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Postfire grazing management effects on mesic sagebrush-steppe vegetation: Spring grazing

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ABSTRACT

The influence of fire-grazing interactions on ecological pattern and process has been fairly well studied in some rangeland ecosystems (e.g., tallgrass prairie) but is only poorly understood in others. On sagebrush-steppe rangelands of the western US, there has been a long-standing concern that fire followed by grazing can cause substantial mortality in sensitive plant species. Vegetation responses to fire-grazing interactions, however, have never been studied in the higher elevation, more mesic portions of the sagebrush-steppe. We investigated whether graminoid, forb, and litter cover; bare ground; and species density and frequency responses differed among burned areas which were grazed at a very light stocking rate (33 ha AUM^{-1}) during spring (May) without postfire deferment, burned areas where 1–2 growing seasons of grazing deferment were applied, and burned areas completely excluded from postfire grazing. Fire-grazing interactions had very few effects on vegetation but did reduce litter cover and bare ground compared to burning alone. This was a case study; consequently, caution should be taken in applying these results beyond their limited scope of inference. In some situations, however, postfire grazing can likely be employed without deferment or after deferring for only one growing season, and not cause substantial adverse impacts on vegetation.

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1. Introduction

Fire is a disturbance which plays a number of critical roles in most rangeland ecosystems. Fire can promote successional cycling and changes in plant species composition (Christensen, 1985; Keane et al., 2004; Spasojevic et al., 2010; Turner et al., 1997; Vermeire et al., 2011), affect nutrient cycling (Boerner, 1982; Ojima et al., 1994), enhance the diversity and productivity of habitats for wildlife and domestic animals (Hobbs and Spowart, 1984; Peek et al., 1979), and increase forage quality, palatability, and availability for grazers (Van Dyke and Darragh, 2007; Willms et al., 1980). Grazing is also a disturbance agent on rangelands that can alter vegetation structure and composition (McNaughton, 1984; Manier and Hobbs, 2007; Milchunas et al., 1988; Milchunas and Lauenroth, 1993), promote enhanced forage quality and palatability (Clark et al., 1998, 2000; Ganskopp et al., 2004; Ganskopp and Rose, 1992) and the effects of fire and grazing can be interactive (Allred et al., 2011a; Hobbs et al., 1991; Knapp et al., 1999; Turner et al., 1994; Zimmerman and Neuenschwander, 1984).

The influence of fire-grazing interactions on ecological pattern and process has been fairly well studied in some rangeland ecosystems but is very poorly understood in others. In native tallgrass prairie, the combination of fire and ungulate grazing can promote and sustain heterogeneity in vegetation cover, affect productivity, and alter species composition (Collins and Smith, 2006; Fuhlendorf et al., 2008, 2009); enhance wildlife habitat (Fuhlendorf et al., 2006); and ultimately feedback to influence the fire regime (Kerby et al., 2007). Outside of the prairie grasslands, some studies have investigated the effects of fire and grazing separately (Underwood and Christian, 2009; Valone and Kelt, 1999) but few have set out to explicitly examine fire-grazing interactions (e.g., Noy-Meir, 1995; Bates et al., 2009).

On sagebrush-steppe rangelands of the western US, there has been a long-standing concern that the combined effects of fire and postfire grazing can cause substantial mortality in sensitive plant species. Citing postfire vigor-recovery rates for perennial bunchgrass species, Wright and Bailey (1982) suggested at least 2 years of rest from livestock grazing may be required before burned

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perennial grasses have recovered sufficient vigor to tolerate postfire herbivory. Based largely on this suggestion, public land-management agencies throughout the sagebrush-steppe ecotype have developed a postfire grazing management guideline which stipulates that burned areas should be rested from livestock grazing for at least 2 growing seasons postfire. Although this guideline has been applied for many years, its scientific foundation remains quite limited, and its legitimacy and efficacy have been and continue to be questioned (Bates et al., 2009; Bruce et al., 2007; Bunting et al., 1998; Sander, 2000).

Early research to evaluate the interactive effects of fire and livestock grazing on sagebrush-steppe vegetation provided some useful information towards resolving this postfire grazing controversy but these studies had some substantial limitations. Rather than applying fire and postfire livestock grazing treatments at the plant-community scale or broader, these early studies used mechanical means to burn and subsequently clip individual bunchgrass plants to evaluate their vigor and mortality responses to simulated fire-grazing interactions (Jirik and Bunting, 1994; Bunting et al., 1998). These burn-and-clip studies intentionally used a very short, uniform stubble height (i.e., 2 cm) to simulate the effects of a high postfire utilization rate on bunchgrass species. Uniform clipping heights, however, may not accurately simulate the defoliation effects of actual cattle grazing on vegetation responses (Wallace, 1990). Furthermore, high forage utilization rates within burned areas are not inevitable. Under a moderate stocking rate, cattle grazing may in fact produce a fairly short, uniform stubble height on bunchgrass during the first few postfire years. Under conservative or very light stocking rates, however, the level of bunchgrass utilization can potentially be much more variable and the mean stubble height somewhat higher than under moderate stocking. Recent work in the short-grass steppe indicates conservative stocking rates are an effective means of minimizing any adverse effects of postfire cattle grazing (Augustine et al., 2010). The effects of conservative postfire cattle stocking rates on responses of sagebrush-steppe vegetation have never been rigorously evaluated, particularly, when applied in combination with differing levels of postfire rest from grazing.

Because of their nature, the burn-and-clip studies also did not evaluate the interactive effects of fire and livestock grazing on plant community-level responses such as cover by growth form or plant species density and frequency by functional group. More recent studies on Wyoming big sagebrush (*Artemisia tridentata* Nutt. ssp. *wyomingensis* Beetle & Young) or basin big sagebrush (*A. tridentata* Nutt. ssp. *tridentata*)/black sagebrush (*Artemisia nova* A. Nelson) rangelands have, however, directly evaluated plant-community responses to prescribed fire and postfire cattle grazing (Bates et al., 2009; Bruce et al., 2007). Generally, these studies found, even under moderate stocking rates and moderate levels of utilization, that one growing season of rest from postfire cattle grazing allowed herbaceous plant recovery to proceed. These studies, however, were conducted in some of the drier areas and community types of the sagebrush-steppe ecotype. In higher elevation, mesic sagebrush-steppe vegetation; where mountain big sagebrush (*A. tridentata* Nutt. ssp. *vaseyanna* Beetle) is generally dominant or co-dominant, plant community-level responses to the interaction of fire and postfire cattle grazing have never been studied.

Our intent with this current study was to address two questions. First, in mesic sagebrush steppe, do plant community-level responses differ among different durations of postfire rest from cattle grazing when a very light stocking rate is used? Second, do vegetation responses to postfire grazing-rest treatment differ among sagebrush-steppe community or vegetation types? We hypothesized mesic sagebrush-steppe vegetation will have similar amounts of perennial grass, forb, and litter cover; bare ground; and species density and frequency levels whether these burned areas received no postfire grazing at all; were grazed at a very light stocking rate during the month of May within the first postfire growing season (i.e., no rest from grazing); or were subjected to different levels of postfire rest from grazing. Further, we expected these vegetation responses would be similar whether the postfire grazing-rest treatment was applied in a vegetation type dominated by mountain big sagebrush and mountain snowberry (*Symphoricarpos oreophilus* A. Gray) or in a type dominated by antelope bitterbrush (*Purshia tridentata* [Pursh] DC) and mountain big sagebrush. We tested these hypotheses in a case study following a landscape-scale, fall prescribed fire applied to mesic sagebrush steppe rangelands of southwestern Idaho, USA.

2. Methods

2.1. Study area

The research was conducted in the Whiskey Hill prescribed-fire study area (43° 9′ 49″ N, 116° 47’ 51” W) located on private lands within the Reynolds Creek Experimental Watershed (RCEW) in the Owyhee Mountains about 80 km south of Boise in southwestern Idaho. Climate is continental. Winters are cold and wet. Long-term (1962–2009) mean annual precipitation at the Whiskey Hill gauges (095 and 095b) was 453 mm (NWRC, 2014). Typically about 34% of this precipitation occurs as snow (Hanson, 2001). Summers are warm and dry. The growing season is about 100 days but frost can occur during any month of the year. Long-term (1967–2010) mean daily maximum, minimum and mean air temperatures at the nearby Lower Sheep Creek weather station (127x07) were 12.7, 3.8, and 8.3 °C, respectively (Hanson et al., 2001; NWRC, 2014).

The Whiskey Hill study area (324 ha) is a fenced rangeland pasture which spans a north-south ridgeline and includes the adjoining west and east-facing hillslopes. Elevation at Whiskey Hill ranges from 1523 to 1878 m. Slopes range from flat to very steep (176.8% or 60.5° maximum) with aspects in all four cardinal directions well represented. Soils are primarily derived from granitic parent materials and composed of a complex of Takeuchi (coarse, loamy, mixed, frigid Typic Haploxerolls) and Kanlee (fine, loamy, mixed, frigid Typic Argixerolls) soil series (Seyfried et al., 2001).

Vegetation at Whiskey Hill is dominated by three cover types: i) mountain big sagebrush – mountain snowberry, ii) antelope bitterbrush – mountain big sagebrush, and iii) native bunchgrass. Besides the 2 dominant species, the mountain big sagebrush-mountain snowberry type includes western juniper, yellow rabbitbrush (*Chrysothamnus viscidiflorus* [Hook.] Nutt.), Saskatoon serviceberry (*Amelanchier alnifolia* [Nutt.] Nutt. ex M. Roem. *alnifolia*), bluebunch wheatgrass (*Pseudoroegneria spicata* [Pursh] A. Löve), squirreltail (*Elymus elymoides* [Raf.] Swezey), Idaho fescue (*Festuca idahoensis* Elmer), Sandberg bluegrass (*Poa secunda* J. Presl.), silvery lupine (*Lupinus argenteus* Pursh), tapertip hawksbeard (*Crepis acuminata* Nutt.), and western stoneseed (*Lithospermum ruderale* Douglas ex Lehm.) (See online Supplemental Materials for a full species list). Other components of the antelope bitterbrush-mountain big sagebrush type include western juniper, native bunchgrasses and forbs. Of these two, shrub-dominated cover types, the mountain big sagebrush-mountain snowberry type generally had the most herbaceous cover, both in the interspaces and under the shrub canopy (Clark unpublished data). The native bunchgrass cover type is dominated by bluebunch wheatgrass, squirreltail, Idaho fescue, and Sandberg bluegrass. Cheatgrass (*Bromus tectorum* L.), an exotic annual grass, exhibits a minor to common presence within all three of these dominant vegetation types. A curl-leaf mountain mahogany (*Cercocarpus*