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Prescribed Fire Effects on Activity and Movement of Cattle in Mesic Sagebrush Steppe☆

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ABSTRACT

Prescribed fire has long been used worldwide for livestock and wildlife management. Prescribed fire effects on activity budgets and movement path characteristics of grazing animals, however, remain largely unknown. We evaluated whether prescribed-fire treatments in mesic sagebrush steppe affect cattle behaviors, which could influence foraging efficiency and, ultimately, impact animal productivity. Mature, lactating beef cows grazing within two study areas located in the Owyhee Mountains of southwestern Idaho, United States were tracked with Global Positioning System collars for 2 yr before and 5 yr after fall prescribed fire. Tracking data were then classified into stationary, foraging, and traveling activity types on the basis of movement distance and velocity thresholds. After fire, cattle in burned sites tended to increase their foraging activity budgets, bout durations, bout counts, and path lengths relative to prefire and cattle in unburned sites. Fire did not affect steepness of cattle foraging paths. Prescribed fire in mesic sagebrush steppe can be used to create opportunities for cattle to improve foraging efficiency by altering their activity budgets and movement path characteristics. Any consequent improvements in foraging efficiency could, in turn, promote increased rates of weight gain, better body condition, enhanced reproductive success, and ultimately, more pounds of beef for market.

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Introduction

Prescribed fire has been used worldwide for centuries to enhance herbaceous forage quality, palatability, and availability for livestock and wildlife (Wikeem and Strang, 1983; Pyne, 1995; Butz, 2009). These forage enhancements, in turn, serve as attractants to livestock and big game, thus affecting the resource-selection patterns and diet selection of these rangeland animals (Peek et al., 1979; Hobbs and Spowart, 1984; Vermeire et al., 2004; Klop et al., 2007; Bates et al., 2009; Augustine et al., 2010; Clark et al., 2014, 2016). It is also possible that fire-induced forage enhancements may affect the activity budgets and movement path characteristics of these animals, which could, in turn, influence their foraging efficiency or net nutrient intake rate. Enhanced foraging efficiency can ultimately result in higher rates of weight gain, better body condition, lower susceptibility to disease, increased survival rates, and improved reproductive success (White, 1983; Parker et al., 1996). While the efficacy of prescribed fire as a tool for managing grazing animal distribution and diet quality has received much study, prescribed-fire effects on the activity budgets and movement path characteristics of grazing animals remain largely unknown, particularly in the mesic sagebrush steppe.

Prescribed fire in sagebrush steppe reduces shrub cover and competition from shrubs, thus enhancing the accessibility and productivity of herbaceous forages (Davies et al., 2007; Bates et al., 2009). Prescribed fire also removes standing litter accumulations from forage plants and improves palatability (Willms et al., 1980; Ganskopp et al., 1992; Ganskopp et al., 1993). Herbaceous regrowth following prescribed fire often provides higher-quality forage than that available before burning (Cook et al., 1994; Van Dyke and Darragh, 2006a, 2006b). Consequently, burned areas commonly provide palatable and accessible forage plants at a higher density per unit area and a higher nutritional-quality level than unburned areas. At a broader scale, prescribed fire can increase the number and density of vegetation patches containing these palatable, accessible, and nutritious forage plants (Gill et al., 2003; Fuhlendorf and Engle, 2004; Allred et al., 2011). These fire-induced

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changes in the quality, density, and distribution of foraging patches can, in turn, create new opportunities for grazing animals to improve foraging efficiency relative to prefire conditions (Canon et al., 1987). According to optimal foraging theory, large herbivores should attempt to match foraging time or effort devoted within a patch with the nutrition provided by that patch (Langvatn and Hanley, 1993; Wallis de Vries and Daleboudt, 1994). Increased density of high-quality forage patches, as might be induced by prescribed fire, provides animals with opportunities to intensively exploit these nutrient-rich patches and to reduce time and effort expended in transitioning between these patches. Consequently, attempts by grazing animals to improve foraging efficiency in response to fire treatments would likely be manifested as differences between burned and unburned sites in terms of observed animal activity budgets, bout counts, and bout durations, as well as in movement velocity, path tortuosity, path length, and other movement response metrics (Owen-Smith, 1979; Wronski, 2003; Augustine and Derner, 2014). If prescribed fire in sagebrush steppe indeed promotes enhanced foraging efficiency for cattle, such enhancements could, in turn, promote increased rates of weight gain, better body condition, improved reproductive success, and ultimately, greater beef production.

The objectives of this study were to 1) evaluate whether prescribed-fire vegetation management treatments in the mesic sagebrush steppe affected cattle activity budgets, bout counts, and bout durations by contrasting these behavioral state responses between burned and unburned sites; 2) investigate mobility responses to prescribed fire including foraging and travel velocity, path tortuosity, path length, and path steepness; and 3) synthesize the findings from these behavior analyses within the context of fire effects on landscape heterogeneity, patch quality, and foraging efficiency.

Materials and Methods

Study Areas

The research was conducted in two study areas within the Reynolds Creek Experimental Watershed (RCEW) located 80 km south of Boise in southwestern Idaho. The Breaks study area (176 ha) is a fenced rangeland pasture dominated by an east-facing hillslope (43°6′29″N, 116°46′37″ W). The Whiskey Hill study area (324 ha) is a fenced rangeland pasture that spans a north-south ridgeline and includes the adjoining west and east-facing hillslopes (43°9′49″N, 116°47′51″W). Detailed maps and descriptions of the Breaks and Whiskey Hill study areas and methodologies used are provided by Clark et al. (2016) and Clark et al. (2014), respectively. Consequently, only brief descriptions are provided here.

Climate is continental with maritime influences. Winters are cold and wet. Long-term (1965 − 2009) mean annual precipitation at the Breaks was 562 mm and at Whiskey Hill was 454 mm (NWRC, 2016). About one-third of the precipitation at both areas occurs as snow (Hanson, 2001). Summers are warm and dry. Long-term (1967 − 2010) mean daily maximum, minimum, and mean air temperatures at the Lower Sheep Creek weather station (127 × 07), which is within 5 km of both study areas, were 12.7°C, 3.8°C, and 8.3°C, respectively (Hanson et al., 2001; NWRC, 2016).

Elevation at Breaks ranges from 1 547 to 1 761 m and from 1 523 to 1 878 m at Whiskey Hill. Slopes at both areas range from flat to very steep (107.5% or 47.1-degree maximum at Breaks and 176.8% or 60.5-degree maximum at Whiskey Hill) 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 at both areas (Seyfried et al., 2001).

Before burning, both study areas were dominated by three vegetation cover types: 1) mountain big sagebrush–mountain snowberry (*Symphoricarpos oreophilus* A. Gray), 2) antelope bitterbrush (*Purshia tridentata* [Pursh] DC)–mountain big sagebrush, and 3) native bunchgrass grassland. Riparian herb (*Carex* spp., *Juncus* spp., and *Poa* spp.) and riparian tree/shrub (*Populus* spp., *Salix* spp., and *Rosa* spp.) were two other less common but important vegetation types present at both study areas.

Fire Treatments

About 34 ha of the central portion of the Breaks study area were burned in a prescribed fire conducted on 24 September 2002. The fire produced a mosaic of lightly burned sites (6 ha), moderately burned sites (23 ha), severely burned sites (5 ha), and unburned sites (6 ha) within the fire perimeter. Unburned sites, inside and outside of the fire perimeter, represented 80.1% of the total pasture area (176 ha).

About 131 ha in the center of the Whiskey Hill study area were burned in a prescribed fire conducted on 27 September 2004. A mosaic of lightly to moderately burned sites (108 ha), severely burned sites (23 ha), and unburned sites (33 ha) were produced within the fire perimeter. Unburned sites inside and outside of the fire perimeter represented 59.6% of the total pasture area (324 ha).

Boundary polygons for burned and unburned sites within the study areas were acquired using dual-channel Global Positioning System (GPS) unit (Trimble Pro XRS, Trimble Navigation, Inc., Sunnyvale, CA) immediately after each prescribed fire. These GPS data were postdifferential corrected to an expected accuracy of ± 0.73 m and ± 0.85 m (95% CEP) at Breaks and Whiskey, respectively.

Cattle GPS Tracking—Breaks Study Area

During each of the 6 study yr at the Breaks study area, 10 lactating, mature beef cows were randomly selected from a larger, total ranch population of about 750 cows. Starting 27 June 2001, the 10 selected cows of the year were fitted with GPS tracking collars (model 2200 LR: Lotek Wireless, Inc., New Market, Ontario, Canada) programmed to collect and store GPS locations every 10 min. These collared cows were then grazed with their suckling calves and 4 additional, uncollared cow-calf pairs for 15 d within the fenced study area. During the following year, another 15-d prefire grazing trial was conducted with a new sample of 10 collared cows, their suckling calves, and 4 uncollared cow-calf pairs beginning 26 June 2002. Postfire grazing trials (15 d) were conducted in late June/early July of 2003, 2004, 2005, and 2007 using a combination of Lotek model 2200 LR GPS collars and Clark ATS+ GPS collars (Clark et al., 2006) collecting location data every 10 min. New sets of randomly selected cattle were collared in each of these postfire years. A protocol of random selection without replacement was used; consequently, cows selected for collaring during a study year were excluded from selection for all subsequent study years. All trials occurred after peak production during the period when bluebunch wheatgrass was in the seed-formation and seed-ripened/early yellowing phenological stages. A grazing trial was not conducted during 2006 because cattle were not available from the producer cooperator during that postfire year. Assuming each cow and her calf represented 1.15 metabolic animal unit equivalents (AUEs), the stocking rate in the pasture was about 0.091 AUEs ha^{-1} or 21.9 ha animal unit months $(AUMs)^{-1}$ each trial. This is a relatively light stocking rate for mesic sagebrush steppe rangelands during midsummer.

Classification of animal activity can be accurately accomplished using GPS collars and validated by direct visual observation sampling (e.g., Ungar et al., 2005, 2011; Anderson et al., 2012; Augustine and Derner, 2013). In our study, concurrent with the GPS data collection, collared cattle were periodically observed during the daylight hours, using the focal-animal sampling method described by Altmann (1974) and applied under study conditions similar to ours by Ganskopp (2001). Focal animals were visually observed continuously, and changes in behavior lasting longer than 30 sec were classified and recorded into an ethogram as one of three classes: stationary, foraging, or traveling. The GPS time of each observation was recorded to the nearest second. Duration of focal animal sampling sessions ranged from

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