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Effects of Intermediate-Term Grazing Rest on Sagebrush Communities with Depleted Understories: Evidence of a Threshold☆,☆☆

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ABSTRACT

Millions of hectares of sagebrush (*Artemisia* L.) plant communities have been degraded by past improper management, resulting in dense sagebrush stands with depleted herbaceous understories. Rest from grazing is often applied to promote recovery. However, the effect of intermediate-term (5–10 years) rest from grazing in sagebrush communities with depleted herbaceous understories and dense sagebrush is relatively unknown. We compared well-managed, moderate grazing (grazed) with intermediate-term (5 and 6 years) rest (ungrazed) at five sites in southeastern Oregon. Sites were Wyoming big sagebrush (*Artemisia tridentata* Nutt. subsp. *wyomingensis* Beetle & Young) communities with dense sagebrush and depleted herbaceous understories. Perennial herbaceous cover was greater in ungrazed compared with grazed areas, but this was expected because herbivory removes foliar vegetation tissue (i.e., cover). Density of herbaceous vegetation, diversity, and species richness did not differ between ungrazed and grazed areas. Similarly, bare ground, litter, and biological soil crust cover did not differ between treatments. These results suggest that intermediate-term rest is unlikely to elicit recovery of the understory compared with moderate grazing in these communities. The results of this study also suggest that degraded Wyoming big sagebrush communities likely have crossed a threshold that may be difficult to reverse.

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Introduction

Wyoming big sagebrush (*Artemisia tridentata* Nutt. subsp. *wyomingensis* Beetle & Young) communities are one of the most extensive plant communities in the sagebrush ecosystem that occupies > 500,000 km^2 in the Intermountain West (Küchler, 1970; Miller and Eddleman, 2000). These communities provide critical habitat for sagebrush-associated wildlife and are an important forage base for livestock production (Davies et al., 2011). However, large tracts of Wyoming big sagebrush plant communities have been degraded through historical overgrazing by sheep, cattle, and horses, resulting in communities with few large perennial bunchgrasses and perennial forbs and an increased dominance of shrubs (Davies et al., 2011; Miller and Eddleman, 2000; West, 1983). West (2000) estimated that 25% of the entire sagebrush ecosystem was composed of sagebrush plant communities with degraded herbaceous understories and increased shrub dominance. The percent of the Wyoming big sagebrush ecosystem with degraded herbaceous understories and increased shrub dominance is probably much greater than the average for the entire sagebrush ecosystem because it is less resilient to disturbance than wetter, cooler sagebrush communities (Chambers et al., 2007; Chambers et al., 2014; Davies et al., 2011). Restoration of these plant communities has become a critical management concern because of their value as wildlife habitat, as well as to provide quality livestock forage, increase resistance to exotic annual grasses, and enhance resilience to wildfire (Davies et al., 2011).

Degraded Wyoming big sagebrush communities have proven to be exceedingly difficult to restore. Using fire or mechanical methods to reduce sagebrush dominance to increase resource availability to native perennial herbaceous vegetation has generally resulted in increases in exotic annuals with little response from native perennial bunchgrasses and forbs (Beck et al., 2012; Davies et al., 2012; Pyke et al., 2014). Seeding native perennial bunchgrasses after mechanically reducing sagebrush has also been a general failure, with small increases in native bunchgrasses but large increases in exotic annual grasses and forbs (Davies and Bates, 2014). The lack of successful treatments to restore Wyoming big sagebrush plant communities may, in some ways, suggest that restoration should not be attempted. However, these plant communities historically burned in infrequent wildfires and it is likely that they will inevitably burn and then convert to exotic annuals post fire (Davies and Bates, 2014). Therefore, it is imperative to investigate methods to

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restore these communities. All the previously discussed approaches applied a disturbance that reduced or removed sagebrush in an attempt to increased native perennial understory vegetation. These treatments increased exotic annuals (Beck et al., 2012; Davies and Bates, 2014; Davies et al., 2012; Pyke et al., 2014), which are often favored by disturbances (Chambers et al., 2007; Norton et al., 2007; Seabloom et al., 2003). Therefore, a different approach is needed, likely one that does not significantly disturb the sagebrush overstory as the loss of sagebrush in these communities can increase the growth of exotics (Prevéy et al., 2010). A potential approach to promote recovery of these communities may be to exclude grazing by livestock. Rest from grazing may facilitate recovery (increases in abundance) of large native bunchgrasses and perennial forbs because defoliation may be limiting their ability to increase. Grazing can place grazed plants, through the loss of photosynthetic tissues, at a competitive disadvantage with ungrazed plants (Briske and Richards, 1995; Caldwell et al., 1987).

Rest from grazing by cattle is traditionally applied to the sagebrush steppe ecosystem to promote recovery from past grazing effects and fire (Davies et al., 2014a). Most commonly rest is applied for 1 year as part of a grazing management system and for 1 or 2 years after disturbances such as fire (Bates et al., 2009). However, longer-term grazing rest has been applied or proposed for some sagebrush plant communities. The effects of rest in sagebrush communities has mainly been long-term (>10 years) rest and in communities retaining a largely intact herbaceous understory or without a dense sagebrush overstory (Anderson and Inouye, 2001; Courtois et al., 2004; Davies et al., 2009, 2010; Manier and Hobbs, 2006; Rickard, 1985; West et al., 1984). Information on effects of intermediate-term (5–10 years) rest on sagebrush communities is rare (Davies et al., 2014a) and has been limited to sites with large native perennial bunchgrasses and forbs dominating the understory (e.g., Bates and Davies, 2014; Bates et al., 2009; Davies et al., 2014b).

Though grazing rest has been proposed by some authors (e.g., Beschta et al., 2013; Fleischner, 1994) to promote recovery from damage caused by past improper grazing practices and prevent further ecosystem degradation, it remains unclear if grazing rest conveys more ecosystem benefits than well-managed, moderate grazing. Rest from grazing is clearly advantageous over detrimental grazing practices of heavy, repeated growing season use, but moderate grazing at times may achieve similar results as grazing rest (Davies et al., 2014a). However, many grazing studies do not report grazing levels or only compare heavy, repeated defoliation during the growing season with grazing rest (Jones, 2000; Svejcar et al., 2014). Thus, information comparing effects of intermediate-term rest and well-managed, moderate grazing are lacking. This information is critical to allow for more informed land management decisions as natural resource managers attempt to restore and protect sagebrush communities.

The purpose of this research project was to determine effects of intermediate-term (5 and 6 years) rest from grazing compared with moderate grazing by cattle on Wyoming big sagebrush communities with a depleted herbaceous understory and high sagebrush cover. We predicted that intermediate-term rest would increase the density and cover of native perennial bunchgrasses and forbs, increase the cover of biological soil crusts, decrease the density and cover of annual grasses and forbs, and increase species diversity and richness. We did not expect intermediate-term grazing rest to influence sagebrush cover and density.

Materials and Methods

Study Area

This study was conducted in Wyoming big sagebrush communities in southeast Oregon between 40 and 50 km southwest of Burns, Oregon, United States. Before treatment the herbaceous understory was considered depleted and sagebrush cover was high. Large perennial bunchgrass cover and density averaged across all study sites was 1.2% and 2.4 individual$\cdot m^{-2}$, which is 7.5 to 10.2 times less cover and 4 times less dense than the average reported for relatively intact Wyoming big sagebrush communities in this region (Davies and Bates, 2010; Davies et al., 2006). Sagebrush cover averaged 19.4% across study sites, which is 1.6- to 2-fold greater than the average sagebrush cover in Wyoming big sagebrush communities with intact herbaceous understories (Davies and Bates, 2010; Davies et al., 2006). Historical livestock use of this area was heavy (>50% utilization of available forage) and often season long, but recent use was well-managed, moderate grazing (Davies et al., 2012). Well-managed, moderate grazing by cattle of native Wyoming big sagebrush plant communities is <50% utilization and alternating season of use or incorporating periods of rest to ensure that plants are only defoliated during the growing season (spring) every other year or less frequent. The depleted understory, as evident from the vast differences between our study sites and relatively intact Wyoming big sagebrush communities, was likely caused by historical heavy livestock use. These sites were not dominated by annuals as exotic annual grass cover and annual forb cover averaged < 1% and 4.4%, respectively. Sandberg bluegrass (*Poa secunda* J. Presl) and bottlebrush squirreltail (*Elymus elymoides* [Raf.] Swezey) were the most common perennial grasses at study sites. Thurber's needlegrass (*Achnatherum thurberianum* [Piper] Barkworth) and/or bluebunch wheatgrass (*Pseudoroegneria spicata* [Pursh] A. Löve) were also found at study sites and would have likely been the dominant/codominant perennial grasses if these sites were not degraded (NRCS, 2013). Elevation of study sites was between 1263 and 1350 m, and topography was relatively flat (0—4%). Soil depths ranged from 50 to 100 cm to a duripan and were loamy and well drained. Climate was representative of the northern Great Basin with cool wet winters and hot dry summers. Long-term average annual precipitation (1981–2010) ranged from 240 to 270 mm among study sites (PRISM, 2014). Crop year (Oct. 1—Sept. 30) precipitation was 107%, 93%, 137%, 78%, 100%, and 88% of the long-term average in 2009, 2010, 2011, 2012, 2013, and 2014, respectively (PRISM, 2014).

Experimental Design and Measurements

We used a randomized complete block design with five blocks (sites) to determine the response of Wyoming big sagebrush communities to intermediate-term rest from grazing. Treatments were: 1) intermediate-term rest (ungrazed) and 2) well-managed, moderate grazing by cattle (grazed). Treatments were randomly assigned to one of two 30 × 60 m plots at each of the five sites. These five sites occurred in different grazing pastures and were on average separated by 10 km. Intermediate-term rest was applied by constructing 60 × 150 m grazing exclosures in January and February of 2009. A 30 × 60 m plot inside of each 60 × 150 m grazing exclosure was sampled to determine the effects of grazing rest. A 30 × 60 m grazed treatment plot was adjacent to each grazing exclosure with a 10-m buffer between them at each site. The grazing treatment was applied at the pasture level and pastures were > 1000 ha in size. Grazing pressure was 40% utilization of available forage, which is considered moderate use in this environment. Season of use alternated between spring use (May and June) and summer use (July and August) each year. Rotation of season of use varied among the pastures.

Vegetation, litter, bare ground, and biological soil crusts were measured in June the fifth and sixth growing seasons (2013 and 2014) after grazing exclosures were constructed. Herbaceous vegetation, litter, bare ground, and biological soil crusts were measured along four 50-m transects using 0.2-m^2 quadrats placed at 3-m intervals (starting at 3 m and ending at 45 m), resulting in 15 quadrats per transect and 60 quadrats per plot. The 50-m transects were laid out parallel to the long edge of the plot and spaced 5 m apart. Foliar cover of herbaceous vegetation by species and ground cover of litter, biological soil crust, and bare ground were visually estimated in the 0.2-m^2 quadrats using markings that divided quadrats into 1%, 5%, 10%, 25%, and 50% segments.