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Weather Constrains the Influence of Fire and Grazing on Nesting Greater Prairie-Chickens☆,☆☆

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ABSTRACT

Grasslands are highly imperiled as a result of widespread conversion for agriculture and alteration from human development. Remaining grasslands are susceptible to mismanagement, development and fragmentation, and variable weather associated with global climate change. Understanding the response of declining grassland species to these challenges will be important for informed conservation and management. We assessed Greater Prairie-Chicken *(Tympanuchus cupido)* survival and nest site selection in tallgrass prairie characterized by interacting fire and grazing disturbance and oil and gas infrastructure. We found that Greater Prairie-Chicken survival was most affected by weather variability (expressed in our models as solar radiation) while most other variables had little influence. Focal disturbance did not affect survival directly, but vegetation height, which is greatly influenced by fire and grazing processes, was positively associated with nest survival. Greater Prairie-Chickens chose nesting locations that maximized time post fire while minimizing tree cover and distance to leks. Future conservation efforts for Greater Prairie-Chickens should focus on variable fire regimens that create areas of residual biomass to increase vegetation height and potentially reduce the effects of solar radiation while decreasing woody vegetation that is avoided by nesting females. However, even the best management practices may prove to be futile in the southern Great Plains if climate change continues to create unfavorable nest survival conditions. Management that creates and maintains suitable nesting sites through the use of interacting fire and grazing should maximize the potential for high reproduction in years when local weather variables are favorable.

Introduction

Grasslands are one of the most imperiled ecosystems in the world (Hoekstra et al., 2005), and loss of grassland environments is widespread. As a consequence, many grassland species are in decline and of conservation concern. Grassland birds specifically have experienced major population declines over the last half century (Vickery et al., 1999; Sauer et al., 2012). In addition to habitat loss, global changes in climate and an increase in energy infrastructure in rangeland ecosystems threaten conservation of remaining grassland organisms (Kuvlesky et al., 2007; Pruett et al., 2009; Hovick et al., 2014a). To improve future conservation and management of grasslands and their associated biota, there is a need to understand the relative impacts of management, anthropogenic structures, and a changing climate.

Grasslands are disturbance dependent ecosystems that rely on grazing and fire processes to drive and shape ecosystem structure and function (Collins & Wallace, 1990; Anderson, 2006). Traditionally, the application of fire and grazing in rangelands has been under a utilitarian paradigm and goals have been production based, which often results in homogenous systems that are largely devoid of heterogeneity (Fuhlendorf et al., 2012). Although these practices have been mostly successful at limiting heavily grazed and ungrazed areas, they have limited disturbance-driven heterogeneity and biodiversity (Fuhlendorf et al., 2012). More recently, however, the focus of conservation in rangelands has begun a paradigm shift that promotes the conservation of pattern and process through the restoration of natural disturbances (Derner et al., 2009; Fuhlendorf et al., 2009; Fuhlendorf et al., 2012). The use of interacting fire and grazing (i.e., pyric herbivory) can increase the breadth of niches available in rangelands, thereby favoring diversity and potentially improving long-term stability in these systems (Otsfeld et al., 1997; Wiens, 1997; Fuhlendorf et al., 2006; Hovick et al., 2014b). As a result, recent studies in the Great Plains have called for management that promotes patchy disturbance (Patten et al., 2007; With et al., 2008; Augustine & Sandercock, 2011; McNew et al., 2012). Concurrently with this paradigm shift, new challenges are emerging as energy development in rangelands is increasing and global climate change

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is creating more variable weather patterns (Lyon & Anderson, 2003; Holloran et al., 2010; Obermeyer et al., 2011; IPCC, 2013).

Energy extraction processes and the associated infrastructure can have many negative direct and indirect effects on native rangelands species (Kociolek et al., 2011; Obermeyer et al., 2011; Douglas et al., 2012). Although the direct effects are often most obvious and well documented (Kunz et al., 2007; Wolfe et al., 2007; Kociolek et al., 2011), the avoidance or displacement associated with energy infrastructure can be much greater than direct habitat loss resulting from development (Zeiler & Grünshauchner-Berger, 2009; Pearce-Higgins et al., 2012; Hovick et al., 2014a; Winder et al., 2014). Additionally, the increased direct and perceived fragmentation to grasslands that results from anthropogenic structures may exacerbate future challenges associated with greater climate variability and mismanagement by reducing species' abilities to shift to suitable habitats (Pruett et al., 2009; Lawler et al., 2013).

Climate-driven changes have increased biodiversity loss and understanding how species respond to a warming and more variable climate is a central challenge facing ecologists (Dawson et al., 2011). Climate changes are now occurring at unprecedented rates (IPCC, 2013), which raises concerns for extinctions in species that are unable to adjust (Veneir et al., 1999). Moreover, changes are not uniform in space or time and patterns can be complex as a result of interplay between region-specific and species-specific factors that are affected by local management (Tingley et al., 2012). Greater investigation of species' responses to current weather conditions can improve predictions of species' responses to future climate change and potentially inform conservation efforts allowing organisms to persist.

Increasing climate variability, management that promotes homogeneity, and the construction of new energy structures in previously unfragmented rangelands are all challenges facing Greater Prairie-Chickens (*Tympanuchus cupido;* hereafter "prairie-chicken"). Prairie-chickens have been referred to as an indicator and umbrella species of the tallgrass prairie ecosystem (Poiani et al., 2001; Pruett et al., 2009), and they have experienced one of the greatest distribution contractions and population declines of any grassland species (Schroeder & Robb, 1993; Robbins et al., 2002). Remaining prairie-chicken populations are highly susceptible to human alterations of the landscape because of their complex life history traits and need for large, open, and unfragmented landscapes (Johnsgard, 2002; PIF, 2012). Yet the effects of these potential threats have gone mostly unexamined. Previous research has proposed that rangeland practices that promote heterogeneity should be implemented, but few have investigated prairie-chicken survival or habitat use in landscapes with interacting fire and grazing (Patten et al., 2007; McNew et al., 2012). Furthermore, until recently no research had investigated the effects of energy development on prairie-chickens (Winder et al., 2013; Winder et al., 2014; McNew et al., 2014), and few studies have examined the effects of oil and gas infrastructure (Jarnevich & Laubhan, 2011). Moreover, the influence of climatic variables on prairie-chicken nest survival is largely unknown and because this is a Pleistocene relic species that is well adapted to cold environments, it may be particularly vulnerable to a warming climate at the southern extent of its range (Johnsgard 1983; Storch, 2007).

We examined prairie-chicken nest survival and nest site selection in tallgrass prairie characterized by interacting fire and grazing and anthropogenic structures associated with oil and gas extraction. Our specific objectives were to 1) test the influence of grassland management (i.e., fire and grazing), energy infrastructure, and weather variables on nest survival of prairie-chickens, and 2) examine the relative role of management, energy infrastructure, and lek sites on nest site selection by prairie-chickens.

Methods

Study Site

We examined prairie-chicken nest survival and selection across approximately 30 000 ha of tallgrass prairie composed of The Nature Conservancy's Tallgrass Prairie preserve (hereafter, the preserve) and an adjacent private ranch. Both properties are managed with fire and grazing in a way that creates heterogeneity, but management is done at different scales. The private ranch creates heterogeneity through grazing and fire deferment across pastures, whereas the preserve allows fire and grazers to interact within pastures. At the preserve this takes place across two different units. One has native bison *(Bison bison)* and is ~9 500 ha, while the other unit is managed with cattle *(Bos taurus)* and has five subunits that vary in size (430–980 ha) and the proportion burned (range: 12–100%). Both units are moderately stocked (2.1–2.4 animal unit month ha-1), and all animals are contained by exterior fences for organizational purposes without any interior pasture fencing. To address potential differences between the two properties that may affect survival, we used variables measured at nest sites. Additionally, in preliminary analysis we tested for overall survival differences between properties and found none, so we conducted the final analysis by grouping nests from both properties (β_{ranch} = -0.36, SE = 0.37, CI -1.08 to 0.36).

Data Collection

We trapped prairie-chickens using walk-in funnel traps during the springs of 2011–2013 (Schroeder & Braun, 1991). Trapping started in mid-March and concluded in early May each year. We focused on leks (i.e., central display areas where males gather to attract females) with the most displaying males but attempted to trap all available leks with ≥ 5 males. We monitored traps each morning 1 hour before sunrise until lekking activity ceased or until we were forced to flush birds in order to retrieve trapped individuals.

We attached necklace-style radio transmitters to adult female prairie-chickens at the time of capture. We used series A4100 transmitters weighing approximately 16 g (~1.5 % of the bird's body weight) and having an expected life span of 900 days (Advanced Telemetry Systems, Isanti, MN). Females were then monitored every 1 to 3 days with daily checks after we determined they had localized in an area. We flushed females intentionally after they localized in the same area for 3 consecutive days to observe nest contents and record exact nest locations using a handheld GPS unit. Additionally, we marked nests by placing a large rock 5 and 10 m south of nest sites. To minimize disturbance after finding nests, females were monitored every 2 days at distances > 100 m by triangulation of the radio signal. Once we determined that the female was no longer tending the nest, we revisited the nest site to determine nest fate. A nest was classified as successful if ≥ 1 egg hatched.

We measured vegetation at nest sites using a 0.5 m^2 quadrat centered over the nest location (Daubenmire, 1959). Canopy cover was estimated for the following plant functional groups: grasslike, forb, litter, bare ground, and shrub. We measured vegetation height using the tallest stalk within each quadrat, and litter depth was measured in the northwest corner of each quadrat. Additionally, we visually estimated vegetation density using a Nudd's board adapted for grassland/shrubland use (Nudds, 1977; Guthery et al., 1981).

Weather variables were collected on-site at an Oklahoma Mesonet station (Brock et al., 1995). The weather station collects a variety of weather variables every 5 minutes, 365 days of the year. For the purposes of this study, we included weather variables that have been shown to affect nest survival in grouse or that we hypothesized may influence the ability of a predator to locate nests (Grisham et al., 2013; Hovick et al., 2014c). The variables of interest included maximum daily temperature, minimum daily temperature, daily precipitation total, average daily relative humidity, average daily barometric pressure, and average daily solar radiation. During the course of our 3-year study, climatic conditions were highly variable both within and across breeding seasons (Table 1).

Finally, we used ArcGIS 10.0 (ESRI 2011) and GeoEye-1 satellite imagery taken in 2010 to measure tree cover and distances to and densities

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