRE AS A MANAGEMENT TOOL IN XERIC SAGEBRUSH ECOSYSTEMS: IS IT WORTH THE RISK TO SAGE-GROUSE?

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Introduction

The sagebrush (*Artemisia spp.*) biome that once dominated western landscapes has significantly diminished over the last century. Connelly et al (2004) estimated 55% of the area that potentially supported sagebrush habitats currently exists in sagebrush based on Kuchler (1970) who described the Great Basin Sagebrush, Sagebrush Steppe, and Wheatgrass-needlegrass Shrubsteppe. Wisdom et al. (2005) identified several threats or disturbances responsible for this decline including weather and climate, agricultural conversion, human development, intensive livestock grazing, feral horse grazing, woodland expansion, exotic plants, and wildfire. Welch (2005) similarly estimated 50% of sagebrush has been lost to human development.

The increasing occurrence of wildfire in sagebrush-dominated landscapes is likely among the greatest threats to greater sage-grouse across three floristic provinces within the range of the species including the Southern Great Basin, Northern Great Basin and Snake River Plain. In Nevada, of the 22 million acres of identified sagebrush habitats within the range of sage-grouse, approximately 2.6 million acres have burned since 1999. This represents a 12% habitat loss in a 9-year time span (Espinosa and Phenix 2008). Recently, large fires in northeastern California, eastern Oregon and southern Idaho have also reduced sage-grouse habitat, rendering many thousands of acres uninhabitable by sagebrush obligate species. Within the Snake River Plain region, Whisenant (1990) reported the mean fire return interval in Wyoming big sagebrush communities has been reduced from 50-100 years to less than 10 years where repeated fires have allowed cheatgrass and other exotic annuals to replace native shrub and herbaceous vegetation.

In spite of considerable loss of functional sagebrush habitats from wildfire and other factors (e.g., energy development, agricultural conversion, and urban expansion), some natural resource professionals promote using different types of treatments to reduce sagebrush cover on remaining intact sagebrush habitats (Bunting et al. 1987, Wyoming Interagency Vegetation Committee 2002, Davies et al. 2008, McAdoo et al. unpublished report). These treatments include prescribed fire, mechanical alterations, herbicide applications and intensive, short-duration livestock grazing. Justification for these treatments have included the need to increase resiliency of sagebrush-grassland habitats to wildfire, improve forage for livestock grazing, diversify age-structure of sagebrush, reduce “decadent” stands of big sagebrush, and enhance sage-grouse habitat (Wyoming Interagency Vegetation Committee 2002).

We question the biological and ecological value of treatments that remove sagebrush in xeric sagebrush communities and are concerned about long-term negative impacts to sage-grouse. Prescribed burning in xeric low to mid elevation sagebrush habitats raises some of the greatest concern because of the considerable risks and questionable benefits. Xeric sagebrush communities typically receive ≤12” precipitation annually and include Wyoming big sagebrush (*Artemisia tridentata ssp. wyomingensis*), low elevation mountain big sagebrush (*Artemisia tridentata ssp. vaseyana*), and low (*Artemisia arbuscula*) or black sagebrush (*Artemisia nova*) communities *(*Goodrich 2001).

Increased frequency and extent of wildfires and a host of other disturbances to sagebrush grasslands coupled with the contention by some natural resource professionals that treatment of many remaining sagebrush habitats is necessary, warrant addressing this issue more broadly than on a project by project basis. The objectives of this paper are to 1) review documentation and research related to the effects of fire on sage-grouse and their habitats and 2) provide recommendations on the use of prescribed fire and alternative considerations for habitat restoration.

Natural Fire in Big Sagebrush Ecosystems

A review of available literature reveals disparities among estimated fire return intervals for both the mountain (*A. tridentata ssp. vaseyana*) and Wyoming big sagebrush communities (Baker 2006). Some level of variation should be expected as environmental conditions at study sites can be very different (Wambolt et al. 2002). Another reason for these differences in fire frequency estimates rests with differences in terminology and calculation methods (Baker 2006). Nevertheless, recent research suggests burn intervals are much longer than earlier estimates have suggested (Baker 2006, Cooper et al. 2007).

In Wyoming big sagebrush communities, Wright and Bailey (1982) estimated that the fire return interval is about 100 years. Other studies suggest that fire rotations were actually between 100 – 240 years and recovery rates of Wyoming sagebrush communities after fire is very slow (Hemstrom et al. 2002, Baker 2006, Cooper et al. 2007, Beck et al. 2009). Baker (2006) reviewed five sources of evidence regarding estimates of historical range of variation and found that fire rotations averaged >200 years in low sagebrush, 200-350 years in Wyoming big sagebrush, 150-300 years in mountain big sagebrush, and 40-230 years in mountain grasslands containing patches of mountain big sagebrush with longer rotations in areas where sagebrush intermixes with forests. *Fire rotation* is the expected time to burn once through a land area equal to that of a landscape of interest (Baker and Ehle 2001, Reed 2006), a key parameter to know and understand in managing fire (Baker *in press*).

Welch (2005:199) provided a list of 10 ecological and biological characteristics of big sagebrush that reveal a lack of adaptation to fire. In particular, mountain, basin (*A. t. ssp. tridentata*), and Wyoming big sagebrush die from fire and do not re-sprout

(Pechanec et al. 1965; Tisdale and Hironaka 1981). Further, sagebrush seed has no effective mechanism for spreading, resulting in an estimated pioneering rate for mountain big sagebrush of 24 feet per year in areas lacking a soil seed bank (Welch 2005:204). Viable sagebrush seeds must be at the soil surface to have the possibility of germinating and growing into a shrub, which is a vulnerable location during hot fires (Welch 2003:18). All of this suggests that big sagebrush did not historically occur in or adapt to an environment with frequent fires and would likely be characterized as a high severity fire regime (Agee 1996, Welch 2005).

Prescribed Fire as a Management Tool

Prescribed fire may be useful for achieving biological objectives; however, reintroducing fire is a complex task (Agee 1996). Prescribed fire has been used as a management tool to alter vegetation throughout the world. In North America, prescribed fire has been applied extensively in grasslands, pine forests, aspen communities, oak woodlands, savannahs and even wetlands. Although fire is a natural part of many ecosystems, its effects may not be natural or desirable if fire frequency or intensity is outside of the natural range of variability for that ecosystem, or if the natural range of variability is reintroduced in an ecosystem that has undergone unnatural shifts in species composition or structure (Agee 1996).

Sagebrush Community Response

The susceptibility of sagebrush to fire and subsequent slow recovery is well documented. In southeastern Idaho, shrub structural features, including percent cover of Wyoming and three-tip big sagebrush and total shrub height, did not recover in magnitude or variability to pre-burn levels 14 years following fire (Beck et al. 2009). Blaisdell (1953) noted little re-establishment of what was probably a Wyoming big sagebrush stand 12 years after fire. Wambolt and Payne (1986) reported a substantial reduction in Wyoming big sagebrush canopy cover compared to a control and other study plots in southwest Montana 18 years post burning. For the same study area 30 years after burning, Watts and Wambolt (1996) reported that Wyoming sagebrush canopy cover was no longer statistically different from the control plot. Lesica et al. (2007) also reported slow recovery rates of Wyoming big sagebrush in southwestern Montana, observing less than 2% recovery after 23 years in 6 separate stands. Cooper et al. (2007) investigated 24 paired burned and un-burned sites in eastern Montana and estimated full recovery time of Wyoming big sagebrush cover on burned sites to be well over 100 years.

Whereas big sagebrush plants are killed by fire, the natural tendency is for these habitat types to eventually return to pre-treatment condition (Peterson 1995) unless there is a lack of sagebrush seed or the recovery process is interrupted by other factors such as invasion of cheatgrass or other annuals (Billings 1990). Type conversion of these habitats to one dominated by cheatgrass or other invasive annual weed species is a high risk and of great concern (Bunting et al. 1987), particularly if those species are present in the existing pre-burn community, where perennial grasses and forbs are suppressed or absent (Chambers et al. 2007). Davies et al. (2008) reported that prescribed fall burning of late seral Wyoming big sagebrush-bunchgrass communities stimulated the herbaceous component and increased the resistance of the communities to cheatgrass invasion 4 years post-burn. In that study, the vegetation communities where treatment and control plots were delineated did not have established cheatgrass, but instead cheatgrass seed was artificially introduced as part of the research. The authors felt their results may have been substantially different if cheatgrass were a part of these vegetation communities and cautioned about the use of prescribed burning where invasive annual grasses were present or in close proximity (Davies et al. 2008).

A popular belief regarding big sagebrush is its competitive role in suppressing herbaceous understory (grasses and forbs). However, many studies contradict this view (Blaisdell 1953, Daubenmire 1975, Peek et al. 1979, Anderson and Holte 1981, Kuntz 1982, McNeal 1984, Mangan and Autenrieth 1985, Sturgis and Nelson 1986, Fraas et al. 1992, Wambolt and Watts 1996, Wambolt et al. 2001, Sowell et al. in press). Herb response within burned areas have been variable with some sites showing considerable increases over more than 15 years post-treatment (Wambolt and Payne 1986) and others showing limited, negative, or very short term responses (Daubenmire 1970, Uresk et al. 1976, 1980, Peterson 1995, Fischer et al. 1996). Interestingly, similar positive herbaceous responses to fire have been reported in pure (shrub-free) mixed grasslands suggesting, in some cases at least, the grass response resulted from factors other than the elimination of sagebrush (Daubenmire 1970, Uresk et al. 1976, 1980). Regardless of the perennial herb response to fire, big sagebrush, which is eliminated by fire, produces substantial foliage (biomass) that serves ecologically important roles, directly supporting many sagebrush obligate and associated species (Peterson 1995:3-6, Welch 2005).

Moreover, Wambolt and Payne (1986) reported a 106% increase in perennial grass production, a 92% increase in perennial forb production, and a 32% decline in Wyoming big sagebrush canopy cover in their control plot resulting simply from 18 years of grazing rest. Robertson (1971) in Nevada and Anderson and Holte (1981) in southeast Idaho reported similar responses of perennial grasses to grazing rest while also experiencing an increase in big sagebrush canopy coverage. Prior to grazing rest, preferred forage grasses at both of these study areas were reported to have been diminished due to long histories of improper grazing.

Prescribed Fire in Pinyon/Juniper Woodlands

Great Basin pinyon pine and juniper woodlands have expanded their pre-European settlement distribution by more than 60% since 1860 due to fire suppression, climate change, and inappropriate management of livestock grazing (Gruell 1999; Miller and Rose, 1999; and Miller and Weigand, 1994). Less than 10% of current woodlands are of age classes exceeding 140 years (Miller and Tausch 2001). As these woodlands fill in across the landscape, the continuity of crown fuel increases (Tausch 1999). This is an ongoing process across the Great Basin (Weisberg et al. 2007, Miller and Tausch 2001, Miller et al. 2005). Crown cover exceeding 50% is sufficient to carry high-intensity fire during dry or windy periods and woodlands with this coverage now occupy 25% of the current range of pinyon-juniper woodlands (Miller and Tausch 2001). That area is expected to double over the next 50 years. As pinyon and juniper stands mature, competition for available resources increases, most understory vegetation is eliminated, and the landscape becomes more susceptible to catastrophic wildfire due to increases in woody fuel loads (Reiner 2004).

Conifer removal is necessary to maintain historic sagebrush communities on landscapes with expanding conifer distribution and density (Miller et al. 2005). Prescribed fire, mechanical treatments, and hand thinning of conifers have been recommended and implemented at multiple locations throughout the Great Basin to slow the spread of these woodlands into sagebrush and mountain shrub communities as well as reduce the risk of high-severity wildfire. Prescribed fire has been acknowledged as the most cost effective tool at managing expansion of these woodlands and historically has been the primary disturbance agent in this ecosystem (Miller and Weigand 1994). However, effective use of prescribed fire requires a better understanding of the extended impact it has on nutrient levels in pinyon-juniper woodlands (Rau et al. 2007), perennial herb response, and the response of associated sagebrush ecosystems. Additionally, understanding how patterns of diversity and abundance in animal communities change over environmental gradients and varying tree densities will aid in more effectively using fire treatments to manage expansion of pinyon-juniper woodlands (MontBlanc et al. 2007).

In a central Nevada site characterized by mountain sagebrush and single leaf pinyon (*Pinus monophylla*) with some Utah juniper (*J. osteosperma*), prescribed burning caused both immediate and persistent changes to soil mineral N and P up to 4 years following treatment (Rau et al. 2007). This may prove beneficial to vegetation recovering from burns in arid locations where water and nutrients are scarce (Sturgis 1993). However, much still depends on the residual abundance of native shrubs and perennial herbs. If there are vegetation voids, the risk for invasion by annual invasive species, such as cheatgrass, increases (Chambers et al. 2007).

Regardless of the type of treatment, it is important to consider historic factors, including disturbance regimes that may have led to the area's current state when developing a management prescription for a particular pinyon-juniper woodland. Romme et al. (2009:204) explains, "Vegetation treatments are often justified, in part, by asserting that a particular treatment (e.g., tree thinning or prescribed burning) will contribute to restoration of historical conditions, i.e., those conditions that prevailed before the changes wrought by Euro-American settlers. However, in the absence of site specific information about historical disturbance regimes and landscape dynamics, ''one-size-fits-all'' treatments are likely to be ineffective, and some well-meaning ''restoration'' efforts may actually move pinyon–juniper ecosystems further from their historical condition. Some kinds of vegetation treatments may even reorganize ecosystems in such a way that restoration of historical patterns and processes becomes more difficult."

<u>Effects of Prescribed Burning on Sage-grouse and their Habitat</u>

Scientific evidence supporting the use of fire for sage-grouse conservation is scant. There is however considerable information documenting negative effects of fire on sage-grouse.

Prescribed burning in Wyoming big sagebrush and three–tip sagebrush (*A. tripartita*) communities during a drought resulted in a large decline of the sage-grouse breeding population and loss of leks (Hulet 1983, Connelly et al. 2000*b*). Byrne (2002) documented avoidance of burned little sagebrush and Wyoming big sagebrush by nesting and brood-rearing females in Oregon. In Idaho, burning mountain big sagebrush had long-term negative impacts on sage-grouse breeding habitats (Nelle et al. 2000). In southwest Wyoming, sage-grouse showed variable responses in the use of burned areas (Slater 2003).

A few studies have speculated that fire may be beneficial for sage-grouse (Klebenow 1972, Sime 1991) and several studies have recorded sage-grouse use of burned sites (Klebenow and Beall 1977, Martin 1990, Coggins 1998, Slater 2003), particularly in mesic settings. Nevertheless, this research lacks scientifically-tested conclusions as to the net impact of prescribed burning on sage-grouse productivity or survival over time. Realizing these kinds of conclusions can be difficult to obtain, we raise this point in deference to the considerable evidence suggesting direct negative impacts to sage-grouse.

In a technical bulletin characterizing habitat changes across the range of sage-grouse, Miller and Eddleman (2001) identified four factors that determine impacts of fire on sage-grouse habitat: (1) site potential, (2) site condition, (3) functional plant group(s), and (4) pattern or size of the burn. They suggested that goals for managing sage-grouse habitat to achieve an optimal balance of shrubs, forbs and grasses at community or landscape levels are similar to goals for restoring or maintaining form, function, and process in sagebrush steppe habitats.

Miller and Eddleman (2001:24) also summarized negative impacts of fire on sage-grouse habitat, including loss of winter and nesting habitat due to removal of sagebrush canopy. They indicated there is no evidence to suggest fire will enhance sage-grouse habitat in Wyoming big sagebrush dominated communities where there already is a balance of native shrubs, perennial grasses and forbs. They further recommend against burning where sagebrush cover is a limiting factor for sage-grouse, where the understory lacks perennial forbs and grasses and introduced annuals are present, or where high amounts of rabbitbrush (*Chrysothamnus* spp.), horsebrush (*Tetradymia canescens*), or snakeweed (*Gutierrezia sarothrae*) are present. These species re-sprout and can increase in abundance following fire. Nelle et al. (2000) reached a similar conclusion and reported that prescribed fire negatively affected habitat conditions for sage-grouse nesting and brood rearing up to 15 years post-burn.

Fire can also affect insects, which are important food for young sage-grouse (Klebenow and Gray 1968, Johnson and Boyce 1990, Fischer et al. 1996). The effect of fire on insect species diversity and abundance is variable depending on a multitude of environmental factors and research methods. MontBlanc et al. (2007) investigated the effects of prescribed burning on ant (*Hymenoptera*) species richness in a pinyon-juniper woodland in central Nevada and found significantly more ant species after treatment on burned plots. The researcher suggested that thatch ants fulfill most of their dietary needs by tending aphids on sagebrush (McIver and Yandell 1998) and if the sagebrush community did not re-establish quickly, thatching ant colonies could, over time, experience a decline in abundance or even colony demise. Nelle et al. (2000) reported elevated ant and beetle abundance at burned sites in southeastern Idaho with a subsequent decline in abundance to pre-burn levels 3-5 years post burn. Fischer et al. (1996) also reported a decline in ant abundance 2 and 3 years post burn in southeastern Idaho. In Oregon, Pyle and Crawford (1996) reported abundance of 2 beetle species were unaffected by fire. In a southwestern Wyoming study, Slater (2003) failed to detect a significant difference in insect abundance and biomass between all burned and unburned sites. Slater detected a lower abundance of ants and total mass of optimal-sized insects at brood sites from within burns compared to brood sites outside of burns. Slater also recorded significantly lower beetle abundance on 1-year old burns and significantly higher beetle abundance on a 12-year old burn, relative to unburned sites.

Beck et al. (2009), after investigating the impact to wintering, nesting, and early brood habitat 14 years post burn, concluded managers should not consider prescribed fire in xeric sagebrush habitats. Instead, they recommended implementing treatments that maintain sagebrush. Eng and Schladweiler (1972) similarly recommended conserving large landscapes with available wintering cover because of the extended use sage-grouse make of these areas. Woodward (2006:65) concluded, "Some portions of grouse habitat may benefit from management for greater herbaceous cover, but never at the sake of sagebrush." Baker (2006) also recommended that fire should not be introduced into sagebrush ecosystems until native understory plants have been restored, particularly in situations where there is the potential for replacement by cheatgrass. In these situations he recommended fire suppression as an appropriate management action to help avoid further cheatgrass conversions. Connelly et al. (2000) recommended in areas of large-scale habitat loss (e.g., >40% of original wintering areas) to protect all remaining sagebrush habitat. Wambolt et al. (2002:11) also recommended against the use of prescribed fire in sage-grouse breeding or wintering areas, further concluding, "In general, activities that remove sagebrush or fragment sagebrush habitats into smaller pieces should be avoided to the extent possible."

The Issue of Scale

Sage-grouse are a landscape scale species (Dalke et al. 1963, Connelly et al. 1988, Leonard et al. 2000) that require large areas to complete their annual life cycle. Their distribution is closely tied to current distribution of sagebrush habitats (Wambolt et al.

2002, Schroeder et al. 2004). In central and southwest Wyoming, about 25% of 340 nest locations were over 6.5 km (4 miles) from the lek hens were captured on; 15% extended beyond 8 km (5 miles) (Holloran and Anderson 2005). Doherty (2008) found 21% (80 of 381 nests) of nests extending beyond 5 km (3 miles) of the lek of capture. In Idaho, the mean nest distance to lek of capture was 4.6 km (2.9 mile) (Wakkinen et al. 1992). These findings indicate a single lek may support hens from the surrounding 13-80 $miles^2$ (34-207 km^2) or more of habitat. Broad spacing of nests appears to be a nest survival strategy (Holloran and Anderson 2005, Doherty 2008). Migratory sage-grouse cover larger areas, moving over 10 km (6.2 miles) between seasonal ranges (Connelly et al. 2000a) with habitat use areas exceeding 2,700 km^2 (1,040 $miles^2$) (Connelly et al. 2000a, Leonard et al. 2000).

As a landscape species, sage-grouse are adapted to seeking specific habitat needs over sizeable areas (Connely et al. 2004). Sage-grouse habitat configurations are largely defined by vegetation patterns at landscape and microsite scales (Connelly et al. *in press*). Land managers assessing sage-grouse habitat limitations should consider the scales at which these birds operate. For example, a 3,000-acre grazing allotment may represent only part of the annual range for a population of sage-grouse. Assessing potential habitat limitations for sage-grouse should consider the scale of area available to these birds for meeting their annual needs (Johnson 1980).

Doherty et al. (2008) suggested understanding landscape-scale habitat selection during critical life stages is essential for developing conservation recommendations but seasonal habitats often overlap (Connelly et al. 1988). For instance, winter habitat may also provide nesting and brood habitat. Thus, a prescribed fire intended to improve brood habitat may conflict with other important seasonal uses. The occurrence of large wildfires, agricultural conversion, urban/suburban development, roads and associated traffic, transmission lines, oil and gas facilities, wind energy facilities and other disturbances affect habitat function. As an example, when Aldridge and Boyce (2007) evaluated habitat at multiple scales, they found sage-grouse selected large expanses of sagebrush and avoided anthropogenic edge during the breeding season. Doherty et al. (2008) found that sage-grouse avoided energy development in otherwise suitable habitats during winter. Thus assessing the need and potential impact of prescribed fire must consider habitat limitations resulting from natural and anthropogenic disturbances to help define intact functional habitat and to also understand potentially exacerbating impacts of vegetation treatments.

Treatment patch size is another important consideration. In Wyoming, Slater (2003) found that 85% of general sage-grouse use of burned sites occurred within 60m of the burn edge. Similarly, Wilson (2000) found 80% of flushed birds from treated areas (burned or disked/reseeded) were within 60m of sagebrush (remnant island or treatment edge) in Utah. Based on these findings, Slater (2003) recommended that treatment areas should not exceed 120m in width but containing prescribed fire to meet these specifications would be difficult. Pederson et al. (2003) similarly warned that although small fires may benefit sage-grouse, large fires (those that burn 10% or more of available breeding habitat) occurring at high frequencies may lead to the extinction of sage-grouse populations.

Habitat Restoration

Big sagebrush has been labeled a nuisance invading species and an effective competitor with little forage value for livestock compared to native bunchgrass communities (Vale 1974, Knick and Rotenberry 1997, Knick et al. 2003, Welch 2005). An abundance of the species was considered by some to be the product of improper livestock grazing practices (Peterson 1995). Considerable documentation emerging over the past 40+ years has revealed these popular ideas are generally not accurate (Welch 2005), and in fact sagebrush grasslands in good ecological condition are a stable (climax) habitat that supports a diversity of perennial forbs and grasses (Daubenmire 1970, Mueggler and Stewart 1980, Beetle and Johnson 1982, Anderson and Inouye 2001). Peterson (1995:34) summed this up by stating, “Sagebrush is a product of the range, range condition is not a product of sagebrush.” In spite of this, landscapes dominated by big sagebrush have been targets for prescribed burning to reduce sagebrush abundance in an effort to improve grass and forb production (Pechanec et al. 1965, Frandsen 1985, Bunting et al. 1987) as well as to control annual grasses, control pinyon and juniper woodland expansion (Connelly et al. 2004), and to generally “improve” wildlife habitat (Bunting et al. 1987, Peterson 1995).

Stevens (2004) provided 10 principles of rangeland renovation speaking to site potential, timing and other necessary considerations for a successful restoration project. For the purposes of wildlife habitat restoration, we offer an additional principle. That is, to understand and work within the ecological context of the site considered for restoration. From the standpoint of sage-grouse, this would mean understanding sage-grouse seasonal use of the prospective burn site and what short and long-term impacts the proposed treatment would have.

Charlet (2008:20) concluded, “‘no action’ in most cases in xeric habitats, is superior to aggressive action in the absence of baseline data and experimental design.” He further points out that high impact manipulative projects on vegetation throughout Nevada may create more harm than good by simplifying vegetative structure and further enabling alien weeds to colonize. Restoring degraded rangelands is a complex and difficult undertaking that has significant implications for sage-grouse conservation. These quandaries underscore the importance of conserving intact sagebrush grassland habitats, which is ecologically and financially a more sound approach than allowing these habitats to degrade to the point of considering substantial human intervention.

Ecological site descriptions and state and transition models can be informative tools for helping understand ecological processes in rangelands (Briske et al. 2006). However, in the context of sage-grouse habitat, we are concerned that state and transition models developed for sagebrush grasslands could overemphasize (or be misinterpreted as to) the need for treatments while minimizing the relatively stable essence of sagebrush grassland habitat types as an ecological endpoint or climax state (Daubenmire 1970, Beetle and Johnson 1982, Mueggler and Stewart 1980, Knight 1994). Bestelmeyer (2006) describes a process for establishing and refining state and transition concepts based first on best science followed by an iterative series of monitoring and inventory steps that lead to model refinements. We recommend that state and transition models be based on best science, principles of plant ecology, and scientific observation, avoiding speculation or popular biases.

Restoration and Prescribed Fire

Xeric sagebrush grassland habitats vary widely in health or vegetative integrity (Daubenmire 1970, Mueggler and Stewart 1980). Grazing history, soil texture, soil loss, soil compaction, soil disturbances, soil nutrients, available moisture, weather, competition from exotic invaders, predominant forb and grass species, and others factors drive occurrence and abundance of understory plants as well as occurrence of bare soils (Welch 2005, Monsen et al. 2004, Peterson 1995, Tiedemann and Lopez 2004). Allen (1995) points out the difficulty of establishing late successional species in early succesional soils. More specifically, she indicates that in areas where the A horizon has been removed through erosion, true restoration of mid or late successional species is seldom achievable. This problem is reduced to soil genesis, which may take centuries or more to achieve naturally (Allen 1995). Thus, intactness of the A horizon soil layer is an extremely important consideration when assessing sites that support sagebrush with little understory and has strong implications when prescribed fire is considered as part of the restoration process.

Stevens and Monsen (2004) listed a variety of mechanical, chemical, and fire treatments that may have application for restoring big sagebrush habitat. Although prescribed burning may be less expensive than some treatments (Frandsen 1985, Bunting et al. 1987), burning may be the least preferred technique. In a Wyoming big sagebrush setting, burning often removes or kills all sagebrush plants, which is not recommended for treating a lack of understory (Stevens and Monsen 2004), and has negative consequences for sage-grouse and could result in an increase in annual weeds and grasses. When Wyoming or basin big sagebrush is common in a prospective treatment area, mechanical treatments are considered by some to be more appropriate (Commons et al. 1999, Brockway et al. 2002).

Prescribed fire tends to burn the best remaining nesting and wintering habitats, can be difficult to control, and often leaves areas with poor understory (Connelly et al. 2000a, Beck et al. 2009). Further, Connelly et al. (2000a) recommended that fire should not be used in sage-grouse breeding habitats dominated by Wyoming big sagebrush or in xeric mountain big sagebrush communities because of the risk of invasion by annual grasses. Sagebrush grassland fire literature reviewed for this paper suggests variable and somewhat uncertain outcomes in terms of intended versus actual fire behavior, fire intensity, perennial grass and forb response varying by species and site (Whisenant 2004:102-103), exotic invader response, and resprouting response by other shrub species. These variables in turn also affect long-term sage-grouse habitat quality. If prescribed fire is used as a restoration technique, treatments will need to be very small to accommodate the extended time required for sagebrush pioneering (Stevens and Monsen 2004) and to minimize other potentially negative impacts.

Monsen (2004:26) clarified the use of aggressive treatments by stating, "If an adequate composition of desirable species that is capable of recovery and natural spread remains, artificial seeding is unnecessary. If properly managed, plants that have been weakened by excessive grazing and browsing can normally recover and begin producing seed within a few years." Monsen (2004:26) further observed, "Some disturbed areas within the Wyoming big sagebrush zone in southern Idaho have remained in almost a static condition for more than 50 years with protection from grazing. However, considerable improvement resulted following 3 unusually wet years." Allen (1995) made a similar statement about natural moisture pulses, which can be key to realizing a vegetation response. Range deterioration has its origins over a relatively long history; it may only be reasonable to anticipate xeric habitats requiring an extended time to heal. A more conservative long-term approach to restoration serves to maintain sagebrush while realizing less risk of doing more harm than good (Charlet 2008).

With regard to restoration treatments where sagebrush stands lack an understory, we recommend the following:

- Avoid use of prescribed fire in xeric sagebrush habitats.
- Conduct mechanical and/or chemical restoration treatments only with an understanding of their impacts on sage-grouse habitats and how these areas are affected by other factors such as habitat conversion and anthropogenic developments (that is, cumulative effects on the landscape).
- In areas of large-scale habitat loss, protect all remaining sagebrush habitats from further loss, fragmentation, or treatment that reduces sagebrush canopy cover.
- Use an adaptive approach with the intent of minimizing impacts to sage-grouse, sagebrush, and perennial native vegetation. Consider impacts on all native organisms and ecosystem processes.
- Review past treatments in similar range sites to ascertain vegetation responses. Use pilot treatments to refine techniques and study vegetation responses.
- Conserve and enhance remnant native vegetation and soils (Allen 1995).
- Where feasible, use carefully managed grazing in place of intensive treatments that involve fire, mechanical or chemical applications.

Conclusions

The sagebrush biome has diminished and been fragmented across much of its historic range. Several factors are responsible including agricultural conversion, large wildfires, pinyon pine and juniper expansion, urban development and, more recently, energy development. Xeric sagebrush communities, largely made up of Wyoming big sagebrush, are not adapted to fire and are characterized as having a high severity fire regime. Natural fire rotation in these settings appears to be measured in centuries not decades. Invading species such as cheatgrass have further raised the stakes for permanent vegetation type conversion from sagebrush stands to exotic annual grass/forb communities as a result of fire, particularly where understory herbs are already depressed.

Managers have implemented prescribed fire in remaining sagebrush grasslands to achieve certain objectives, which at times have suggested benefits to sage-grouse. Our review of the literature includes considerable documentation revealing direct negative impacts of fires on sage-grouse habitats and populations. In contrast, little conclusive evidence exists to support prescribed fire treatments as benefiting sage-grouse. Numerous researchers have instead realized the need for maintaining sagebrush as a critical habitat component for sage-grouse and many other native species.

Prescribed burning may have some application in pinyon and juniper woodlands as long as there is a native perennial herbaceous community present in the understory. If not, there is a high risk of invasion by annuals and other noxious weeds. If cheatgrass or medusahead is present in the understory of pinyon-juniper woodlands (in a condition class conducive to restoration) then mechanical treatment or hand-thinning should be used rather than prescribed fire. Managers should apply research findings regarding specific thresholds pertaining to tree canopy cover and understory components. If these thresholds are exceeded a new unstable alternative vegetative state can result. Prescribed fire should not be used outside of identified thresholds. When prescribed fire is used to subdue pinyon pine and/or juniper woodlands, sagebrush stands should be protected to conserve sagebrush habitat and allow sagebrush recruitment back into burned areas.

In general, prescribed fire can result in further habitat conversion or fragmentation. Prescribed fire is less selective and tends to burn the best remaining habitats, often causing additional ecological harm. Most of the recommendations cited do not suggest prescribed fire unless a native perennial herbaceous component remains in the understory and invasive species like cheatgrass are absent and even then this approach does not receive broad support. Relatively few landscapes fitting these criteria remain in xeric sagebrush communities, particularly within the Great Basin.

In some circumstances where sagebrush occurs but lacks herbaceous understory, chemical or mechanical treatments that thin sagebrush cover and allow for mechanical seeding of native grasses and forbs may be necessary to accelerate restoration of sagebrush grassland habitats. Treatments are most appropriate where loss of topsoil is an imminent risk. Treatments should not be implemented without a high likelihood of success. Additional research regarding treatments such as these, as well as the utility of prescribed fire in mesic big sagebrush communities, will assist managers with improving prescriptions for certain landscapes with consideration for sagebrush obligate species like sage-grouse.

Given the large losses of sagebrush habitats, we encourage managers to first consider means to conserve and improve native vegetation integrity and habitat function as opposed to promoting projects that attempt to establish uncertain disturbance regimes with stand replacing treatments that further fragment degraded sagebrush habitats and risk establishment of invasive species. Realizing these habitats deteriorated over long periods of time extending over large expanses, a long-term approach to large-scale restoration appears more feasible. A combination of fire suppression and more conservative management techniques should be considered first. For those habitats in a healthy intact status, actively conserving these areas pays ecological dividends and avoids the future prospect of intensive treatments with uncertain success.

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