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A Critical Examination of Timing of Burning in the Kansas Flint Hills

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ABSTRACT

Frequent burning is a crucial ecological and economic component of the Kansas Flint Hills. Although burning is important for the preservation of tallgrass prairie and improving livestock production, it has become a controversial societal issue because of its potential impact on air quality standards. Over the past 80 years, recommendations on burning in Kansas have ranged from total fire exclusion to burning only in late April; and for the past 40 years, the concept that burning should only occur in late spring has become ingrained in the cultural practices of rangeland management. Yet the scientific basis for these recommendations has received little rigorous scrutiny. Herein, we critically review the research on dormant-season burning in the Flint Hills that formed the foundation for modern burn practices in Kansas. Close examination of the historical data does not support the tenet that burning must be limited to a narrow window in late spring. Many conclusions of the research that led to recommending burning only in late spring were ambiguous, not subjected to statistical analysis, or were influenced by an antiburn bias. Current research suggests that timing of a burn is not as critical as ranchers have been led to believe and burning does not have to be restricted to a narrow window in late April. There is an absence of scientific evidence that burning earlier in the spring adversely affects forage production, plant species composition, soil moisture, or cattle weight gain. Although there is a need for research on the consequences of burning grazed pastures at different times of the year, expanding the window for burning earlier in the dormant season should help alleviate air quality issues downwind of the burned areas and potentially be beneficial to ranchers.

Introduction

The Flint Hills are the largest remnant of tallgrass prairie in North America, extending from northeast Kansas southward into Oklahoma and encompassing approximately 25 000 km^2. The area has remained virtually intact as native prairie since settlement because the limestone and flint outcroppings that characterize the landscape make much of the land ill-suited for cultivation. Topographically, the upland soils are relative rocky, shallow, and overlay clay strata, whereas the lowland soils are deep and arable. In most years the native prairie grasses are highly productive and forage quality is relatively high in the early growing season. For more than 100 years, the Flint Hills have been predominantly utilized for seasonal grazing by cattle (Malin, 1942). More than one million stocker cattle annually graze in the Flint Hills, either season long or only in the first half of the growing season (Duesterhaus et al., 2008). Pasture burning is an important management practice to increase livestock production (Bernardo et al., 1988), although the amount of grassland burned varies widely among years throughout the region (Mohler and Goodin, 2012).

Fire, drought, and herbivory were all crucial factors in the development of tallgrass prairie (Axelrod, 1985; Anderson, 2006). Over the past 40 years, most research on Flint Hills burning has focused on the ecological effects of fire frequency, with experimental burns ranging from annual to 20-year intervals (Gibson, 1988; Collins, 1992; Collins, 2000; Briggs et al., 2002; Heisler et al., 2003; Spasojevic et al., 2010; Collins and Calabrese, 2012). Those studies demonstrated that the warm-season grasses, which are the cornerstone of tallgrass prairie vegetation, are favored by frequent burning. Increased dominance of warm-season grasses in prairie that is annually burned in late spring, however, lowers species richness compared with infrequently burned prairie (Collins, 1992; Briggs et al., 2005; Limb et al., 2010; Spasojevic et al., 2010; Collins and Calabrese, 2012; Bowles and Jones, 2013). In prairie that has not been burned for many years, grass litter accumulates, soil resources increase, warm-season grasses and other herbaceous species decline, and woody species progressively expand (Engle and Kulbeth, 1992; Hoch et al., 2002; Briggs et al., 2005; Ratajczak et al., 2012; Craine and Nippert, 2014).

Most of the initial research on burning in Kansas was conducted on ungrazed sites, and some of the observed responses may not be commensurable with grazed areas. Fire and grazing are not independent drivers of vegetational change, and an interaction between the two can affect plant and animal responses through both positive and

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negative feedbacks (Coppedge et al., 1998; Johnson and Matchett, 2001; Briggs et al., 2002; Fuhlendorf and Engle, 2004; Fuhlendorf et al., 2009; Augustine et al., 2010). Although species richness is reduced with annual burning, prairie that is burned and moderately grazed has higher species richness than prairie that is burned and not grazed (Collins, 1992; Towne et al., 2005; Collins and Calabrese, 2012). In addition, fire intensity is lower in grazed pastures than in ungrazed prairie because herbivory reduces the fuel load and produces a mosaic landscape where some species are protected from fire. The lower fire intensity has been implicated as a potential reason why fire is sometimes ineffective in eliminating woody species from grazed pastures (Hoch et al., 2002; Veach et al., 2014). Notwithstanding potential shortcomings in extrapolating research from ungrazed sites to grazed sites, research in ungrazed prairie has been the historical foundation for recommendations on when the Kansas Flint Hills should be burned.

Despite recent advances in our understanding of fire in the region, the one constant for almost all research on Flint Hills burning has been that the fires have occurred in late spring. Research on the timing of burns has been a subordinate issue compared with research on the consequences of fire frequency. In other grassland regions, strategic prescribed fire at different times in the dormant season has been utilized as a management tool to selectively depress or enhance plant species (Ruckman et al., 2012; Luna et al., 2014), manipulate the balance of C_3 and C_4 species (Steuter, 1987), control woody species (Owens et al., 2002; Ansley et al., 2015), stimulate flowering (Platt et al., 1988; Pavlovic et al., 2011), or alter the proportion of plant functional groups (Coppedge et al., 1998). Although time of burning can affect various aspects of the plant community, late spring has become accepted as the default time for almost all fire research in the Kansas Flint Hills.

The general acceptance that late spring is the best time to burn the prairie originates from a small set of studies conducted more than 40 years ago. In the subsequent decades, ranchers have not been exposed to any alternative options on time of burning. The recommendations to burn in late spring were predicated on the belief that burning at that time would minimize reductions in biomass production, reduce soil moisture loss, increase production of warm-season grasses, eliminate woody species and undesirable forbs, and increase cattle weight gain (Anderson, 1964; Anderson, 1965; McMurphy and Anderson, 1965; Anderson et al., 1970). The ecological and economic reasons promoted in these recommendations were influential incentives for ranchers to only burn in late spring.

There is little dispute that frequent burning in late spring has maintained Flint Hills grasslands. Widespread synchronized pasture burning in late spring, however, has become a societal issue that affects numerous people because air quality thresholds are often exceeded. The production of large amounts of smoke from en masse late-spring burning facilitates the formation of ground-level ozone in concentrations that often exceed US Environmental Protection Agency (EPA) standards (Liu, 2014; Kansas Flint Hills Smoke Management, 2015). Airborne chemical and particulate pollutants created from burning can increase the incidence of asthma, cardiovascular problems, lung cancer, and acute bronchitis (Pope et al., 2002). Exceeding federal air quality standards can trigger regulatory costs for municipalities and instigate potential interstate lawsuits when smoke is transported across state borders (Kansas Department of Health and Environment, 2010). Recent proposals by the EPA to lower the allowable ozone threshold will only increase the importance of sound recommendations on the timing of burning in the Flint Hills.

Potential mechanisms to reduce downwind smoke pollution include policies that regulate the amount of burning on a particular day, burning less frequently, or burning earlier in the spring to distribute smoke production over a longer time period when ozone is less likely to be formed. However, bureaucratic intervention on regulating individual burns or burning less frequently would be unpopular and may not be feasible options for regional grassland stewardship. If burning earlier in the spring is to be considered as a reasonable solution to reduce smoke pollution, then an in-depth reevaluation of the research that led to the current recommendations of late-spring burning is necessary.

Engle and Bidwell (2001) previously reviewed the response of North American prairies to seasonal fire and concluded that prairie vegetation is more resilient to burning at different times in the year than what is commonly believed. However, they also postulated that "Conventional wisdom in the region holds that burning in the dormant season other than in the late dormant season (late spring) always reduces herbage production and increases weedy forbs relative to desirable forage grasses" (p. 3). Subsequent to that review, there has been extensive research on the response of tallgrass prairie to time of burning, which calls into question many generalities that are accepted as conventional wisdom.

Our objective here is to critically review the research that established the foundation for the long-standing recommendation that grasslands in Kansas should only be burned in the late spring. To accomplish this, we focus on the initial studies from burning on different dates that were conducted at Kansas State University from 1930–1970. Although fire research over the past 30 years throughout the region (primarily at Konza Prairie and Oklahoma State University) has contributed immensely to understanding various aspects of grassland burning, there is a paucity of information on timing of burns. Therefore the intent of this review is to examine the limitations and any potentially misleading conclusions drawn from the studies that were responsible for forming the recommendations that Flint Hills prairie should only be burned in late spring. Because most pasture burning in the Flint Hills traditionally occurs annually during the dormant season, fire in the growing season (i.e., summer burning) is not covered here.

Early research on time of burning in the flint hills

Intentional burning by Native Americans occurred at different times of the year, and historical records of early pioneers are replete with observations of autumn and early spring fires. Once European immigrants settled in the area, however, any grassland burning was considered dangerous and undesirable. By the 1880s, the influx of transient cattle from Texas for summer grazing was an impetus for ranchers to revive intentional burning because animal performance was better if the old grass cover was removed (Kollmorgen and Simonett, 1965; Isern, 1985). At that time there was widespread opposition to pasture burning, and most nonranchers considered prairie fires destructive and unnecessary (Hoy, 1989; Hoy and Isern, 1995). In a preliminary examination on burning, Hensel (1923a) observed that "Opinion among stockmen on the burning question is divided. Some favor it strongly, while others are decidedly opposed to it. Among scientific men, the belief has always been held that it is injurious" (p. 184).

To address the impact of pasture burning, Kansas Agricultural Experiment Station initiated a study in 1918 to compare vegetation between a burned plot and an unburned plot in an ungrazed area. After 4 years of annual burning in late March to early April, Hensel (1923b) concluded that the study "failed to show that burning is injurious" (p. 642). In a subsequent experiment, Aldous (1934) established a series of 10 × 20 m plots on an ungrazed upland prairie to study the effects of burning either annually or biennially at four different times in the dormant season. Treatments were winter burn (1 December), early-spring burn (20 March), midspring burn (10 April), late-spring burn (5 May), and an unburned control. After 6 years, Aldous concluded that although annual burning increased the number of plant stems, it was not a beneficial practice because it lowered soil moisture levels in some years and reduced average biomass production by 33 − 47% compared with the unburned plot. The largest reductions in biomass occurred the earlier the plot was burned.

In both of these initial burn studies, the treatments were not replicated in space and the unburned plot was annually mowed and raked in late April because litter accumulations "attracted rodents and tended to cause abnormal fungus growth" (Aldous, 1934, p. 13). Treating the