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Livestock weight gain and prairie dogs

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Are livestock weight gains affected by black-tailed prairie dogs?

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There is little empirical data addressing the important and controversial question of how prairie dogs (*Cynomys* spp) affect livestock weight gains in western rangelands. This is particularly relevant in the shortgrass steppe, where the area occupied by prairie dogs has increased substantially in recent years, exacerbating conflicts with livestock producers. In our 6-year study, livestock weight gains decreased linearly, but at a rate slower than the rate of colonization by black-tailed prairie dogs (*Cynomys ludovicianus*). This decrease in livestock gains resulted in lower estimated economic returns. For example, pastures with 20% of area occupied by prairie dogs reduced the estimated value of livestock weight gain by $14.95 per steer (from $273.18 to $258.23 per steer) and by $2.23 ha^{-1} (from $40.81 to $38.58 ha^{-1}). In pastures with 60% occupancy, reduced livestock weight gain lowered estimated value by $37.91 per steer and $5.58 ha^{-1}, or about 14%.

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Prairie dogs (*Cynomys* spp) are colonial, herbivorous, burrowing rodents (Figure 1) that have a relatively high dietary overlap with both native and domestic grazers (Detling 2006). Because they have long been viewed as competitors with livestock for forage, prairie dogs have been the target of large-scale eradication campaigns for over a century. This, together with loss of habitat and the introduction of sylvatic plague into the western portion of their range, has resulted in as much as a 98% reduction in the area of North American grasslands that they occupy (Forrest 2005).

However, recognizing that prairie dog habitat contributes to the maintenance of grassland species diversity and is critical for preservation of the endangered black-footed ferret (*Mustela nigripes*), interest in conserving prairie dogs has increased (Miller *et al.* 1990, 1994; Wuerthner 1997; Kotliar *et al.* 1999). As a result, there is now a heated debate between conservation biologists and livestock producers as to the merits of allowing prairie dog populations to expand on western rangelands (see Vermeire *et al.* 2004; Forrest 2005). Unfortunately, there is scant scientific evidence pertaining to the question of primary concern to livestock producers: to what extent are livestock weight gains affected by the presence and abundance of prairie dogs? The lack of such information has fundamental economic consequences for managers of both public and private lands.

Prairie dogs may potentially reduce carrying capacity of rangelands for large herbivores by consuming forage, clipping plants to enhance predator detection, building soil mounds around their burrow entrances, and changing plant species composition (Vermeire *et al.* 2004; Detling 2006). Studies have shown that summer weight gains of yearling steers in Oklahoma mixed-grass prairie did not differ significantly in pastures with and without prairie dogs (O'Meilia *et al.* 1982), and abundance of prairie dogs was greater with heavy cattle grazing compared to areas recently excluded from grazing (Uresk *et al.* 1982). However, several limitations in these studies have been identified (see Vermeire *et al.* 2004). Because there are few other empirical field studies on the subject (Vermeire *et al.* 2004; Detling 2006), additional research is needed, controlling for prairie dog presence in different types of grasslands, to understand how prairie dogs affect livestock performance.

Despite relatively frequent, plague-induced local extinctions, particularly following El Niño events, both the number of black-tailed prairie dog (*Cynomys ludovicianus*) colonies and the area they occupy have been increasing on the Pawnee National Grasslands (PNG) in northern Colorado since 1981 (Stapp *et al.* 2004; Antolin *et al.* 2006). In the mid-1990s, several black-tailed prairie dog colonies established naturally in pastures of the USDA-ARS Central Plains Experimental Range (CPER), a shortgrass steppe grazing research site adjacent to PNG (Figure 2). The objectives of the research reported here were to (1) measure the rate of expansion of these prairie dog colonies on CPER pastures, (2) evaluate the effect of percentage of pastures newly colonized by prairie dogs on cattle weight gains, and (3) estimate the impact that prairie dogs may have on the economic returns of livestock grazing in shortgrass steppe.

Methods

Our CPER study site (40°49'N, 107°47'W), approximately 60 km northeast of Fort Collins, Colorado, has a mean annual temperature of 8.6°C and mean annual

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Courtesy of M Ashby

Figure 1. *Black-tailed prairie dogs (*C ludovicianus*) and cattle at the USDA-ARS CPER located near Nunn, CO.*

aboveground production of 1000 kg ha^{-1} (Lauenroth and Sala 1992). Vegetation is dominated by blue grama grass (*Bouteloua gracilis;* Milchunas *et al.* 1989; Derner *et al.* 2006), and soils are mostly sandy loams (Ustollic Haplargids: fine-loamy, mixed, mesic). Long-term (65 years) annual precipitation is 341 mm (Figure 3). The CPER has four main prairie dog colonies (Figure 2). Areas of the colonies, defined by the perimeter of the outermost burrows of each colony, as determined by handheld GPS units (Biggins *et al.* 2006), were measured annually from 1999 to 2004, with the exception of 2001. Indices of prairie dog density were estimated over at least 4 days, between July 15 and August 31 in 2002, 2003, and 2004, using plot-based visual methods (Severson and Plumb 1998). Counting was initiated after 17:30, when prairie dogs are most active above ground, and counts continued at 15-minute intervals until nine counts were completed. A total of 108 counts were made. We obtained population estimates (X_i) from visual counts (Y_i) by the formula $X_i = (Y_i - 3.04)/0.4$ (Severson and Plumb 1998).

Between 1999 and 2004, livestock weight gains were compared between two colonized pastures (5W and 22W) and two pastures without prairie dog colonies. Comparisons with occupied pastures 27–34 and 29–30 were not carried out because uncolonized pastures of the same size and with the same breed, sex, and age of cattle were not available. Each pasture to be compared had (1) yearling steers with initial entry weights of 263 ± 37 (mean ± 1SD) kg per animal, (2) the same area (129.5 ha), (3) moderate stocking density of 1 yearling per 6.5 ha (Bement 1969; Hart and Ashby 1998), and (4) a 5-month grazing season (mid-May to mid-October). Drought dictated earlier removal in 2000 (September 6) and 2002 (August 9). Over the 6-year study, seven comparisons met all criteria (Table 1). We did not measure vegetation composition or production. However, in the nearby shortgrass steppe on the PNG, a comparison of vegetation between similar-aged prairie dog colonies and adjacent uncolonized areas showed that peak biomass of grasses was only 50% as great on prairie dog colonies, while biomass of forbs was about 50% greater (Hartley and Detling unpublished). Nevertheless, cattle have been observed on prairie dog colonies at CPER and PNG approximately in proportion to their availability, and foraging was their predominant activity on

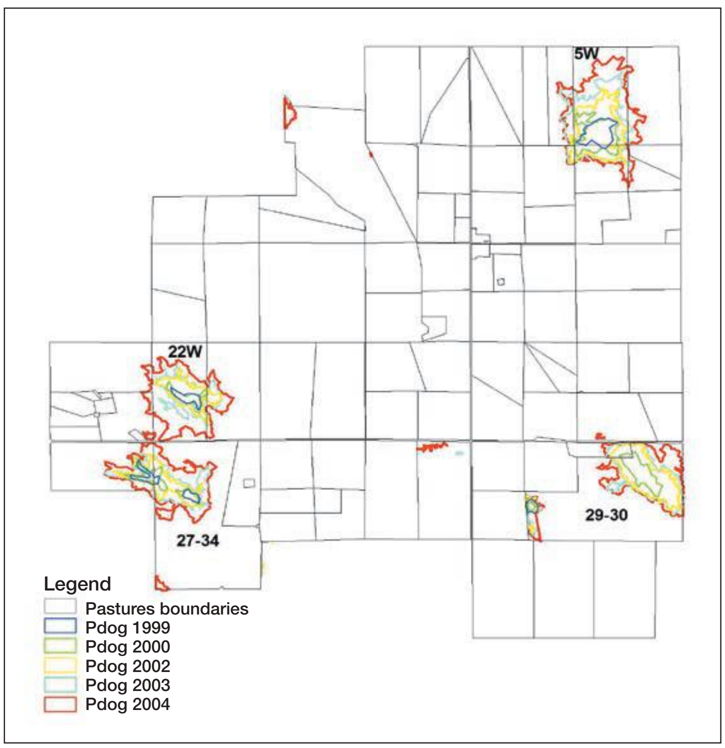

Figure 2. *Areas of prairie dog colonies from 1999 to 2004 at the USDA-ARS CPER.*

colonies during peak grazing hours (Guenther and Detling 2003).

Seasonal weight gains (kg per steer) were determined by weighing individual animals at the beginning and end of each grazing season. T-tests were used to compare seasonal animal weight gains in each of the seven pasture combinations. Beef production (kg gain ha^{-1}) was determined by summing individual animal weight gains in each pasture and dividing by the area of the pasture. Relative gain (%) was calculated by dividing beef production in pastures with prairie dogs by production in pastures without prairie dogs. Linear regression analysis (SAS 9.1) was used to determine the relationship between relative livestock weight gain and percentage of pasture occupied by prairie dogs.

The economic impacts of prairie dogs were estimated on a per steer and a per unit area basis. The impact of colonization per steer was calculated using initial starting weights of 263 kg per steer and adding average seasonal gains of 122.5 kg per steer (see Results) in uncolonized pastures to obtain an end-of-season weight of 385.5 kg per steer. The current price of yearling steers in this weight range (375–398 kg in Colorado, www.ams.usda.gov/mnreports/gl_ls165.txt, accessed 4 March 2006) is \$2.23 kg^{-1}. This results in a livestock weight gain value of \$273.18 per steer for pastures without prairie dogs. We then used the regression equation (see Figure 4) to estimate reductions in weight gain for steers in pastures colonized to various degrees. To estimate the economic impacts of prairie dogs on a per unit area basis, we multiplied the average beef production in uncolonized pastures (18.3 kg ha^{-1}; see Results) and the market price (\$2.23 kg^{-1}) resulting in a value of \$40.81 ha^{-1} for pastures without prairie dogs. We again used the regression equation to estimate reductions in seasonal returns for pastures when various percentages of the pasture were occupied by prairie dogs.

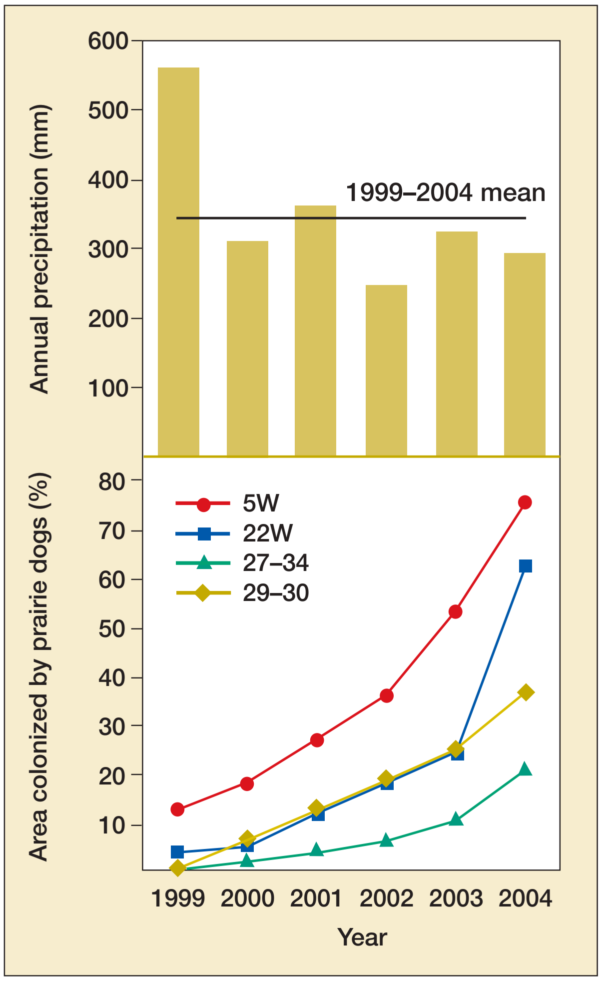

Figure 3. *Annual precipitation during the study period (1999–2004) and percent of four individual pastures colonized by prairie dog colonies at the USDA-ARS CPER located near Nunn, CO.*

Results

Annual precipitation was below average in 4 of the 6 study years, with only 1999 being well above average (Figure 3). There were substantial increases in the size of prairie dog colonies within pastures during this period (Figures 2 and 3); the two pastures used for comparisons of livestock weight gains (22W and 5W) had 4–13% of the area occupied by prairie dogs in 1999 and 63–76% in 2004. Visual counts on prairie dog colonies were variable, but maximum yearly visual counts on each colony yielded a population density estimate of 28 prairie dogs ha^{-1} (range 20–40 ha^{-1}). For instance, the colony in pasture 5W (Figure 2) increased from 31 to 150 ha between 2000 and 2004, which relates to a population increase from approximately 870 to 4200 prairie dogs.

Over the 6-year study, mean seasonal cattle weight gains in uncolonized pastures ranged from 71.9 kg per steer in 2002, a severe drought year, to 166.9 kg per steer in 1999 (Table 1), a year with exceptionally high precipitation (Figure 3). In pastures colonized by prairie dogs, the range of seasonal cattle weight gains was from 65.0 to 163.9 kg per steer, with the low and high values also occurring during 2002 and 1999, respectively (Table 1). Over the seven pasture–year combinations, in which annual growing conditions and precipitation differed (Figure 3), mean seasonal cattle weight gain in uncolonized pastures was 122.5 kg per steer, which was 6% greater than that of gains by steers (115.2 kg per steer) in pastures that had a range (4 to 63%, mean = 24%) of colonization by prairie dogs (Table 1). Significant ($P < 0.10$) differences in weight gains between pastures with and without prairie dogs occurred in 1999, 2002, and 2004, but only the 2004 comparison was highly significant ($P < 0.0001$). Of note, this comparison involved the pasture with the highest percentage of colonization (63%). On an area basis, mean cattle weight gain in uncolonized pastures was 18.3 kg ha^{-1}

Table 1. Mean (± 1 SE) livestock weight gains in 129.5 ha pastures with and without prairie dogs at moderate stocking densities (approximately one steer per 6.5 ha) at the CPER near Nunn, CO

Year	*Grazing period*	*Pasture*	*Area colonized by prairie dogs (%)*	*Number of steers*	*Gain per head (kg)*	*Gain per area (kg ha^{-1})*
1999	May 18–Oct 7	5W	12.9	20	163.9 (3.5)	25.3
	May 18–Oct 7	7N	0	20	166.9 (3.9)	25.8
	May 21–Oct 5	22W	4.3	20	148.1 (4.2)	22.9
	May 21–Oct 5	10S	0	20	159.0 (4.5)*	24.6
2000	May 19–Sept 6	5W	18.4	20	71.7 (2.8)	11.1
	May 19–Sept 6	7N	0	20	76.3 (2.2)	11.8
	May 18–Sept 6	22W	5.8	21	79.5 (2.1)	12.9
	May 18–Sept 6	28N	0	21	79.5 (2.2)	12.9
2001	May 15–Oct 11	5W	27.3	16	161.3 (6.0)	19.9
	May 15–Oct 11	7N	0	16	166.6 (4.0)	20.6
2002	May 14–Aug 9	5W	36.3	20	65.0 (2.5)	10.0
	May 14–Aug 9	1W	0	20	71.9 (2.8)*	11.1
2004	May 18–Oct 13	22W	62.7	20	116.8 (2.7)	18.0
	May 18–Oct 13	24NW/SE	0	20	137.3 (3.0)**	21.2

* indicates significant ($P < 0.10$) difference between pasture comparisons within a year
** indicates significant ($P < 0.0001$) difference between pasture comparisons within a year

across the seven pasture–year combinations, whereas the mean weight gain in pastures colonized by prairie dogs was 17.2 kg ha^{-1} (Table 1).

Relative livestock weight gains decreased linearly with increasing percentage of the pasture colonized by prairie dogs (Figure 4); however, this decrease was slower than the increase in area colonized by prairie dogs. For example, relative to pastures without prairie dogs, livestock weight gains decreased by 5.5% when 20% of the pasture was colonized by prairie dogs, and by 13.9% with 60% colonization.

Recent colonization of pastures by prairie dogs impacted estimated economic returns to livestock producers via reductions in livestock weight gains during the grazing season (Table 2). For example, a 20% level of colonization by prairie dogs reduced the estimated value of livestock weight gain by $14.95 per steer (from $273.18 to $258.23 per steer) and by $2.23 ha^{-1} (from $40.81 to $38.58 ha^{-1}), a 5.5% reduction. In pastures with prairie dog colonization at 60%, the value of livestock weight gain was reduced by $37.91 per steer and $5.58 ha^{-1}, or about 14%.

Table 2. Economic impacts of prairie dogs on livestock producers calculated from regression equation shown in Figure 4

Area colonized by prairie dogs (%)	*Gain (kg head^{-1})*	*Value of gain per steer ($)*	*Gain (kg ha^{-1})*	*Value of gain per ha ($)*
0	122.5	$273.18	18.3	$40.81
20	115.8	$258.23	17.3	$38.58
40	110.6	$246.64	16.5	$36.80
60	105.5	$235.27	15.8	$35.23

Calculations assume a price of $2.23 kg^{-1} for weight gain (see Methods)

Discussion

The rapid rates of expansion of the black-tailed prairie dog colonies in our four shortgrass steppe study pastures, from a total area of 29 ha in 1999 to 343 ha in 2004, were similar in magnitude to those reported by Antolin *et al.* (2006) for the adjacent PNG, where colonies increased more than six-fold in area (303 ha to 1886 ha) during the same period. In more productive, mixed-grass prairie, mean annual rates of expansion of the nine most rapidly growing colonies (out of 11 at their study site) studied by Dalsted *et al.* (1981) was 27%, for a doubling time of about 3 years. This contrasts sharply with two other colonies Dalsted *et al.* (1981) studied, one of which was in Wind Cave National Park. This colony was studied intensively by Hoogland (2001) and had annual growth rates of less than 1% because it was located within a small valley surrounded by wooded hillsides, which provided no suitable habitat. While these results clearly demonstrate the potential for black-tailed prairie dog colonies to expand rapidly during periods of drought and without control efforts, the long-term data of Stapp *et al.* (2004) and

Antolin *et al.* (2006) also demonstrate that individual colonies on the shortgrass steppe periodically go temporarily extinct, primarily as a result of plague. The rapid expansion of colonies at both the CPER and PNG from 2000–2003 occurred during a drought period, when there were few plague outbreaks; plague is not known to have occurred at the research site of Dalsted *et al.* (1981) in South Dakota. At a landscape scale, colony expansion is slowed or even reversed during plague outbreaks, even though some individual colonies may be expanding (Antolin *et al.* 2006). It is unlikely that the recent, rapid colony expansion observed at CPER will be sustained over the long term. Plague epizootics in prairie dogs appear to be strongly correlated with the wetter and warmer winters and cooler summers during El Niño events, and the probability of extinction increases as colony size increases above about 14 ha (Stapp *et al.* 2004).

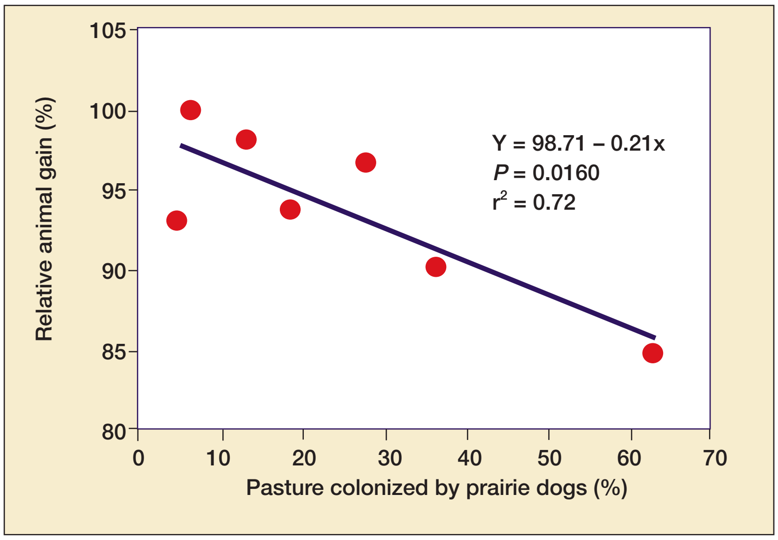

Figure 4. *Response of relative livestock weight gain (percentage, weight gain in pastures with prairie dogs/weight gain in pastures without) to increasing area colonized by prairie dogs at the USDA-ARS CPER.*

Cattle gained less weight in pastures with prairie dogs, but the reduction in weight gains was proportionately less than the increase in area colonized by prairie dogs. This is probably attributable to the high grazing resistance of the dominant perennial grasses blue grama (*Bouteloua gracilis*) and buffalograss (*Buchloe dactyloides*). The grazing resistance has probably resulted from convergent selection pressures of long evolutionary history of grazing and semiaridity (Milchunas *et al.* 1988). Despite the high level of disturbance caused by prairie dogs, the grazing resistance of these highly palatable grasses prevents rapid plant community changes to less palatable forbs and sub-shrubs. The longer term impacts of continued high levels of disturbance on this plant community suggest that vegetation composition shifts do occur eventually (Hartley and Detling unpublished). With recent colonization and moderate prairie dog densities, however, impacts of prairie dogs on shortgrass steppe on the CPER are less than would be expected on sites with older colonies and higher population densities. In addition, we would expect lower impacts in shortgrass steppe compared to more productive ecosystems, as prairie dogs graze vegetation to approximately the same height in shortgrass steppe and mixed-grass prairie (Guenther and Detling 2003), and belowground constraints (eg soil water) drive plant–soil relationships in more semiarid systems (Burke *et al.* 1998). Further research is needed to ascertain: (1) the effects of prairie dogs on livestock weight gains in this ecosystem over longer periods, with potentially greater changes in vegetation composition on the colonized areas; (2) cattle weight gain after prairie dog abundance is reduced due to plague; and (3) the level of colonization that results in net economic losses to livestock producers. Land managers may need to decrease stocking rate as prairie dogs increase in order to compensate for reductions in livestock weight gains and to reduce grazing pressure and overuse of unoccupied areas within pastures; this will probably increase gain per animal but may decrease gain ha^{-1} (Bement 1969).

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