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Original Research

Space Use of Female Greater Prairie-Chickens in Response to Fire and Grazing Interactions☆

Virginia L. Winder [a,*], Lance B. McNew [b], Jim C. Pitman [c,1], Brett K. Sandercock [d]

[a] Department of Biology, Benedictine College, Atchison, KS 66002, USA
[b] Department of Animal and Range Sciences, Montana State University, Bozeman, MT 59717, USA
[c] Kansas Department of Wildlife, Parks and Tourism, Emporia, KS 66801, USA
[d] Division of Biology, Kansas State University, Manhattan, KS 66506, USA

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ABSTRACT

Ecological interactions between fire and grazing have shaped the evolutionary history of grassland ecosystems. Currently, grassland birds have experienced ongoing population declines, following widespread implementation of intensive rangeland management practices that reduce habitat heterogeneity. Patch-burn grazing is an alternative rangeland management strategy that promotes habitat heterogeneity and biodiversity. We conducted a 3-yr. field study in the central Flint Hills of Kansas to compare the spatial ecology of female Greater Prairie-Chickens *(Tympanuchus cupido)* in rangelands managed with intensive rangeland management versus patch-burn grazing. This is the first study on the effects of patch-burn grazing on the space use decisions of Greater Prairie-Chickens at the home range scale. We used seasonal estimates of home range for 6-mo breeding and nonbreeding periods, as well as resource utilization functions to investigate the response of female prairie chickens to landscape metrics describing fire, grazing, and proximity to anthropogenic structures or lek sites. In our analysis of all radio-marked females, distance to lek was consistently the strongest predictor of space use during both breeding and nonbreeding seasons. Females captured at properties managed with patch-burn grazing selected areas with low stocking rates and high fire frequencies, and they avoided recently burned areas. Our study provides new evidence that patch-burn grazing can improve grassland habitat for Greater Prairie-Chickens, an umbrella species in the tallgrass prairie ecosystem. Patch-burn grazing created preferred habitats for female Greater Prairie-Chickens, with a relatively frequent fire return interval, a mosaic of burned and unburned patches, and a reduced stocking rate in unburned areas avoided by grazers. Widespread implementation of patch-burn grazing could result in significant improvements in habitat quality for wildlife in the tallgrass prairie ecosystem.

Introduction

Grasslands are among the most threatened ecosystems in the world, primarily because of extensive conversion to croplands (Vitousek et al., 1997; White et al., 2000; With et al., 2008; Fuhlendorf et al., 2012). In North America, > 95% of the historical extent of tallgrass prairie has been lost to rowcrop agriculture, oil and gas extraction, and urban development during the past century (Samson et al., 2004; Hoekstra et al., 2005). The ~2 million - ha Flint Hills ecoregion of Kansas and Oklahoma represents ~80% of the remaining tallgrass prairie in North America (Samson and Knopf, 1994; With et al., 2008; Rahmig et al., 2009). The shallow, rocky soils of the Flint Hills make the ecoregion unsuitable for rowcrop cultivation, but >90% of the grasslands in the Flint Hills are used to support an economically valuable cattle industry (With et al., 2008). In the 1970s, many rangeland managers in the Flint Hills shifted from year-round grazing at moderate stocking rates with periodic prescribed burning to a rangeland management practice based on intensive early stocking combined with annual burning (hereafter, "intensive early stocking"; Smith and Owensby, 1978). Ranchers implementing intensive early stocking use prescribed fire annually in the spring to promote growth of high-quality forage plants that support intensive stocking of pastures with steers for ~100 days, during April to July. Intensive early stocking aims to maximize livestock production by generating uniform forage conditions that promote even grazing across the landscape (Hart, 1978; Fuhlendorf and Engle, 2001; Holecheck et al., 2004; Allred et al., 2014).

Historically, grazing and fire were natural processes, and the ecological interaction of these factors has shaped the development of grassland ecosystems (Milchunas et al., 1988; Knapp et al., 1999; Askins,

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* Correspondence: Virginia L. Winder, Dept of Biology, Benedictine College, Atchison, KS 66002, USA.
E-mail address: vwinder@benedictine.edu (V.L. Winder).
[1] Current address: Jim C. Pitman, Western Association of Fish & Wildlife Agencies, Emporia, KS 83202, USA.

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2000; Fuhlendorf and Engle, 2001; Fuhlendorf et al., 2006). Fire influences ungulate grazing patterns because grazers prefer recently burned areas with high-quality forage (Coppedge and Shaw, 1998; Allred et al., 2011). In turn, reduced grazing in unburned areas leads to accumulation of standing plant litter, which affects the timing, extent, and intensity of subsequent fires (Fuhlendorf and Engle, 2001). The historic interaction between fire and grazing created a shifting mosaic of vegetation that fulfilled habitat requirements for the dynamic life cycles of species in the grassland ecosystem (Fuhlendorf and Engle, 2001; Brennan and Kuvlesky, 2005; Fuhlendorf et al., 2006; Sandercock et al., 2015). Rangeland management in the Flint Hills currently generates a homogenous pattern of disturbance and reduces structural and spatial heterogeneity of grassland habitats. The ecological effects of a departure from natural pattern and process are a concern, and implementation of intensive early stocking coincided with population declines in grassland wildlife species (Zimmerman, 1997; Knapp et al., 1998; Brennan and Kuvlesky, 2005; Reinking, 2005; With et al., 2008). Overall, grassland birds have declined continent wide at a greater rate than any other guild of terrestrial birds in North America over the past 70 years (Knopf, 1994; Fuhlendorf et al., 2006).

Patch-burn grazing is an alternative rangeland management strategy that promotes biodiversity and agricultural productivity and could meet the management goals of conservation biologists and rangeland managers (Christensen, 1997; Ostfeld et al., 1997; Wiens, 1997; Fuhlendorf and Engle, 2001; Fuhlendorf et al., 2006). In the Flint Hills ecoregion, ranchers implementing patch-burn grazing divide pastures into ~3–5 patches using fire breaks, without cross-fencing. Typically, one patch in each pasture is burned on a rotational basis each year, and cattle are allowed to move freely among patches within a pasture, but due to selective grazing, the most recently burned patch receives the heaviest grazing pressure. Patch-burn grazing treatments can be modified on the basis of ecosystem-specific rainfall patterns and vegetation recovery rates. For example, a rancher in a shortgrass prairie ecosystem might subdivide a pasture into 8–10 patches and burn 1–2 patches each year, with a longer recovery time between disturbance. Patch-burn grazing creates a temporally and spatially shifting mosaic that includes patches in different stages of successional recovery (Coppedge and Shaw, 1998; Fuhlendorf and Engle, 2001). Patch-burn grazing mimics historical fire-grazing interactions, which could benefit declining species of grassland animals by promoting structural, compositional, and spatial heterogeneity of vegetation, while still providing viable revenue from cattle production (Fuhlendorf and Engle, 2001, 2004; Churchwell et al., 2008; Coppedge et al., 2008; Powell, 2008; Rensink, 2009; Limb et al., 2011).

Greater Prairie-Chickens (*Tympanuchus cupido,* hereafter "prairie chickens") are endemic to native grasslands of North America. Population numbers have decreased by ~50% over the past 30 years in the Flint Hills ecoregion, following habitat loss and changes in rangeland management that affect habitat quality (Johnson et al., 2011; Pitman et al., 2012). Prairie chickens have large seasonal home ranges (~10–25 km^2) and require a mosaic of habitats for successful reproduction and survival, including open sites for leks, tall vegetative cover for concealment during nesting, and areas of intermediate vegetative structure that are rich in forbs for brood-rearing (Gregory et al., 2011; Johnson et al., 2011; Hagen et al., 2013; Matthews et al., 2013; Winder et al., 2014b, 2015a, b). Prairie chickens have a promiscuous mating system, and males display for females at communal lek sites (Nooker and Sandercock, 2008; Johnson et al., 2011). Females attempt at least one nest each year, lay large clutches of 8–14 eggs, regularly renest after clutch loss, and provide sole parental care to offspring (McNew et al., 2011).

Quantitative information on the spatial ecology of prairie chickens is limited, especially with respect to potential responses to rangeland management and seasonal differences in habitat use (Niemuth, 2011). For some lekking grouse, individuals attend leks during the fall nonbreeding period when the photoperiod is similar to the spring lekking period. Lek attendance during the fall can play a critical role in settlement decisions and reproductive success for the following spring (Rintamäki et al., 1999). Decisions about habitat selection by female prairie chickens can influence population viability because differential habitat selection is often linked to variation in demographic rates (Boyce and McDonald, 1999; Garshelis, 2000; Aldridge and Boyce, 2007; Dzialak et al., 2011; McNew et al., 2013). Habitat selection by females influences nest success (McNew et al., 2015), and reproductive success and female survival in turn drive population dynamics (Hagen et al., 2009; McNew et al., 2012a). To investigate the effects of rangeland management on habitat use, we collected year-round movement data on radio-marked females captured on properties managed with intensive early stocking or patch-burn grazing in East Central Kansas. We used kernel density estimation of seasonal home ranges and resource utilization functions (RUFs) to investigate the seasonal responses of female prairie chickens to landscape metrics describing fire, grazing, patchiness, anthropogenic structures, and lek sites (Marzluff et al., 2004; Kertson et al., 2011). The interaction between fire and grazing influences the long-term site occupancy by prairie chickens (McNew et al., 2012b), and patch-burn grazing creates a mosaic of heterogeneous habitats, providing prairie chickens with a greater diversity of habitat types from which to choose (Fuhlendorf et al., 2006). If patch-burn grazing creates the diverse habitat types required by prairie chickens, we predicted that prairie chickens would have smaller seasonal home ranges at properties managed with patch-burn grazing than properties managed with intensive early stocking. Additionally, we predicted that female prairie chickens would avoid recently burned and heavily grazed areas, as well as areas with infrequent fire return intervals within their seasonal home ranges.

More than 95% of the Flint Hills ecoregion is privately owned, and the vast majority of the ecoregion is managed for cattle production (With et al., 2008). Given the economic and cultural importance of the cattle industry in the Flint Hills, information on the effects of patch-burn grazing on grassland vertebrates will be integral to building effective conservation strategies for tallgrass prairie in the ecoregion. The results of our field study provide new insights into the quantitative spatial ecology of prairie chickens in response to rangeland management and can be used to improve management and conservation efforts for prairie grouse.

Methods

Study Site

Our field study was conducted during 2011–2013 in an ~3000-km^2 region in portions of Butler, Chase, Greenwood, Lyon, and Morris Counties, five of the most intensively burned counties in the Flint Hills ecoregion (Fig. 1; Mohler and Goodin, 2012). Native grassland was the dominant land cover type in the region (~90%). Road density was relatively low at ~0.58 km of road per km^2 within the region, compared with other areas in the Flint and Smoky Hills (Winder et al., 2015a). Mean precipitation from 1980 to 2010 in the region was 92.4 cm per yr. (National Oceanic and Atmospheric Administration, National Centers for Environmental Information).

Within the region, we had permission to access ~1100 km^2 of private lands (see Fig. 1, hereafter "study site"). A majority of the study site was privately owned land (1050 km^2, 95%), and the remaining sites were managed by the National Park Service at the Tallgrass Prairie National Preserve (50 km^2, 5%). The National Preserve and two privately owned properties (Browning Ranch ~30 km^2 and Koger Ranch ~15 km^2; cumulatively ~10%) were managed with patch-burn grazing while the remaining private lands at our study site were primarily managed with intensive early stocking (~1000 km^2; ~90%; see Fig. 1).

Management strategies on intensive early stocking properties were dependent upon annual weather conditions. In years with typical rainfall, intensive early stocking properties were managed with an annual spring prescribed burn and stocking rates of 1 head per 0.8 ha for ~90 days during April–July (~3 animal unit months, or AUM·ha^{-1}). However, drought conditions during our field study resulted in many intensive early stocking property managers reducing or postponing

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