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Postfire grazing management effects on mesic sagebrush-steppe vegetation: Mid-summer grazing☆

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ABSTRACT

Postfire livestock grazing management in the higher-elevation, mesic portions of the sagebrush steppe lacks a firm scientific foundation to support decision making. Following a prescribed fire conducted in fall 2002, we evaluated effects of different lengths of rest from mid-summer (July) cattle grazing on postfire ground cover and plant species diversity responses in mesic sagebrush steppe. Treatment levels representing no rest; 1, 2, or 3 years of rest from grazing, and a burned-ungrazed control, all had similar effects on graminoid and forb basal cover and plant species density and frequency. However, grazing reduced litter cover and increased bare ground exposure relative to the control. A synthesis of this and other case studies of postfire grazing in sagebrush steppe indicates multiple years of rest from grazing are not strictly necessary for effective and timely recovery of vegetation but, on sloping terrain where potential runoff and erosion hazards exist, multiple years of rest may be needed to promote sufficient rates of litter recovery and reduction of bare ground exposure. These findings support calls for increased flexibility in policies governing postfire grazing management on federal lands and, as such, could influence ecosystem health, livestock production and other services throughout much of the western US.

1. Introduction

While the effects of postfire livestock grazing on ecological patterns and processes have been fairly well studied in some rangeland ecosystems (e.g., prairie grasslands), these effects are rather poorly understood in others. Fire and postfire herbivory can have interactive effects on plant vigor, potentially causing reduced productivity and, in some cases, mortality. Suppressed reproduction and even localized loss of intolerant species may result from adverse combinations of fire and livestock grazing (Bunting et al., 1998; Jirik and Bunting, 1994; Wright and Bailey, 1982). The physical environment can also be impacted by these combined disturbances. Fire generally increases bare ground exposure and postfire grazing can reduce or delay recovery of litter and ground cover thus prolonging elevated risks of soil erosion (Moody et al., 2013; Pierson et al., 2002) and promoting excessive solar heating and soil moisture losses to evaporation (Hulbert, 1969; Facelli and Pickett, 1991; Villegas et al., 2010). Fire and livestock grazing are common place on most rangelands throughout the world. Consequently, selection of appropriate and effective postfire livestock grazing strategies, which may include rest or deferment from grazing, changes in stocking rates, and other adaptations is an important management consideration for rangelands worldwide.

Unfortunately, a scientific foundation to inform and support postfire grazing management and decision making is lacking or inadequate for some rangeland ecosystem types. While the effects of fire and herbivory have received much study in grassland ecosystems such as the tall grass prairie (Allred et al., 2011; Collins and Smith, 2006), mixed-grass prairie (Collins and Barber, 1986), short-grass steppe (Augustine and Derner, 2014; Augustine et al., 2010) and Mediterranean grasslands (Noy-Meir, 1995); studies in shrub-grass ecosystems like the sagebrush steppe are more rare. Some postfire-grazing research, however, has been conducted on several sagebrush-dominated rangelands (Bates and Davies, 2014; Bates et al., 2009; Bruce et al., 2007; West and Yorks, 2002). This past work has tended to focus in the lower-elevation, drier sagebrush ecosystems dominated by Wyoming big sagebrush (*Artemisia tridentata* Nutt. subsp. *wyomingensis* Beetle & Young) and other dryland sagebrush species. Very little postfire grazing research has been done in the higher-elevation, mesic portions of the sagebrush steppe dominated by mountain big sagebrush (*Artemisia tridentata* Nutt. subsp. *vaseyana* [Rydb.] Beetle) along with antelope bitterbrush (*Purshia tridentata* [Pursh] DC.), and mountain snowberry (*Symphoricarpos oreophilus* A. Gray).

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Mesic sagebrush steppe occupies about 7 million ha and thus represents a substantial proportion of sagebrush-dominated rangelands in the western US (Comer et al., 2002). The term "mesic" is used here in a relative sense as these systems can still be rather dry, e.g., cumulative evapotranspirative losses commonly offset much of the annual precipitation input (Kormos et al., 2017). The vast majority of these mesic sagebrush-steppe lands are federally-managed and are grazed by livestock (Knick et al., 2003). Federal land managers commonly employ prescribed fire to control juniper (*Juniperus* spp.) and pinyon pine (*Pinus* spp.) tree encroachment into mesic sagebrush steppe. These fires are intended to rehabilitate or restore vegetation structure and diversity, ecosystem health and function, and delivery of ecosystem services such as wildlife habitat and livestock grazing (Connelly et al., 2000; Davies et al., 2011; McIver et al., 2014; Miller et al., 2014). Pinyon and juniper are native to the western US, but have encroached mesic sagebrush rangelands due to multiple factors including improper land-use practices, lack of fire, climate variability, etc. (Miller et al., 2005; Romme et al., 2009). Effective use of fire to manage conifer encroachment on grazed mesic sagebrush steppe necessitates a rigorous understanding of the interaction of fire and post-fire grazing effects on vegetation structure and diversity.

Clark et al. (2016b) examined the vegetation cover and plant species diversity responses to differing periods of rest from spring (May) cattle grazing following a fall prescribed fire in mesic sagebrush steppe. Even at light stocking rates, however, they found spring grazing during the early reproductive or "boot" phenological stage of forage grasses reduced litter accumulation rates on burned areas thereby prolonging the exposure of bare soils to erosion hazards. To address this concern, we hypothesized cattle grazing during mid-summer when forage grasses like bluebunch wheatgrass (*Pseudoroegneria spicata* [Pursh] A. Love) and squirreltail (*Elymus elymoides* [Raf.] Swezey) have progressed into the less palatable, seed-formation and seed-ripening phenological stages may have less impact on litter accumulation than spring grazing. We tested this hypothesis in a postfire grazing study conducted following a fall prescribed fire at a study area nearby to that of Clark et al. (2016b) and under a mid-summer (July) cattle grazing regime. Specific objectives for this case study were to: (1) determine if vegetation cover and plant species diversity responses differed among different levels of postfire rest from lightly-stocked, mid-summer cattle grazing; (2) evaluate whether these cover and diversity responses to grazing rest differed among the principal sagebrush-steppe communities or vegetation types present; and (3) compare cover and diversity results from this mid-summer grazing study with those of Clark et al. (2016b).

2. Methods

2.1. Study area

The research was conducted in the Breaks prescribed-fire study area (43° 6′ 29″ N, 116° 46' 37" 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 (1965–1975, 2002–2014) mean annual precipitation at the Breaks gauges (#145) was 588 mm (NWRC, 2016). Typically about 1/3 of this precipitation occurs as snow (Hanson, 2001). Annual precipitation during the study (2003–2007) ranged from a low of 463 mm in 2007, 543 mm in 2003, 543 mm in 2004, 655 mm in 2006, and a high of 773 mm in 2005. 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, 2016). Mean daily air temperatures during the study ranged from 8.6 °C in 2005, 8.8 °C in 2004 and 2006, 9.4 °C in 2003, and 9.6 °C in 2007, all of which exceeded the long-term mean.

The Breaks study area (176 ha) is a fenced rangeland pasture encompassing the toe-slopes and narrow stream terraces and riparian areas occurring near the base of an east-facing hillslope. Elevation at Breaks ranges from 1547 to 1761 m. Slopes range from flat to very steep (107.5% or 47.1° 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).

Three vegetation cover types: (i) mountain big sagebrush – mountain snowberry, (ii) antelope bitterbrush – mountain big sagebrush, and (iii) native bunchgrass dominate the study. In addition to the 2 dominant species, the mountain big sagebrush-mountain snowberry type includes western juniper, yellow rabbitbrush (*Chrysothamnus viscidiflorus* [Hook.] Nutt.), Utah serviceberry (*Amelanchier utahensis* Koehne), 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 more complete species list). Other components of the antelope bitterbrush-mountain big sagebrush type include western juniper, native bunchgrasses and biscuitroots (*Lomatium* spp. Raf.). Bluebunch wheatgrass, Sandberg bluegrass, squirreltail, Idaho fescue, and needlegrasses (*Achnatherum* spp. Beauv.) dominate the native bunchgrass cover type. Cheatgrass (*Bromus tectorum* L.) has a minor to common presence within all three of these dominant vegetation types. A perennial stream, Reynolds Creek, flowed through the study area. The riparian zone associated with this stream contained a black cottonwood (*Populus balsamifera* L. ssp. *trichocarpa* [Torr. & A. Gray ex Hook.] Brayshaw) overstory; a peachleaf willow (*Salix amygdaloides* Andersson), redosier dogwood (*Cornus sericea* L. ssp. *sericiea*), and Woods' rose (*Rosa woodsii* Lindl.) shrub layer; and a sedge (*Carex* spp. L.) and Kentucky bluegrass (*Poa pratensis* L.) understory.

2.2. Prescribed fire

On 24 September 2002, the Breaks prescribed fire (81 ha) burned about 34 ha of the study area pasture (176 ha). The intent of this vegetation treatment was to decrease shrub cover, enhance availability of herbaceous forages, and kill as many encroaching western juniper trees as possible without adversely impacting ecosystem health. The fire was conducted by the USDI Bureau of Land Management (BLM) using their standard procedures for prescribed burning in juniper-encroached, sagebrush steppe rangeland (BLM, 2003). Wind speeds during the burn averaged 2.2 m s^{-1} with a range of 0.66–3.5 m s^{-1}. Wind direction remained relatively constant. Air temperature ranged from 20.8 to 22.6 °C and relative humidity 18.1–20.0%. The prescribed burn was successful in that it met the intended results and the results are typical of fall burns. The fire produced a mosaic of areas with low (6 ha), moderate (23 ha), and high (5 ha) burn severity. About 6 ha of unburned areas also remained within the outer perimeter of the fire. These areas of differing burn severity were digitized as polygons using a dual-channel GPS unit (Trimble Pro XRS, Trimble Navigation, Inc., Sunnyvale, California) immediately after the fire was extinguished. Generally, heavier woody fuels promoted longer fire residence times in the antelope bitterbrush-mountain big sagebrush type, consequently, these stands tended to be burned with moderate severity (Clark unpublished data). Finer fuels promoted shorter residence times in the bunchgrass grassland and mountain big sagebrush-snowberry types, generally resulting in low burn severity. However, where burning occurred, it generally killed or greatly suppressed mountain big sagebrush and bitterbrush shrubs and juvenile juniper trees.

Herbaceous vegetation on burned areas recovered quite rapidly. Compared with prefire conditions, perennial forbs and some grasses, particularly squirreltail, increased in cover on formerly shrub-