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Synthesis of the effect of fire on lesser prairie-chickens

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Male lesser prairie-chicken. Photo by Eric Thacker.

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FORWARD

Lesser prairie-chickens are an iconic part of the Great Plains and so their protection is of interest to a variety of stakeholders from landowners to land managers and grassland enthusiasts to researchers. Given the recent federal listing of the lesser prairie-chicken, these stakeholders are engaged in discussions about the best methods to restore, conserve, and protect the species and its habitat. Of particular interest to the Great Plains Fire Science Exchange and the fire community is the effect of fire on lesser prairie-chickens and its role as a best use practice. For this reason, the Great Plains Fire Science Exchange has requested an external, objective synthesis of the existing science on the effect of fire on the lesser prairie-chicken. The Great Plains Fire Science Exchange hopes this synthesis will support science-based policy decisions, habitat management planning efforts, and prioritization of research funding and proposal development.

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INTRODUCTION

Lesser prairie-chickens (*Tympanuchus pallidicinctus*) were once widely distributed throughout the southern Great Plains, but now inhabit only 17% of their historic range (Van Pelt et al. 2013; Figure 1). Additionally, a breeding population decline of approximately 50% occurred between 2012 and 2013 primarily due to severe drought in concert with pre-existing habitat factors that affected much of the occupied range (McDonald et al. 2013). According to the U.S Fish and Wildlife Service (USFWS 2014) this "*rapid and severe decline*" combined with development threats and a court order requiring the Service to process a backlog of candidate species were justification to list the lesser prairie-chicken as a "*Threatened*" species (Endangered Species Act Section 4 Deadline Litigation, USFWS 2014). By definition threatened status means that the lesser prairie-chicken is "likely to become in danger of extinction within the foreseeable future" (USFWS 2014).

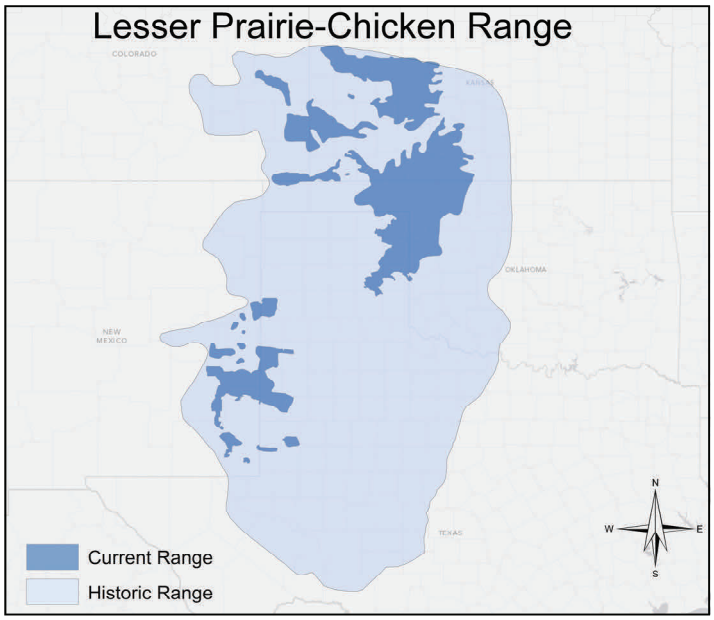

Figure 1. Map of current and historical occupied range of the lesser prairie chicken.

Lesser prairie-chickens are members of the grouse family (*Tetraonidae*) that are endemic to the southern Great Plains of the Unites States (Copelin 1963). They average 15 to 16 inches in length and are identified by the horizontal black barring pattern on their feathers. Lesser prairie-chickens have pronounced pinnae feathers (ear feathers) and reddish gular air sacs (patches with no feathers) on both sides of their neck. While displaying, males will inflate these air sacs and erect the pinnae feathers (Johnsgard 1983). Consistent with other prairie grouse, lesser prairie-chicken males will gather at lek sites each spring to participate in intricate mating rituals. Male lesser prairie-chickens strut and call in an attempt to attract and breed females (Bent 1932). Once hens breed they will typically nest within 2 miles of leks (Suminski 1977, Riley 1978, Giesen 1994) and produce a clutch of 1-14 eggs (Copelin 1963). After the eggs hatch, the hen will brood the chicks for approximately 12 weeks, then the brood will disperse from the hen (Pitman et al. 2006).

Research indicates that lesser prairie-Chicken nesting and brooding habitat is limited, thus one of the critical limiting factors for recovering declining populations (Hagen et al 2009), but lesser prairie-chickens also need broad, heterogeneous landscapes dominated by native grasses throughout their lifecycle. Taylor and Guthery (1980) suggested a contiguous native grassland-shrubland mosaic of approximately 8,000 – 18,000 acres is necessary for lesser prairie-chicken populations to persist. However, the shortgrass, CRP, cropland complex of western KS currently supports approximately two-thirds of the remaining lesser prairie chicken population (McDonald et al 2012). Within these landscapes, lesser prairie-chickens have diverse structural requirements for lekking, brooding, and nesting. These diverse habitat requirements have complicated lesser prairie-chicken management and led to confusion over the positive and negative effects of fire on lesser prairie-chicken habitat.

In this synthesis, we have conducted a formal review and

assessment of the available *refereed* scientific literature on the effects of fire on lesser prairie-chickens. Based on this literature, we present the current state of the science as it relates to the impacts of fire on lesser prairie-chickens in the southern Great Plains.

METHODOLOGY

Our review of the scientific literature on the effects of fire on lesser prairie-chickens was based on publications found through searches on ISI Web of Knowledge, an online clearinghouse of peer-reviewed publications across scientific domains. We based our synthesis on the peer-reviewed scientific literature because it sets the standard for data quality and credibility of information. Publications on fire effects of fauna fall typically into one of the following categories: (1) studies evaluating the first-order response of fauna to variability in fire regimes – specifically how fire-caused mortality, changes in population dynamics over time, or spatiotemporal movements of individuals or populations relate to the size, pattern, frequency, intensity, or severity of fire; (2) empirical studies that quantify habitat value based on how fauna select patches of vegetation within a burned landscape; (3) empirical studies of inference that evaluate the effect of fire on vegetation and then infer, without direct evidence, how those results relate to habitat value parameters that were established in a landscape without fire; and (4) empirical studies that focus solely on the effect(s) of fire on vegetation but do not relate the results to first-order effects or habitat value. These categories served as the basis for our synthesis because they reveal the underlying foundation of scientific knowledge on a topic, and provide a useful approach for identifying existing knowledge gaps and priorities for future research.

SUMMARY OF LITERATURE

A summary of the available peer-reviewed scientific literature that addresses the four categories pertaining to fire effects on lesser prairie-chickens reveals the following:

1. No empirical studies exist to evaluate how lesser prairie-chickens respond to variability in fire regimes – specifically to the size, pattern, frequency, intensity, or severity of fire in lesser prairie-chicken environments.

2. One study has been published on the first-order responses of lesser prairie-chickens to fire and documented lesser prairie-chicken use of burned areas (Cannon and Knopf 1981).

3. One empirical study specifically characterizes the indirect effects of fire on lesser prairie-chickens, as a result of studying the effect of fire on vegetation and then inferring how those results relate to lesser prairie-chicken habitat values (Boyd and Bidwell 2001). While this study is clearly of value, it is important to recognize that such inferences are based on criteria of habitat values that were established in landscapes without fire. Thus, no studies have been published that quantify habitat value of vegetation in response to fire within a landscape that contains lesser prairie-chickens.

4. The primary body of evidence is from empirical studies that focus solely on the effect(s) of fire on vegetation within the historical range of distribution of lesser prairie chickens. We provide an overview of the current scientific consensus on the role of fire in lesser prairie chicken conservation efforts based on the conclusions from these studies.

FACTORS CONTRIBUTING TO DECLINE

Several factors have contributed to the decline of lesser prairie-chickens, with loss of habitat and degradation of existing habitat being referenced most often in the peer-reviewed literature (Jackson 1963; Woodward et al. 2001; Fuhlendorf et al. 2002; Hagen et al 2004). Habitat loss and fragmentation is the result of conversion of rangeland to croplands (Jackson 1963; Fuhlendorf et al. 2002), conversion associated with energy exploration (Hagen et al. 2011), and the loss of grassland to woodlands as a result of woody encroachment (Fuhlendorf et al. 2002; Hagen et al 2004). Habitat degradation refers to any factor rendering lesser prairie-chicken habitat less usable, which includes any range management practice that results in broad-scale uniformity and simplifies landscape heterogeneity in vegetation structure and composition (Derner et al. 2009; Fuhlendorf et al. 2009). Changes in fire regimes are therefore inherently linked to both habitat loss and degradation (e.g. as a result of result of uniform range management practices), and these have been the primary focus of discussion relevant to fire and lesser prairie-chicken population declines. Summaries of this information are provided in the following sections.

CHANGES IN FIRE AND HABITAT

Habitat loss and fragmentation from woody encroachment, as well as the loss of heterogeneity in vegetation structure and composition, are associated with changes in fire regimes since pre-EuroAmerican settlement (Fuhlendorf et al. 2009; Twidwell et al. 2013a). The frequent occurrence of fire across the lesser prairie-chicken range prior to settlement resulted in complex spatial mosaics of different grassland-dominated patches that contained scattered shrubs and few taller woody plants. However, reductions in fire occurrence and fire intensity have enabled woody plants to

dominate rangelands throughout the eastern half of the lesser prairie-chicken range (Fuhlendorf et al. 2002; Taylor et al. 2012; Winter et al 2012; Twidwell et al. 2013a). Some woody species, such as eastern redcedar (*Juniperus virginiana*) and Ashe juniper (*Juniperus ashei*), do not resprout after fire and can be killed if fire intensities are above the critical threshold needed to kill mature juniper trees (Twidwell et al. 2013b). Presently, however, prescribed fires are typically limited to conditions that fail to exceed this fire intensity – juniper mortality threshold (Twidwell et al. 2013b), so with fire restoration of grass-dominated ecosystems from juniper woodlands have been limited to localized areas where land stewards have the ability to conduct high intensity fires outside traditional burning prescriptions (Twidwell et al. 2013a).

Where grasslands are still dominant, the lack of fire, simplification of the extent and pattern of burned areas, and fire's interaction with herbivory has resulted in more uniform vegetation structure and composition (Fuhlendorf and Engle 2001, Derner et al 2009), which fails to provide for the diversity of habitat types required by the lesser prairie-chicken. Patch-burning (a practice based on the process of pyric herbivory) has been used to more closely mimic the spatial and temporal dynamics of the pre-EuroAmerican shifting mosaic (Fuhlendorf and Engle 2001). While grassland bird communities have responded favorably to patch burning, no peer-reviewed publications have directly evaluated the response of lesser prairie-chickens to such a management approach. Instead, the peer-reviewed literature primarily provides indirect evidence of how eco-evolutionary fire regimes created a spatially and temporally shifting mosaic that corresponds to the diverse life history requirements of lesser prairie-chickens. An overview of this literature is given below.

FIRE AND HABITAT REQUIREMENTS

Lesser prairie-chickens have different critical habitat needs for different life stages. We have reviewed the peer-reviewed literature to present the state of the science on the habitat characteristics for critical life stages (lekking, nesting, brooding) as well as the literature linking fire to such habitat requirements. Most of the metrics of habitat value we use come from Hagen et al. (2004), which establishes habitat management guidelines for the distinct life stages of the lesser prairie-chicken.

Fire and Lekking: Lesser prairie-chickens gather at leks each spring to participate in mate selection activities (Bent 1932; Copeline 1963; Hagen et al. 2004). These areas are important because they are the center of all breeding and are a focal point of lesser prairie-chicken management. Lekking habitat consists of areas of bare ground (23-55% bare ground) or low growing vegetation (4-8 in. tall), often on ridge tops or knolls that are higher than the surrounding topography to allow displaying lesser prairie-chicken males to be seen and heard (Hagen et al. 2004). These areas are often associated with livestock watering points, prairie dog towns, two-track roads, mineral licks, abandoned well pads, adjacent crop fields and recent burns (Hagen et al. 2004). Recently burned areas, especially when grazed, create suitable vegetation structure adequate for lekking and consequently attract lesser prairie-chickens (Cannon and Knopf 1979).

Figure 2. Lesser prairie-chickens flight dance. Photo by Torre Hovick.

Fire and Nesting: Nesting habitat requires excellent screening cover to hide nests from searching predators and to also provide thermoregulation requirements (Riley et al. 1992; Patten et al. 2005). Hens select areas with tall grass (> 7-14 in. tall) or shrubs (17-18 in. tall) such as sand sagebrush or shinnery oak (Hagen et al 2004) for protective cover. Nest success has been linked to the amount of dense screening cover, with successful lesser prairie chicken nests occurring within a range of 11-34 in. of visual obstruction (Hagen et al. 2004; Patten et al. 2005). To this end, nesting requirements across the lesser prairie-chicken range correspond to patches on a landscape that have not been burned in 3-4 years. It takes up to three years for shrub height, grass height and screening cover of nesting vegetation to recover from fire in shinnery communities (Boyd and Bidwell 1981), and approximately 4-years after fire for sand sagebrush communities to resprout and return to pre-burn structure (Vermier et al 2004; Winter et al. 2012).

Fire and Brooding: Brooding habitat is considered to be one of the most limiting factors to lesser prairie-chicken populations (Hagen et al. 2009). High quality brooding habitat associated with increased brood survival must have adequate screening cover and available forage (e.g. forbs and insects; Hagen et al 2005). However, research directly linking brooding requirements to fire treatments has not ye been

conducted. The afore mentioned studies have inferred brood habitat requirements from the available vegetation structure in a landscape that was not burned.

Nevertheless, it has been demonstrated by multiple studies that interactions between fire and grazing create habitat with more forbs and insects which is congruent with lesser prairie-chicken brooding requirements (Vermier et al 2004; Doxon et al. 2012; Winter et al. 2012). Successful brooding habitats are considered to be areas that have an abundance of forbs (11-35%) and insects, and range from 14-43% shrub cover and 8-50% grass cover with 10-12 in of visual obstruction (vertical screening cover; Hagen et al 2004). Forb abundance and visual obstruction have been observed in this range 2-3 years following patch-burning in sand sagebrush communities (Vermier et al 2004; Winter et al. 2012), and forbs are more abundant in recently burned patches compared to unburned patches in shinnery oak communities (Boyd and Bidwell 2001). Such increases in forb abundance and richness generally correspond to increases in insect abundance (Doxon et al 2012).

Fire and Landscape Management: While lesser prairie-chicken management is most often discussed in the peer-reviewed literature with respect to reproductive habitat values, landscape-level transformations associated with changing fire regimes have been linked to destabilizing populations. Lesser prairie-chickens avoid modern anthropogenic infrastructure, such as roads, power lines, or energy development (Robel et al. 2004; Pitman et al. 2005; Hagen et al 2011), and fences have been found to be a major source of mortality in some areas (Wolfe et al. 2007). Greater agricultural conversion at broad, landscape levels and even slight increases in tree cover over time (1-3% per decade) have been linked to declining lesser prairie-chicken populations (Fuhlendorf et al. 2002). The latter is directly associated with changes in fire occurrence since pre-EuroAmerican settlement (Twidwell et al. 2013a), especially in the eastern half of the lesser prairie-chicken range, where much of the remaining grass-shrub co-dominated ecosystems have been transformed to eastern redcedar woodlands in the absence of fire (Fuhlendorf et al. 2002; Twidwell et al. 2013a).

CONCLUSIONS

In this synthesis, we reviewed the scientific literature pertaining to the effects of fire on lesser prairie-chickens and their habitat. Overall, research is generally lacking that directly assesses relationships among fire, both as a regime and a discrete event, to its effect on lesser prairie-chicken behavior and habitat value. Yet, research has quantified the effects of fire on vegetation throughout the distribution of the lesser prairie-chicken, which has been linked to known metrics of habitat value and broad landscape-level habitat requirements.

To summarize the literature, lesser prairie-chickens require broad landscapes of fire-dependent grass-shrub vegetation. Changes in the eco-evolutionary fire regime and grazing regime of the southern Great Plains has contributed to extensive habitat loss as a result of woody encroachment and simplification of spatial and temporal variability in vegetation structure as a function of uniformity-based management.

The scientific foundation for lesser prairie-chicken conservation can be improved through research that addresses existing knowledge gaps in fire research. We recognize that land managers have a wealth of valuable observations and experience to contribute to our understanding of the role of fire in habitat management. The disparity of published research to document this knowledge was evident through our own peer review of this synthesis. Future research that links management actions to lesser prairie-chicken populations has the greatest potential to further management of the species. Additional critical research needs include quantifying the spatial scale needed to sustain lesser prairie-chickens in burned (or unburned) landscapes using advances in technology (e.g. GPS) to track individual movements, habitat use, or dispersal. Research that addresses the extent to which contemporary rangeland management practices, such as herbicide applications or grazing systems, alter the spatial and temporal complexity of lesser prairie-chicken habitat compared to eco-evolutionary fire and grazing regimes is also greatly needed. Finally, habitat value requirements were not developed from landscapes that included fire, and they do not account for differences in life stage habitat requirements among ecosystems (e.g. nesting requirements in sand sagebrush versus CRP tallgrass prairie). Filling these research gaps can refine our current understanding of the effect of fire on lesser prairie-chickens and its relative importance compared to other management practices in current conservation efforts.

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