Research Note

Influence of Fire on Black-Tailed Prairie Dog Colony Expansion in Shortgrass Steppe

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Abstract

Factors influencing the distribution and abundance of black-tailed prairie dog (*Cynomys ludovicianus*) colonies are of interest to rangeland managers because of the significant influence prairie dogs can exert on both livestock and biodiversity. We examined the influence of 4 prescribed burns and one wildfire on the rate and direction of prairie dog colony expansion in shortgrass steppe of southeastern Colorado. Our study was conducted during 2 years with below-average precipitation, when prairie dog colonies were expanding throughout the study area. Under these dry conditions, the rate of black-tailed prairie dog colony expansion into burned grassland ($\bar{X} = 2.6$ ha · 100-m perimeter^{-1} · y^{-1}; range = 0.8–5.9 ha · 100-m perimeter^{-1} · y^{-1}; $N = 5$ colonies) was marginally greater than the expansion rate into unburned grassland ($\bar{X} = 1.3$ ha · 100-m perimeter^{-1} · y^{-1}; range = 0.2–4.9 ha · 100-m perimeter^{-1} · y^{-1}; $N = 23$ colonies; $P = 0.066$). For 3 colonies that were burned on only a portion of their perimeter, we documented consistently high rates of expansion into the adjacent burned grassland (38%–42% of available burned habitat colonized) but variable expansion rates into the adjacent unburned grassland (2%–39% of available unburned habitat colonized). While our results provide evidence that burning can increase colony expansion rate even under conditions of low vegetative structure, this effect was minor at the scale of the overall colony complex because some unburned colonies were also able to expand at high rates. This result highlights the need to evaluate effects of fire on colony expansion during above-average rainfall years, when expansion into unburned grassland may be considerably lower.

Resumen

Los factores que influyen en la distribución y abundancia de las colonias de ''Perros de la pradera de cola negra'' (*Cynomys ludovicianus*) son de interés para los manejadores de pastizales debido a la influencia significativa que estos pueden ejercer sobre el ganado y la biodiversidad. Examinamos la influencia de cuatro quemas prescritas y un fuego natural sobre la tasa y dirección de expansión de la colonia de ''Perros de la pradera'' en una pradera de zacates cortos del sudeste de Colorado. Nuestro estudio se condujo durante dos años con precipitaciones abajo del promedio, cuando las colonias de ''Perros de la pradera'' se estaban expandiendo a través del área de estudio. Bajo estas condiciones secas, la tasa de expansión de la colonia de ''Perros de la pradera de cola negra'' dentro del pastizal quemado ($\bar{X} = 2.6$ ha · 100-m perímetro^{-1} · año^{-1}; rango = 0.8–5.9 ha · 100-m perímetro^{-1} · año^{-1}; $N = 5$ colonias) fue marginalmente mayor que la tasa de expansión en el pastizal sin quemar ($\bar{X} = 1.3$ ha · 100-m perímetro^{-1} · año^{-1}; rango = 0.2–4.9 ha · 100-m perímetro^{-1} · año^{-1}; $N = 23$ colonias; $P = 0.066$). En tres colonias en las que solo una porción de sus perímetros se quemó documentamos tasas de expansión consistentemente mayores hacia las áreas de pastizal adyacentes quemadas (38%–42% del hábitat quemado disponible colonizado) y tasas variables de expansión hacia los pastizales adyacentes sin quemar (2%–39% del hábitat sin quemar disponible colonizado). Mientras que nuestros resultados proveen evidencia de que la quema puede incrementar la tasa de expansión de la colonia, aun en condiciones de estructura vegetativa baja, este efecto fue menor en la escala del complejo general de la colonia, porque algunas colonias sin quemar fueron también capaces de expandirse a tasas altas. Estos resultados resaltan la necesidad de evaluar los efectos del fuego sobre la expansión de la colonia durante años con precipitación arriba del promedio, cando la expansión hacia el pastizal sin quemar puede ser considerablemente menor.

Key Words: *Cynomys ludovicianus*, grassland disturbance, prescribed burning, semiarid rangeland, wildfire

INTRODUCTION

In the Great Plains of North America, considerable research has examined the direct effects of grazing and fire on rangeland ecosystems, and studies have demonstrated the strong feedback effects that fire and large herbivores can have on one another and on plant communities (Coppock and Detling 1986; Coppedge and Shaw 1998; Knapp et al. 1999; Fuhlendorf and Engle 2001). In addition to large herbivores, black-tailed prairie dogs (*Cynomys ludovicianus*) can be an important component of the grazing regime, particularly in the short- and

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mixed-grass prairies of the Great Plains (Kotliar et al. 1999; Detling 2006). Considerable research has focused on the role of black-tailed prairie dogs in shortgrass steppe in terms of their effect on vegetation, biodiversity, and cattle (e.g., Kotliar et al. 1999; Kretzer and Cully 2001; Winter et al. 2002; Guenther and Detling 2003; Smith and Lomolino 2004; Derner et al. 2006). Fire is also an important disturbance process influencing vegetation and native vertebrates in shortgrass steppe (Svingen and Giesen 1999; Brockway et al. 2002; Ford and Johnson 2006). However, the degree to which fire can influence black-tailed prairie dog colonies in this ecosystem has not been evaluated.

In mixed-grass prairie, the combination of brush removal and low-intensity (growing season) fire has recently been shown to facilitate prairie dog colony expansion (Milne-Laux and Sweitzer 2006). This effect has been attributed primarily to reduced vegetation height and hence improved visibility and predator detection for prairie dogs (Koford 1958; Garrett et al. 1982).

Understanding effects of fire on black-tailed prairie dog colony expansion is particularly important for public lands, where sustaining prairie dog populations is one of multiple management objectives. Prescribed fire is a potential tool that managers could use to manipulate the direction of colony expansion or to enhance colony expansion in particular locations after plague outbreaks. Because fires reduce vegetation height for the first postfire growing season (Brockway et al. 2002), we hypothesized that fires would 1) increase the rate of colony expansion and 2) influence the direction of colony expansion by facilitating expansion into adjacent burned grassland and concurrently reducing expansion into adjacent unburned grassland.

METHODS

This study was conducted on the Carrizo Unit of the Comanche National Grassland in Baca County, Colorado (lat 37°15′N, long 102°45′W), located near the center of the shortgrass steppe ecosystem (Lauenroth and Milchunas 1991). The area contains flat to gently undulating topography, and long-term mean annual precipitation at nearby Springfield, Colorado, is 403 mm. The study was conducted during a dry period in 2003 and 2004 when annual precipitation was 320 and 350 mm, respectively, and was preceded by a relatively dry year in 2002 (360 mm precipitation). Vegetation on prairie dog colonies is dominated by blue grama (*Bouteloua gracilis* [Willd. ex Kunth] Lag. ex Griffiths), buffalograss (*Buchloe dactyloides* [Nutt.] Engelm.), and purple threeawn (*Aristida purpurea* Nutt.), while noncolonized rangeland is dominated by blue grama, sideoats grama (*Bouteloua curtipendula* [Michx.] Torr.), and buffalograss (Winter et al. 2002). The study area is grazed by cattle, primarily during 15 May–15 November, with stocking rates of approximately 1.2–2.0 ha per animal unit month.

During March 2004, 4 prescribed fires were conducted adjacent to prairie dog colonies. Two prescribed burns affected the entire perimeter of the prairie dog colony. Two prescribed burns affected only a portion of a prairie dog colony's perimeter. We also studied a wildfire that occurred in July 2003 that affected a portion of the perimeter of a prairie dog colony. The boundaries of the wildfire and of prescribed burns were mapped using a handheld Trimble Global Positioning Satellite (GPS) unit (Trimble, Sunnyvale, CA).

The 5 fires were distributed across the central portion of the Comanche National Grassland's Carrizo Unit. We examined expansion rates of prairie dog colonies on all national grassland allotments located within an $\sim 42 \times 30$ km study area encompassing the region in which burns were conducted. The area was bounded on the east by State Highway 287, on the south by County Road J, on the north by County Road DD, and on the west by the Baca County line.

During June 2003 and June–July 2004, boundaries of all black-tailed prairie dog colonies were mapped using Trimble GPS units. Only the area actively occupied by prairie dogs was mapped, with boundaries identified by visually and audibly locating prairie dogs, and by 1) presence of fresh prairie dog scat; 2) recent digging on and near burrow mounds; 3) clipped vegetation, indicating foraging activity; or 4) the characteristic "mowing" that prairie dogs undertake to enhance visibility on the colony (Johnson 2005). Data were differentially corrected with Trimble Pathfinder software (Trimble) and information from a base station in Elkhart, Kansas. The GPS data were incorporated into a geographic information system (GIS: ESRI, ArcMap 9.1) to quantify annual colony area changes.

To focus our analysis on prairie dog colonies where expansion rates were not constrained by availability of adjacent unoccupied shortgrass steppe, we first excluded colonies that expanded to a private property boundary or into other adjacent prairie dog colonies between 2003 and 2004. Second, using a GIS map of soil types from the soil survey of Baca County (Woodyard et al. 1973), we focused our analysis on prairie dog colonies that occurred on soil types within the loamy plains range site, which included clay loams, silt loams, and fine sandy loams with 0%–9% slopes (Woodyard et al. 1973). We excluded colonies where only a small portion ($<$ 500-m perimeter) occurred on the national grassland. For colonies that bordered on private land in 2003, we analyzed expansion rate only for the portion of the colony greater than 50 m from the property boundary. For each colony, we calculated the length of the perimeter of active colony in 2003 and the net change in area of active colony between 2003 and 2004. We used the ratio of hectares of expansion per 100 m of colony perimeter to measure expansion rate. We compared the expansion rate for the portion of each of the 5 colonies affected by fire (ha of expansion into the burned area per 100 m of burned colony perimeter) to the expansion rate for unburned prairie dog colonies that met the criteria above ($N = 23$). Because variation in expansion rate among unburned colonies was high and nonnormally distributed, we used a Wilcoxon rank-sum test to examine the difference between burned and unburned colonies.

In a second analysis, we examined the degree of colony expansion into burned versus unburned shortgrass steppe for the 3 prairie dog colonies the perimeter of which was only partially affected by fire. We first located the centroid of the prairie dog colony in 2003 in ArcMap using the option that constrains the centroid to occur within the colony's boundaries. We then identified the furthest location from the centroid to which the prairie dog colony expanded in 2004 and buffered the centroid by that maximum expansion distance. Within the buffered area, we calculated the total area of burned and

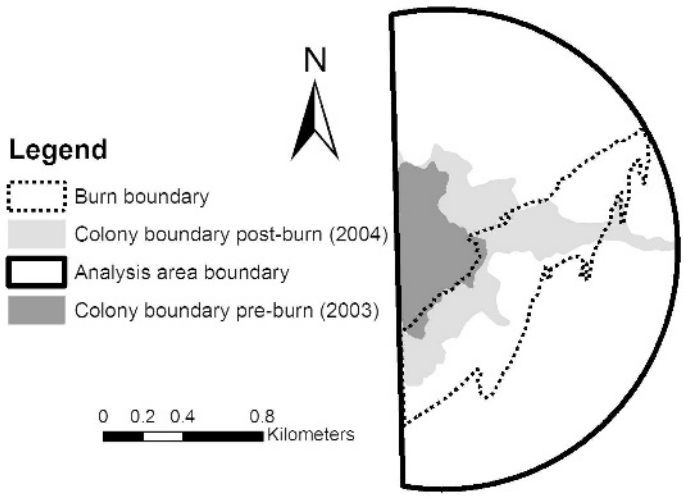

Figure 1. Map of the expansion pattern of a black-tailed prairie dog colony on the Comanche National Grassland following a wildfire in July 2003 (colony 2 in Table 1). The boundary on the west side is a private property boundary.

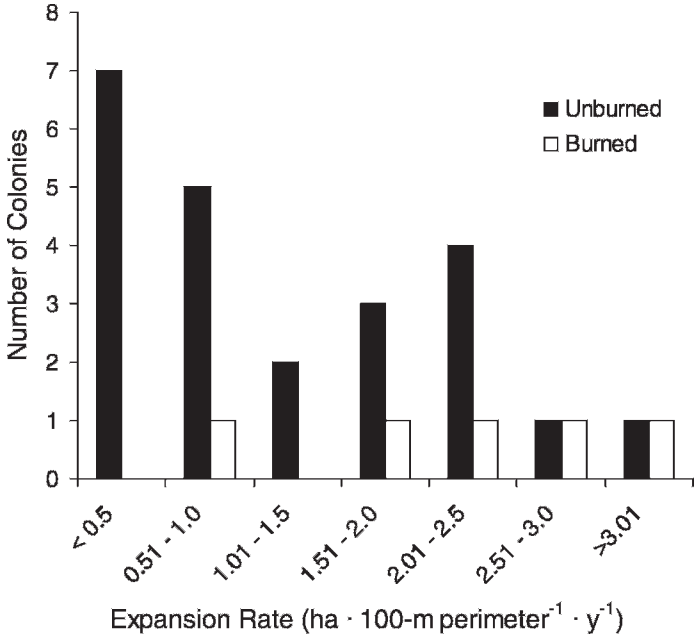

Figure 2. Frequency distribution of black-tailed prairie dog colony expansion rates on the Comanche National Grassland in southeastern Colorado during 2003–2004.

unburned grassland (excluding the area already occupied by prairie dogs in 2003) as our measure of available habitat into which the colony could potentially expand between 2003 and 2004 (Fig. 1). We compared this to the actual burned and unburned area into which each colony expanded during the study period. We used compositional analysis of the log-ratios of available versus colonized habitat (Aebischer et al. 1993) to test for preferential colonization of burned versus unburned grassland.

RESULTS

The expansion rate of black-tailed prairie dog colonies into burned grassland (mean = 2.64 ha · 100-m perimeter^{-1}; median = 2.35 ha · 100-m perimeter^{-1}) was approximately twice the expansion rate into unburned grassland (mean = 1.30 ha · 100-m perimeter^{-1}; median = 0.97 ha · 100-m perimeter^{-1}; Wilcoxon rank-sum test; 2-sided $P = 0.066$; Fig. 2). Rate of colony expansion into unburned grassland varied from 0.2 to 4.9 ha · 100-m of colony perimeter. Burned colony expansion varied from 0.8 to 6.0 ha · 100 m perimeter^{-1}, with no burned colonies exhibiting low ($\leq$ 0.5 ha · 100-m perimeter^{-1}) expansion rates (Fig. 2). However, a substantial proportion of unburned colonies (11 of 23) did expand at rates of more than 1.0 ha · 100-m perimeter^{-1} (Fig. 2).

Analysis of directional expansion of colonies that were burned on only a portion of their perimeter showed that all 3 colonies expanded to a greater degree into the burned compared to unburned grassland (Table 1). Two of the colonies expanded at a dramatically higher rate into the burned grassland, but the third colony expanded to only a slightly greater degree into burned compared to unburned grassland. Because of the variable magnitude of response across colonies, we found no significant difference in the ratio of used (colonized) to available habitat for burned versus unburned grassland (mean log ratios of -0.89 vs. -2.5, respectively, $P = 0.20$).

DISCUSSION

Because prairie dogs can influence both cattle production and biodiversity conservation (Kotliar et al. 1999; Kretzer and Cully 2001; Lomolino and Smith 2003; Smith and Lomolino 2004; Derner et al. 2006), factors affecting the rate and direction of colony expansion are of interest to public and private land managers. This study was conducted during a period of prairie dog colony expansion associated with several years of below-average precipitation (Johnson 2005).

Table 1. Comparison of black-tailed prairie dog colony expansion into burned versus unburned grassland during 2003–2004 for 3 colonies on the Comanche National Grassland where burns occurred on only one side of the colony.

	Area of available adjacent grassland (ha)		Area of grassland colonized (ha)		Percent of available grassland colonized	
Colony	Burned	Unburned	Burned	Unburned	Burned	Unburned
1	43.1	22.4	17.9	0.4	41.6	1.7
2	59.6	200.3	22.8	14.0	38.3	7.0
3	97.6	166.1	41.4	64.5	42.4	38.8
Mean					40.8	15.8

Our results suggest that even under dry conditions, burning of shortgrass steppe can increase the colony expansion rate. This reflects the fact that unburned colonies exhibited variable expansion rates, while all burned prairie dog colonies expanded at high rates.

Vegetation height has long been noted as an important factor affecting prairie dog colony expansion (Koford 1958; Garrett et al. 1982; Milne-Laux and Sweitzer 2006). Even in shortgrass steppe, measurements of vegetation height are 1.7–3.5 times greater off- compared to on-colonies (Winter et al. 2002; Guenther and Detling 2003). Reduction in vegetation cover and height due to burning (Brockway et al. 2002; Ford and Johnson 2006) are likely the key factors underlying the high rates of burned grassland colonization we documented. We also note that attraction of mammalian herbivores to postfire regrowth in other grasslands is attributed to enhanced forage quality (Coppock and Detling 1986; Coppedge and Shaw 1998; Knapp et al. 1999). Fires in shortgrass steppe result in a short-term (1-year) increase in forage nutrient content, particularly for important minerals such as phosphorus and calcium (Brockway et al. 2002), which may be another factor enhancing prairie dog use of burns in semiarid, low-stature rangelands.

Our findings are restricted to relatively dry conditions, when we documented considerable variability in unburned colony expansion rates, including some unburned colonies that expanded as rapidly as burned colonies. Landscape-scale variation in height of unburned vegetation, which may be related to variation in species composition, recent livestock grazing history, and recent local variation in precipitation events, may underlie the variable rates of unburned grassland colonization that we observed. In addition, there can be substantial among-colony variation in prairie dog reproductive rates and juvenile survivorship, even in a relatively small geographic area (Newby 2001), which can influence expansion rates. In years of above-average precipitation, prairie dog colonies may expand at considerably lower rates (Cable and Timm 1987; Johnson 2005; Terrall 2006). As a result, we hypothesize that during wet years when vegetation height is greater, prairie dog colony expansion may be consistently lower across the landscape, and hence prescribed burning may have a stronger effect.

MANAGEMENT IMPLICATIONS

Our results indicate that use of prescribed burning in shortgrass steppe for objectives such as control of unpalatable plant species (McDaniel et al. 1997) or provision of wildlife habitat (Svingen and Giesen 1999) should also consider effects on prairie dog colony expansion. Where biodiversity conservation is a management objective, our results, combined with those of Milne-Laux and Sweitzer (2006), indicate prescribed burning can facilitate prairie dog colony expansion, but success may depend on precipitation patterns and the scale at which the response is viewed. At the scale of a multicolony complex, prescribed burning may have only a minor influence on expansion of the complex in dry years because some unburned colonies can also expand rapidly (Fig. 2). At the scale of an individual colony (Table 1), prescribed burning can ensure that a colony expands rapidly into the burn, but the colony may still expand in other directions. Finally, our findings indicate that where expansion of prairie dog colonies is not desired because of the negative effects on livestock gains (Derner et al. 2006), prescribed burns conducted for other rangeland management purposes should avoid proximity to active colonies.

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