Major Negative Impacts of Early Intensive Cattle Stocking on Tallgrass Prairies: The Case of the Greater Prairie-Chicken (*Tympanuchus cupido*)

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Abstract

Human impacts on tallgrass prairies and their biota have been severe. Among recent impacts is the shift from mosaic or rotational burns in fall and spring to broadscale artificial burns annually in the spring, coupled with "early intensive cattle stocking." We examine the effects of this relatively new management regime on the Greater Prairie-Chicken (*Tympanuchus cupido*). First, the rapidly decline of this species is documented—a broad range expansion at the end of the nineteenth century followed by a drastic range reduction over the course of the latter half of the twentieth century. The core of the species's range has usually been considered to be the Flint Hills of eastern Kansas, yet this region has seen dramatic population declines during the past two decades. These declines are closely associated with different burning regimes: where spring burning regimes and associated early intensive cattle stocking are common, prairie-chickens are declining dramatically, whereas where spring burning is rare and/or rotated, populations are stable. We suggest that this relatively new management technique works to the great detriment of the Greater Prairie-Chicken—and indeed to that of an entire suite of species that depend on prairie vegetation that is not burned yearly.

INTRODUCTION

The tallgrass prairie is the most heavily impacted biome in North America, with less than 5 per cent of its presettlement extent remaining (Samson and Knopf 1994). Remaining tallgrass prairie is highly fragmented, with the largest contiguous unplowed section being the Flint Hills region of extreme northern Oklahoma and eastern Kansas (Reichman 1987, Knapp and Seastedt 1998). Because of their great extent, the Flint Hills have long been recognized as harboring the largest population of Greater Prairie-Chickens (Baker 1953, Johnsgard 1973, Westemeier and Gough 1999) and other species restricted to tallgrass prairie

However, beginning in 1980 in northern Oklahoma (L. Holcombe, pers comm.) and soon thereafter in Kansas—and especially in the past five years—the vast majority of the Flint Hills and adjacent areas have been managed under a fire and grazing regime called early intensive stocking (Smith and Owensby 1978, Launchbaugh et al. 1983). In contrast to the mosaic of burned and unburned areas that traditionally characterized tallgrass prairie cattle ranching (burns every 2-3 years, with stocking and grazing from May to October), extensive portions of these regions are now burned annually in March and April, in preparation for the arrival of cattle from as far away as Mexico (*Lawrence Journal-World*, 27 May 2001). Arriving by truck between mid-March and mid-May, cattle feed on newly emerging grass as soon as 10 days post-burn and continue to graze these areas for 90-120 days (*Lawrence Journal-World*, 27 May 2001; Launchbaugh et al. 1983). This intense grazing regime uses roughly twice the stocking rate (Launchbaugh et al. 1983) and leaves much of the Flint Hills devoid of grass more than a few centimeters high until at least mid-July.

During the past four years, we have been stunned by the extent of this intense agribusiness practice in the Flint Hills and surrounding areas, so here we investigate what influence this phenomenon is having on the native biota. We focus on the Greater Prairie-Chicken (*Tympanunchus cupido*) and present a rangewide analysis of its distribution and population status. In order to investigate prairie-chicken population trends as they relate to fire regimes and grazing intensity, we attempted to correlate best available data on populations in the Flint Hills and adjacent areas with burned areas in 2000 as detected by three independent long-term remote-sensing operations.

THE GREATER PRAIRIE-CHICKEN

The Greater Prairie-Chicken ranks among three species that have seen the most catastrophic range contraction and population declines in North America (Fig. 1; Johnsgard 1973, Schroeder and Robb 1993). This species, likely numbering in the tens of millions in the late 1800s, once ranged from the Great Plains to the eastern seaboard (Johnsgard 1973, A.O.U. 1998). The easternmost population, known as the Heath Hen (*T c. cupido*), was extinct by 1932 (A.O.U. 1998). The subspecies known as Attwater's Prairie-Chicken, *T. c. attwateri*, formerly distributed along the Gulf coastal prairie from southwestern Louisiana to southern Texas, is now critically endangered, with a total of fewer than 60 individuals in two isolated populations in eastern Texas (Silvy et al. 1999).

The species began serious range contraction in the first few decades of the twentieth century, disappearing from Ohio and Indiana by the 1930s In the succeeding 50 years, it disappeared from almost the entirety of the eastern sector of its original range, although stocking from Kansas and Nebraska populations maintains small, intensively managed populations in Illinois, Iowa, and most recently Missouri (Westemeier and Gough 1999). The continent-wide loss and fragmentation of native grasslands has been the primary cause for these declines (Johnsgard 1973). As of 1980, apparently viable populations remained only in Kansas, Nebraska, and sparsely in South and North Dakota, Minnesota, and possibly Missouri (Westemeier and Gough 1999). Numerous authors considering the distribution, abundance, and continuity of the species's distribution have suggested that Kansas's Flint Hills constitute a nucleus of the species's distribution and would be critical to the species's long-term survival (Svedarsky et al. 1999).

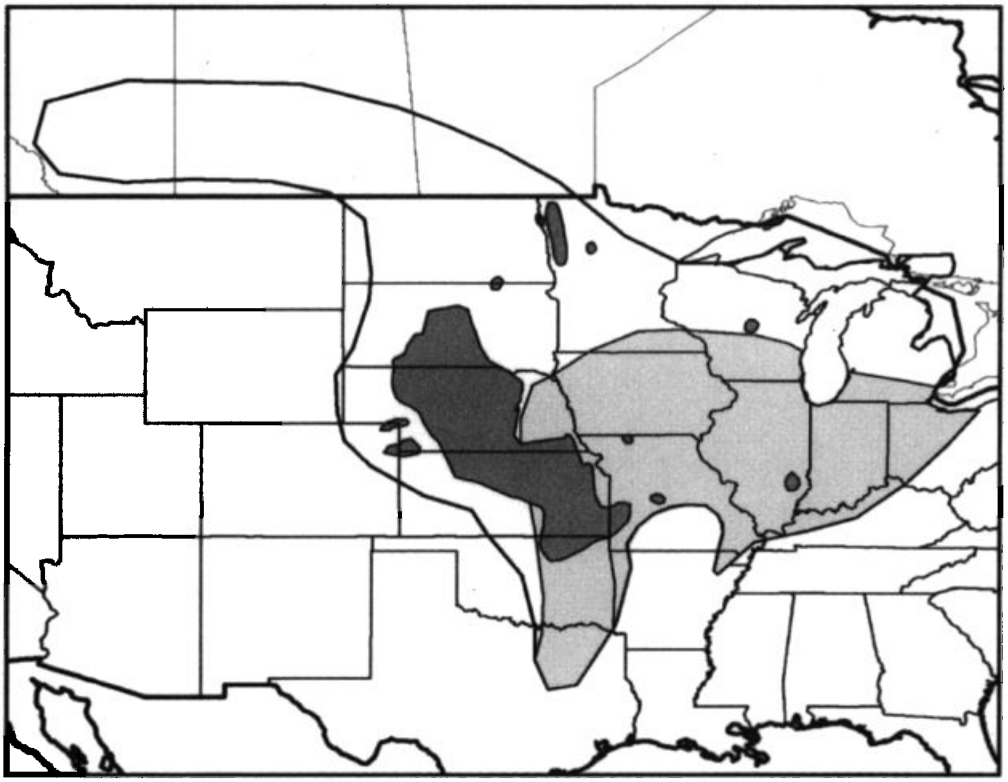

Figure 1. Greater Prairie-Chicken original (light gray shading), late nineteenth-century (black outline), and present distribution (dark gray shading), extracted from Westemeier and Gough (1999).

METHODS

Distributional data—Distributional data for Greater Prairie-Chickens that summarize the species's original range, its expanded distribution in the late nineteenth century, and its present, highly fragmented distribution were drawn from Westemeier and Gough (1999) and from natural history museum specimens (see Acknowledgments). We digitized this information in a GIS environment (using ArcView 3.2) and saved it in raster grid format for further analysis at a resolution of one km. We reduced the extent of the species's distribution to reflect current coverage by native tallgrass and mixed-grass prairies, based on the U.S. Geological Survey's world land use/land cover classification at one-km spatial resolution ("grassland" and "wooded grassland" cover types).

Burn detection.—We used three approaches to summarize the extent and spatial distribution of spring burning within the range of the species, using the year 2000 as an exemplar year. First, we downloaded the year 2000 results of the ATSR world fire atlas facility, which provides detection of nighttime fires for the entire world. However, because controlled burns on prairies are carried out mostly in daytime, this approach greatly underestimated frequency of fires in the region.

Second, we inspected LandSat7 Thematic Mapper images to identify recently burned areas. Here, the color composite scheme in the visible bands allows easy visual detection of burned areas as black smudges on the landscape (M. Jakubauskas, pers. comm.). These images were consulted, and crude digitizations developed, at the U.S. Geological Survey website. However, because images are available only every 16 days, and cloud cover in the spring is frequently sufficient to compromise image quality, we were able to evaluate spring 2000 burns only in the eastern portion of the Flint Hills region (1999 and 2001 provided even less areal and temporal coverage for cloud-free imagery).

To provide a more complete view of spring burns (in 2000), we explored a second approach to detecting recently burned areas Important assumptions of this approach are: first, in spring, that the general trend is of greening of the prairie landscape; and second, that burns and cloud cover are the principal factors that could reduce greenness. In satellite imagery, the normalized difference vegetation index (NDVI) presents an approximation of how green a landscape is: the proportion of photosynthetically absorbed radiation, calculated as (ch2 – ch1) / (ch2 + ch1), where ch2 represents the 0.58-0.68 μ portion of the visible spectrum, and ch1 represents the 0.725-1.1 μ portion of the infrared spectrum. Hence, we used NDVI images (one-week composites) for March-April 2000 and performed the following manipulation in ArcView (version 3.2): (1) find grid squares in which NDVI in a given week is higher (greener) than in the following week; (2) find grid squares in which NDVI value in a given week is higher than in two weeks later. Given that cloud cover in the Great Plains rarely lasts more than a week in spring, (3) find grid cells in which both (1) and (2) are fulfilled. These grid cells are those that "browned down" in spring and remained browner for at least 10-14 days. We assumed that cloud cover is not a factor for such extended periods of time and that drying of soils and vegetation (which would cause a lower, or browner, NDVI value) owing to drought (not common in spring) or spring plowing is not a factor; however, these assumptions prevented our application of this approach outside of the Flint Hills region.

To validate our hypothesis, we used two approaches. First, we compared frequency of these long-term brown-downs (apparent burns) in the Flint Hills, where spring burns are frequent, with northern and eastern Douglas County, where spring burns are infrequent and of very small extent (ATP and MBR, pers. obs.). Second, we compared the distribution of fires and burns detected by the three independent methods (indeed three independent sensors) to evaluate spatial coincidence. Burn data

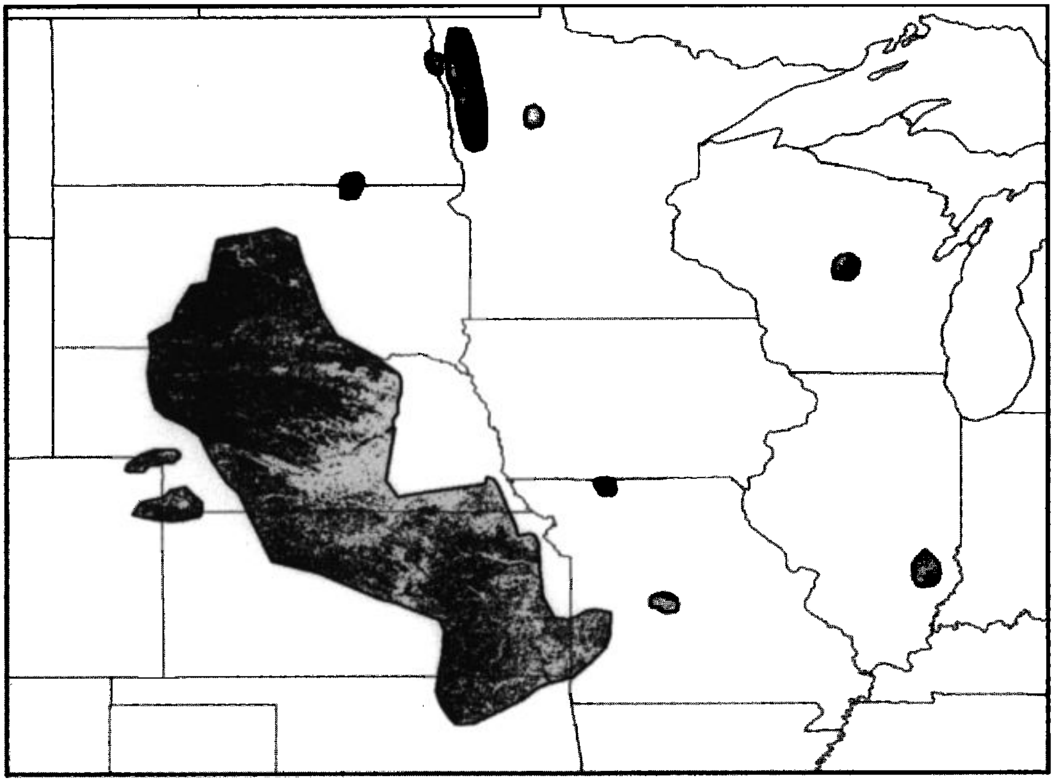

Figure 2. Greater Prairie-Chicken present range (Westemeier and Gough 1999), with the distribution of grassland and wooded grassland (in black) overlain to indicate probable true distribution in those areas.

were also evaluated qualitatively with our own observations of burned areas in the region.

Population trends.—Trend data for each state, as well as for regional and local populations of Greater Prairie-Chickens, were assembled from Svedarsky et al. (1999), supplemented with information provided by J. Taylor, D. McCrea, B. Sandercock, and D. Wiedenfeld. Trends for two regions in Nebraska and on a statewide basis for Kansas, Oklahoma, and South Dakota were assembled from lek data for which ≥8 years of data were available and are presented as three-year running averages for the period 1980-2000. Although data for South Dakota and Kansas are directly comparable (males/lek/square mile), data for Nebraska and Oklahoma were available only in other forms (as average number/lek and as population density index [number of males/lek x number of leks/square mile], respectively); nonetheless, all of these indexes are intercorrelated, resulting in similar interpretations. While we are aware that these survey data do not translate directly into population density estimates—and are not directly comparable from state to state—we present the information available from each state to illustrate the likely population trends across the range of the species.

RESULTS

Prairie-chicken distribution.—Historical patterns of prairie-chicken distribution show a dynamic range for the species. Originally more southerly in its distribution in the Great Plains, it expanded greatly to the north and west at the end of the nineteenth century (Fig. 1). Its present distribution is now dramatically reduced to a few small patches in the eastern sector, and one larger swath in the central Great Plains, extending from Kansas and northern Oklahoma north to South Dakota (Fig. 1).

This "present" distribution, however, includes several land cover types not used by prairie-chickens, and so we reduced it to reflect the geographic distribution of tallgrass and mixed-grass prairie (Fig. 2). The species's core range may be said to lie along the western fringe of its present range (South Dakota, Nebraska, Kansas): its actual and potential distribution elsewhere is reduced to small, isolated fragments.

Spring burning.—The three approaches to assessing spring burn frequency revealed similar geographic patterns: burns were concentrated in the Flint Hills region, from northernmost Oklahoma north to northern Kansas in the vicinity of Manhattan (Fig. 3). As predicted, the Flint Hills saw extensive fires and burning, whereas Douglas County did not. The actual fires detected (ATSR sensor data)—being nighttime fires in a region where controlled burns are done in no small part in the daytime (ATP and MBR, pers. obs.)— are clearly but a subset of the true number of fires in the region.

The LANDSAT7 imagery, where cloud-free imagery existed, showed a much broader pattern of burned areas. In the Flint Hills, upland areas (the actual prairies) were almost ubiquitously burned, but floodplains along rivercourses were seldom burned; these areas are largely cropland and obviously protected from the prescribed burns.

The apparent burned areas (three-week brown-downs) detected via AVHRR imagery coincided closely with areas detected via the LANDSAT7 imagery. These areas, although considerably more difficult to interpret directly as burned areas, appear to represent landscape features rather than cloud contamination, given close correlation with land cover: prairie vegetation browned down (= burned), whereas cultivated areas along watercourses did not (Fig. 4). Correlation with known fires (ATP and MBR, unpubl. data) is quite close, and indeed where LANDSAT7 imagery was available, coincidence of the two hypothesized burned areas was quite close.

In sum, much of the tallgrass prairie from northern Oklahoma north to northern Kansas is burned each spring. Our observations each year, as

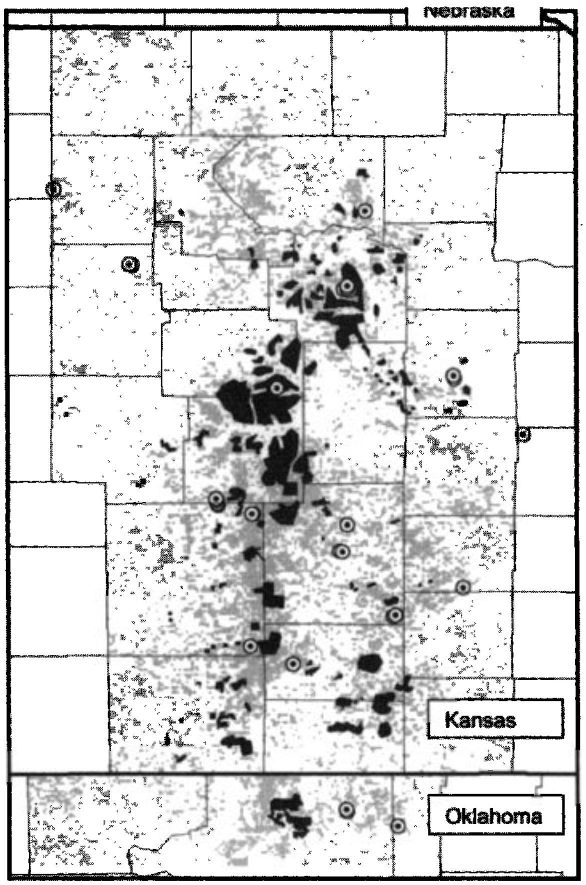

Figure 3. Fire occurrences between 15 March and 15 May 2000 in the Flint Hills region (few or no fires or burns were detected by the fire-detection sensor or by the LANDSAT7 imagery outside of this region). Nighttime fires detected via the World Fire Atlas are shown as dotted circles; burns apparent on the LANDSAT7 imagery are shown in black; and apparent burned areas detected by brown-down over consecutive weeks are shown in light gray.

well as more casual inspection of imagery from other years, confirm that the year 2000 was not unusual but rather is quite representative of burning patterns in recent years. None of the approaches we employed detected extensive spring fires or burns in Nebraska or South Dakota. Hence, the core of the range of the species is subjected to two diametrically opposed fire management schemes: spring fires dominate in Kansas, whereas spring fires are much less frequent, and typically entail rotational burning, in Nebraska (T. Labedz, pers. comm.) and South Dakota (D. McCrea, pers. comm.).

Population trends.—Population trends differ markedly among regions (Fig. 4; presented as three-year running averages). Nebraska and South Dakota populations were increasing or are stable. Kansas and Oklahoma populations, however, declined precipitously since 1980: lek counts (both states) and hunting harvest data (Kansas) both indicated steady declines in populations. Causal interpretation of differences in population trends as resulting from differences in fire management schemes is of course not necessarily warranted; however, the association is clear.

DISCUSSION

The analyses above point to two important lessons: first, that the Greater Prairie-Chicken is undergoing a major decline in the core area of its distribution; and second, that fire management practices and intensive grazing in this core area appear responsible for local declines and extirpations The combination of fire and intense grazing has been demonstrated to have a major negative impact on forb growth and reproduction, and on populations of invertebrates and vertebrates (Zimmerman 1997, Kaufman and Kaufman 1997, Rohrbaugh et al. 1999). For example, Kaufman and Kaufman (1997) stated that "annual burning of rangelands, a common ranching practice in the Flint Hills, may be the factor that most affects small mammals of the tallgrass prairies of central North America [...] Our results of ungrazed tallgrass prairie on the Konza Prairie [in the Flint Hills] suggest that large-scale burning at an annual frequency will have a negative impact on many if not all small mammals" This result is echoed for virtually the entire fauna and flora of this region

Given that the Kansas prairies are the focus of a 4.9-billion dollar beef industry in Kansas (*Lawrence Journal-World*, 27 May 2001), and with the instigation of the early intensive stocking regime (Smith and Owensby 1978), the Greater Prairie-Chicken is experiencing serious population declines in this region. Applegate and Horak (1999) summarized Kansas population trends from two data sets for 1960-1996. Both data sets demonstrated steep population declines since the early 1980s, with the more reliable data set (booming ground censuses) indicating an overall decline of approximately 65% in the past 20 years. These population declines are also reflected in numbers of prairie-chickens taken annually by hunters in Kansas: from a mind-boggling 109,000 birds in 1982 to ca 12,000 in 1998-1999 (Kansas Department of Wildlife and Parks).

The situation in Oklahoma mirrors that of Kansas, with significant declines since 1982 (Horton and Wolfe 1999). The two largest prairie-chicken populations in Oklahoma are at the southern terminus of the Flint Hills, where intensive early stocking was implemented in 1980 (L Holcombe, pers. comm.). Horton and Wolfe (1999) and Applegate and Horak (1999) suggest that the intensive early stocking regime is the primary reason for the declines. In contrast, Nebraska and South Dakota, which harbor the largest populations outside of Kansas, have shown populations that are stable or increasing in the same period. Particularly revealing are the stable populations in southeast Nebraska just to the north of the Flint Hills (Johnsgard 2001). Although survey data for southeastern Nebraska are available for only the past seven years, their stability is clear (Taylor 2000, Johnsgard 2001, J. Taylor, pers. comm.): unlike Kansas's Flint Hills and Osage Plains, southeastern Nebraska prairies are not subjected to annual spring burning and the early intensive stocking regime (T. Labedz, pers. comm.).

The intensive grazing regime in Kansas is not limited to the Flint Hills but has also become standard practice in the Osage Plains of eastern Kansas. Just in the past 5-6 years, the remaining fragmented, tallgrass prairie in the Osage Plains has begun to be burned in spring annually (W Brecheisen pers. comm., ATP and MBR, pers. obs.). Like the Flint Hills, we strongly suspect that prairie-chicken declines in this region (= "eastern cropland" and "blackjack" in Applegate and Horak 1999) are largely related to the annual spring burning and cattle stocking.

During observations in the past three years in the Flint Hills, we have found only two bird species (Common Nighthawk *Chordeiles minor*, and Upland Sandpiper *Bartramia longicauda*) that commonly utilize grasslands subjected to spring burning and intense early stocking. Even for these species, trampling by cattle may be an important source of nest mortality, as has been documented for Eastern Meadowlarks (*Sturnella magna*) in the Flint Hills of Oklahoma (Rohrbaugh et al. 1999).

In contrast, tallgrass prairie and fallow pasture not burned for at least one year generally hold the full complement of tallgrass prairie bird species, including prairie-chickens and the severely declining Henslow's Sparrow (*Ammodramus henslowii*) (Zimmerman 1988, 1997). Indeed, in the Kansas Breeding Bird Atlas, Henslow's Sparrow was recorded in only

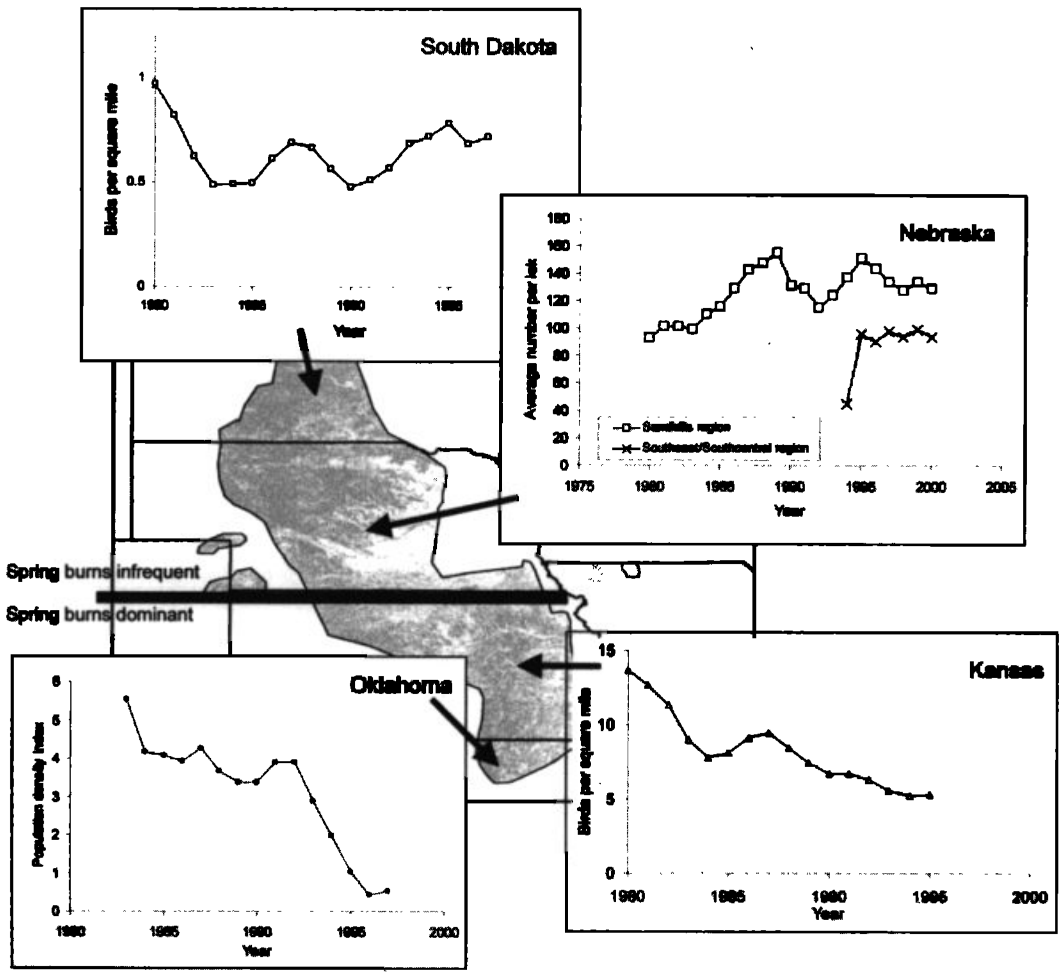

Figure 4. Population trends (presented as three-year running averages) in the core of the geographic distribution of the Greater Prairie-Chicken: stable or increasing populations are apparent in Nebraska (Taylor 2000; J. Taylor, pers. comm.) and South Dakota (Fredrickson et al. 1999), where spring burning is rare or absent; whereas precipitous declines are observed in Kansas (Applegate and Horak 1999) and Oklahoma (Horton and Wolfe 1999), where spring burning is dominant. See Results for explanation of data.

nine of 112 Flint Hills survey blocks (six of 74 priority blocks in the region), and its scarcity there was attributed to "grazing and burning practices" (Busby and Zimmerman 2001). Prior to major modifications to prairie ecosystems wrought by Euro-Americans, this species was undoubtedly widespread and abundant—if not ubiquitous—throughout the Flint Hills and the adjacent Osage Plains. Today, we estimate that less than 1% of the original range of Henslow's Sparrow in these regions remains inhabited.

Moreover, an entire suite of birds, mammals, reptiles, and insects similarly thrive in prairie that is not burned yearly but that sees a variety of burn frequencies (Knapp and Seastedt 1998); these species, like the prairie-chickens, are becoming endangered regionally by the yearly burning regime. Not surprising, the three largest tracts of tallgrass prairie in the Flint Hills (Konza Prairie and Fort Riley Military Reservation, Kansas; and Tallgrass Prairie Preserve, Oklahoma) that are *not* subjected to the intensive early stocking regime harbor the largest populations of both the prairie-chicken and the sparrow (Zimmerman 1993, Cully and Michaels 2000, Reinking et el. 2000).

CONCLUSIONS AND RECOMMENDATIONS

Based on the trends and patterns documented herein, as well as on our observations of prairie species across the Flint Hills region in recent years, we and numerous colleagues involved with tallgrass prairie biotas are convinced that the spring burning regime with early intensive livestock grazing represent a serious threat to numerous elements of biodiversity Greater Prairie-Chickens, as well as several other species (e.g., Henslow's Sparrow), have suffered drastic reductions in distribution and population size in the state. This threat is of particular concern given that the Flint Hills region is considered to hold the core populations of these species—this situation thus constitutes a threat to the global survival of an entire suite of species.

In short, spring burning followed by early intensive stocking of cattle on an annual basis make the prairie all but uninhabitable for these species. This technique, combined with other problems (e.g., invasion of the prairies by *Sericea cuneata* [Fabaceae], resulting in spraying for control), could easily place the species in serious danger of regional extirpation or even extinction altogether. We concur with recommendations made by Applegate and Horak (1999) and Horton and Wolfe (1999) regarding burning regimes: reducing burn frequency, adjusting the seasonality of burning, and reducing grazing pressure constitute critical components of the strategy. In effect, for prairie to represent a viable habitat for these species, a mosaic of burn frequencies of 1-5 years is necessary (Knapp and Seastedt 1998). Hence, a system centered around rotational prescribed burning, combined with reduced grazing pressure, is highly recommended.

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