Prairie Dogs, Cattle, and the Conservation of Diversity in Desert Grasslands

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Abstract:

Using replicated landscape level reintroductions we examine the interaction of cattle and prairie dogs, and the effects of prairie dog reintroduction on biomass and diversity. Initial results of this long-term study indicate that while local level effects on diversity are limited, even relatively small colonies have indirect effects on other organisms that extend well beyond the boundaries of the colony. At the same time the benefits of prairie dog reintroduction are at least as tangible for ranchers, as they are for conservationists. In addition to the increase in forage quality documented in numerous previous studies, prairie dogs removed shrubs and increased vegetation biomass with both cattle and native herbivores disproportionately foraging in the vicinity of prairie dog towns. The grazing by cattle can be critical to sustaining prairie dog colonies by removing standing vegetation that hides predators. This study suggests that much of the conservation importance ascribed to prairie dogs comes not from prairie dogs alone, but from the interaction of prairie dogs with large herbivores including both native species and domestic cattle. Prairie dog reintroduction is show to be a potentially important restoration tool in degraded rangelands, with rotational grazing to allow prairie dog towns to recover from grazing pressure potentially crucial for sustaining the benefits of prairie dog on biomass and diversity.

Introduction:

In 1902 one of the country's most influential mammalogists C. Hart Merriam estimated the cattle reduced range productivity by 50 to 75% percent. This estimate and others contributed to the long-standing perception that pastoral land uses and prairie dog conservation were fundamentally incompatible (Miller et al. 1994, Long 1998, Donahue 1999). In contrast to these long-held beliefs, there is a growing body of literature indicating that prairie dogs have no demonstrable negative impacts, and measurable benefits to cattle and other large herbivores. Large grazers such as bison and antelope are shown to preferentially forage in the vicinity of prairie dog towns (Krueger 1986), and studies of the weight of steers grazed within prairie dog towns and prairie document no difference (Hansen and Gold 1977, O'Meilia et al. 1982), or significant increases compared with those in adjoining prairie (Boggess and Brown ____). This is probably because while there is a small overlap in diet between prairie dogs and cattle with a 4 to 7 % level of competition (Uresk and Paulson 1988), grazing by prairie dogs has repeatedly been demonstrated to elevate protein (N) content in forage, increasing the forage value and energy benefits of many plants (Coppock et al. 1983, Wydeven and Dahlgren 1985, Krueger 1986, Knowles 1986, Whicker and Detling 1988, Detling 1998). Prairie dogs can also reduce the cover of woody shrubs that frequently out compete grasses in many rangelands (Waltzing et al. 1997). Removal of prairie dogs from southwestern ecosystems is postulated to have been a cause of epochs of shrub increase in the 1900s in many southwestern ecosystems following prairie dog extirpation programs (Oakes ____).

In contrast, most ecologists and conservationists believe that prairie dogs increase system diversity and structural heterogeneity and are therefore key to sustaining the diversity of many grasslands (Whicker and Detling 1988, Miller et al. 1994, Jones et al. 1994, Power et al. 1996, Waltzing et al. 1997, Miller et al. 2000 – but see Step 1998). Because range "improvement" programs have often focused on eradication of prairie dogs, and such eradication is viewed as potentially causing "the collapse of an entire natural community", an inherent conflict is often assumed to exist between prairie dog conservation and ranching interests (Long 1998, Donahue 1999). Yet loss or deferment of grazing is often associated with a reduction in the extent of prairie dog colonies. As early as 1899 naturalists in Kansas noted that following eradication of bison (the predominant large grazer in the system), that prairie dog numbers declined (Mead 1899, as reported in Truest et al. 2000). Snell and Hlavachick (1982, cited by Cable and Timm 1987), documented that after four consecutive growing seasons of deferment from livestock grazing, a colony shrank from 110 to 12 acres. In Arizona written accounts of the 1850s indicate few animals West of the territories' eastern border, whereas by the 1880s following the "cattle boom" (Curtin et al. 2002), prairie dogs appear to have expanded their range considerably into southeastern Arizona (Hubbard and Schmitt 1984). This pattern suggests that the prevalence of prairie dogs in southeast Arizona in the late 1800s and early 1900s was an artifact of the introduction of large numbers of livestock in the late 1800s.

The body of evidence indicates that not only are prairie dogs frequently important for preserving the structure and function of many rangeland ecosystems, but that cattle grazing is often important for sustaining prairie dogs. Because the majority of prairie dog research has been conducted on the Great Plains, with the majority of herbivore interaction studies focusing in bison, there is little direct experimental evidence of the effects of prairie dogs on desert grasslands, or of the interaction of prairie dogs with domestic cattle. In this paper the effects of the interaction of prairie dogs and cattle on the biomass and diversity of desert grasslands is examined to address two questions: 1) What are the relative impacts of prairie dogs and cattle on the diversity of desert grassland, and 2) Are livestock management and prairie dog conservation compatible in desert grasslands?

Experimental design:

In 1999, 102 Black-tailed prairie dogs (Cynomys ludovicianus) were translocated from the Turner Vermijo Park Ranch to the Gray Ranch in southwestern New Mexico. We superimposed the reintroduction efforts on the experimental design of grazing and fire studies being conducted in the 8,870 acre (3,696 ha) McKinney Flats Study Area, allowing us to contrast the major driving variables in southwestern grasslands (climate, fire, prairie dogs, and cattle grazing)(Curtin 2002). Four reintroductions were each placed within a separate growing seasons of deferment from livestock grazing, a colony shrank from 110 to 12 acres. In Arizona written accounts of the 1850s indicate few animals West of the territories' eastern border, whereas by the 1880s following the "cattle boom" (Curtin et al. 2002), prairie dogs appear to have expanded their range considerably into southeastern Arizona (Hubbard and Schmitt 1984). This pattern suggests that the prevalence of prairie dogs in southeast Arizona in the late 1800s and early 1900s was an artifact of the introduction of large numbers of livestock in the late 1800s.

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In 2000, 250 cows were introduced to the research area following ten years of rest from grazing. Cattle numbers have since varied between 250 and 180 head depending on the availability of forage, with an average target utilization of vegetation of 50% percent (a level consistent with livestock management in the region). Biomass and utilization is measuring using a technique combining clipping measurements and ocular estimates developed by Robin Marsett and the USDA ARS in Tucson, Arizona. The research area is rotationally grazed with a four pasture rest-rotation system designed to both mimic progressive livestock management in the region, and to create four replicate study pastures (Figure 1).

Response variables measured included vegetation (the primary production with the system), small mammals (primary consumers and a key stone guild with the ecosystem – Brown and Heske 1990), and lizards (secondary consumers and an assay of invertebrate composition). Within each 2,200 acre sub-pasture is a 1 x 1 km study area that contains four 500 x 500 m treatment areas composed of fire/grazing, fire/no-grazing, no-fire/no-grazing, and no-fire/grazing plots. Within each treatment area and on the prairie dog towns is a 200 x 200 m study area. Lizard sampling is conducted three times a summer using pit-fall traps located at the sampling stakes. Small mammal sampling is concurrent with the lizard sampling using folding Sherman traps at the same sampling stakes (Figure 2). Current analysis involves contrasts of each prairie dog town, with the grazed-unburned plot within the same sub-pasture. To assure that the prairie dog translocation were successful it was necessary to place new experimental colonies onto the site of abandoned prairie dog colonies, this meant that there was no true non-prairie dog treatment baseline. This factor, coupled with the difficulty of predicting the exact locations of prairie dogs prior to sampling, meant that little pre-reintroduction sampling was conducted and measurements of cattle and prairie dogs are limited to current comparisons. Eventually after the colonies expand sufficiently, prairie dog exclosures will be erected on the site to contrast the structure and function of active with inactive colonies. Statistical analysis was conducted through the use of paired analysis using a T-Test within the statistical program Statview ™.

Results:

Cattle and pronghorn antelope (Antilocapra americana) disproportionately use the prairie dog towns. As a rough index of relative use, following the 2001 growing season the number of cow and antelope droppings were contrasted between prairie dog colonies and grazed plots. Prairie dog towns had a mean number of cow droppings of 295 per 150 x 150 sample plot, compared with 102 in grazed areas (N = 3). Antelope droppings averaged 12 per plot on the prairie dog towns, and were immeasurable on the grazed areas (N = 3). This indicates that cattle use the prairie dog colonies with at least three times the frequency of grazed plots selected at random, while antelope use the colonies at more than 10 times the frequency of grazed plots selected at random.

Almost immediately following release prairie dogs starting girdling mesquite (Prosopis Spp.) adjoining their burrows (Figure 3). On the northwest colony all of the small mesquite on the site were removed within the initial months following reintroduction. On the southwest colony a number of larger mesquite 4 cm diameter, while not initially killed, have been repeatedly girdled. Similar patterns occurred on the southeast town with smaller individuals (under 4 cm) have been girdled. Larger mesquite have not been girdled, but at this point none of these larger individuals is in close proximately to the town. In addition to reducing unpalatable woody species such as mesquite, prairie dogs also appear to increase the palatability of relatively unpalatable suffrutescent grasses (bushy grasses with a perennial stem that may live for several years – Burgess 1995) such as Galleta (*Hilaria spp).* Cattle were observed for forage on *Hilaria* in the vicinity of the towns, whereas it is avoided in areas were it is not regularly clipped by prairie dogs. Since Hilaria is the dominant grass on many of the towns, this considerably increases the amount of available forage for cattle on these sites.

The prairie dogs had mixed effects on the composition of major functional groups (Figure 4). From 1999 through 2002, vegetation biomass was significantly higher on the prairie dog towns ($P = 0.0001$). Mean dry weight of vegetation matter per 40 cm^2 sampling plot was 50.3 grams (SD = 38.6) on the prairie dog colonies, versus 37 grams (SD = 26.1) on the grazed control plots. Species richness (number) was significantly lower on the prairie dog towns than grazed control plots ($P = 0.001$). Mean number of species per 150 x 150 study plot was 19.7 (SD = 5.1) versus 27 (SD = 6.8) on grazed control plots. No statistically significant change in species composition occurred with the proportion of grasses, sub-shrubs, and soil cover remaining constant in the four years following reintroduction.

From 1999 through 2002 the mean number of species of small mammals (not counting prairie dogs) per 150 x 150 meter plot was significantly lower on the prairie dog towns, versus grazed control plots ($P = 0.01$). The mean number of species was 3.6 (SD =

Therefore understanding the effects of small mammals, and their interaction with livestock, is key to restoring and sustaining arid and semi-arid grasslands.

I. Implications of prairie dog reintroduction for diversity and rangeland conservation:

A functional understanding of the implications of prairie dog reintroduction for diversity is partially understood by examining the interaction of prairie dogs with the other keystone mammal in desert grasslands, Kangaroo rats (Dipodomys spp). Kangaroo rats have been crucial keystone species responsible for sustaining the structure and function of grassland ecosystems (Brown and Heske 1990, Chew and Whitford 1992, Curtin et al. 2000), with their burrow systems important hot-spots for sustain diversity (Hawkins and Nicoletto 1992, Brown et al. 1997). Curtin and Brown (2001) hypothesized that kangaroo rats and prairie dog represent different engineering species (e.g. Jones et al. 1994) filling certain "invariant niches that maintain the continuity of the system". Therefore a key question was whether prairie dog would displace kangaroo rats, which in turn could potentially alter the composition of grasslands. As in prairie dog colonies near Janos 50 kilometers south of our site in northwestern Chihuahua, Mexico prairie dogs appear to locally displace kangaroo rats from mounds within the boundaries of the colony, but kangaroo rats continue to persist within the system within the open landscape adjoining the colonies.

The initial results of this long-term study indicate that prairie dog reintroductions have a diverse impact on ecological systems. Based on data from on and around existing prairie dog towns it is too simplistic to state that prairie dogs have a positive impact on diversity, rather, there are winners and losers. While the prairie dogs decreased vegetation diversity (species number), they increased vegetation biomass. Small mammals show a negative response to prairie dog reintroduction, while lizards had a positive response. Increased numbers of lizards, amphibians, and snakes on the prairie dog towns, compared with adjoining rangelands with occasional kangaroo rat mounds, appear to be a reflection of increases the amount of refugia associated with more concentrated numbers of holes. It is not yet clear if the reduction in mammals is due to direct competitive displacement, or from environmental change.

Yet focusing on local or Alpha diversity (Whittaker 1975) by contrasting diversity within prairie dog reintroductions and cattle grazed control plots somewhat misses the point because the effects of prairie dogs extend well beyond the immediate vicinity of the colony. Burrowing owls (Athene cunicularia) that were rare on the pasture prior to prairie dog reintroduction became common in the vicinity of the colonies almost immediately following reintroduction. On a 26 mile breeding bird survey the only place the regionally declining Ferruginous hawks (Buteo regalis) (Caballos et al. 2003) appear is adjoining the prairie dog towns. Prairie dog reintroductions also redistribute resources across the landscape. Despite being barely more than 1 hectare in size each and thus tiny fraction of the 3,696 ha research area, large grazers including antelope and cattle frequently traveled 5 to 7 kilometers away from water to forage on the colonies. The relatively high quantity of antelope and cattle dung suggests a considerable redistribution of resources as recycled nutrients from across the pastures are aggregated in the vicinity of the towns.

II. Implications of prairie dog reintroduction for ranching:

At the onset of the study we had assumed that prairie dogs remove vegetation biomass, so a core question was would the increase in nutrients of the vegetation documented in many studies compensate for the reduction in forage. Therefore the biggest surprise in the data was the consistent yearly difference in biomass with higher biomass on the prairie dog towns compared to grazed areas. The higher vegetation biomass on the towns are likely in part a reflection of increased nutrient levels and a response to herbivory, but in itself does not explain why the results are so different from common perceptions. We view the results to be in part the result of three factors. First, while the typical plant size appears to be smaller on the prairie dog colonies, there appears to be greater number of plants per square meter. Viewed obliquely for the vantage point of human eye level, fewer shorter stature plants often appear less plentiful than fewer larger ones. Second, many sites with prairie dogs and bison or cattle have historically been grazed year round. Because our sites are grazed rotationally, with biomass sampling conducted following the growing season, vegetation on the colonies has an opportunity to recover. Finally, in contrast to the Great Plains, prairie dog towns in southwestern grasslands appear to be primarily relegated to bajadas (deep soiled slopes) and valley bottoms where soils are relatively deep and nutrient rich. This means that prairie dog colonies are located on intrinsically rich sites and thus may frequently have higher biomass then grazed sites chosen at random. Long-term study on our experimental colonies, coupled with comparisons with existing natural colonies, will be key to assessing the validity of these hypothesizes.

The increased vegetation biomass, disproportionate use by cattle, and availability of *Hilaria spp.* frequently avoided by cattle, and higher nutrient content documented in previous studies (Coppock et al. 1983, Krueger 1986, Whicker and Detling 1988, Delting 1998), suggests that prairie dog reintroductions can have positive benefits for ranchers. Ironically, in many ways these patterns are more tangible than the benefits to conservation which are more temporally and spatially variable and thus harder to quantify. The results of our study, coupled with the existing literature, suggest a positive feedback loop between cattle and prairie dogs. The prairie dogs increase forage quality and potentially increase biomass, while the cattle by grazing in the vicinity of the towns mow the grass short thereby reducing the prairie dogs susceptibility to predators. Because the cows focus their foraging activities in an area about 40 percent larger than the actual prairie dog town, they in tern are expanding the area of potential prairie dog colonization, which in turn can lead to increased amounts of rich forage for the cattle and increase habitat for prairie dogs (Figure 5). This synergistic relationship between cattle and prairie dogs suggest that much of the system diversity ascribed to prairie dog towns is a reflection of not just the work of prairie dogs, but also an interaction between prairie dogs and large ungulate species including not just native species such as antelope, bison, and deer, but also domestic species such as cattle.

Summary and Recommendations:

While prairie dogs impacts on diversity are mixed at the local level on the scale of meters, at the landscape level at the scale of hectares or kilometers, the impacts are profound. Even relatively small colonies such as the experimental reintroductions that occur on a tiny fraction of the landscape (approximately 1 hectare out of each 916 ha sub-pasture), have an immense ability to influence the distribution and abundance of other organisms across the landscape. Examples documented here include changes in the distribution of Burrowing owls and Ferruginous hawks, and the movement of Antelope and cattle to forage in the vicinity of the towns.

Rather than an inherent conflict between cattle and prairie dogs, these organisms are shown to have a synergistic relationship with prairie dogs removing shrubs and increase the nutrient content of forage, while cattle by reducing vegetation cover decease the threats from predation and allow the towns to expand into new areas. Because prairie dog towns in desert grasslands inhabit inherently rich sites that are prone to shrub encroachment, and that are typically inhabited by poor forage species such as Hilaria spp. (Curtin 2000, Per. Obs.) the use of prairie dogs as a landscape restoration and management tool can provide considerable benefits to ranchers by providing a sustainable means of increasing or sustaining forage production in ecological sites typically prone to shrub invasion. Such a strategy creates a win-win situation in which both rangeland diversity and function, and rural livelihoods are sustained.

Because large herbivores are drawn to prairie dog colonies, it appears that in many cases the bare and deteriorated habitats associated with prairie dog towns may often be the result not of prairie dogs, but of an interaction between prairie dogs and other large grazers. Therefore rotational grazing may be key to sustaining ecosystem function by allowing forage to periodically recover. Prior to reintroduction, localized burning or mowing in the vicinity of the reintroduced colonies can be essential to both protect the prairie dog from predation, and in initiating the synergistic relationship between prairie dogs and cattle.

Acknowledgments:

This research was supported in part by funding from the Joint Fire Sciences Program and the USDA Forest Service Rocky Mountain Research Station. Additional supporters include the Animas Foundation, Arid Lands Project, Hewlett Foundation, Malpai Borderlands Group, Gordon and Betty Moore Foundation, New Mexico Game and Fish, Thaw Charitable Trust, Turner Foundation, Wallace Research Foundation, and the World Wildlife Fund.

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Figure Captions:

Figure 1. The experimental design is a portion of a larger study of the interaction of fire, grazing, and climate. For this analysis we will focus on the three towns with comparable conditions in the Southwest, Southeast, and Northwest pastures because the initial prairie dog town in the northwest pasture, in addition to being isolated from the other colonies, is also considerably drier (8 inches versus 10 inches in the other towns – metric) and thus is not a true replicate. In 2002 a new prairie dog colony was established in the Northeast pasture to restore the full factorial design.

Figure 2. Plant and animal density and diversity is sampled along five 150 m lines in the center of these study areas. Vegetation is sampled at two meter intervals within 40 cm quadrates for frequency and cover once a year in the fall. At every thirty meters along the 150 m lines we have placed a stake resulting in a 5 x 6 stake grid where vegetation biomass measurements and lizard and mammal censuses occur.

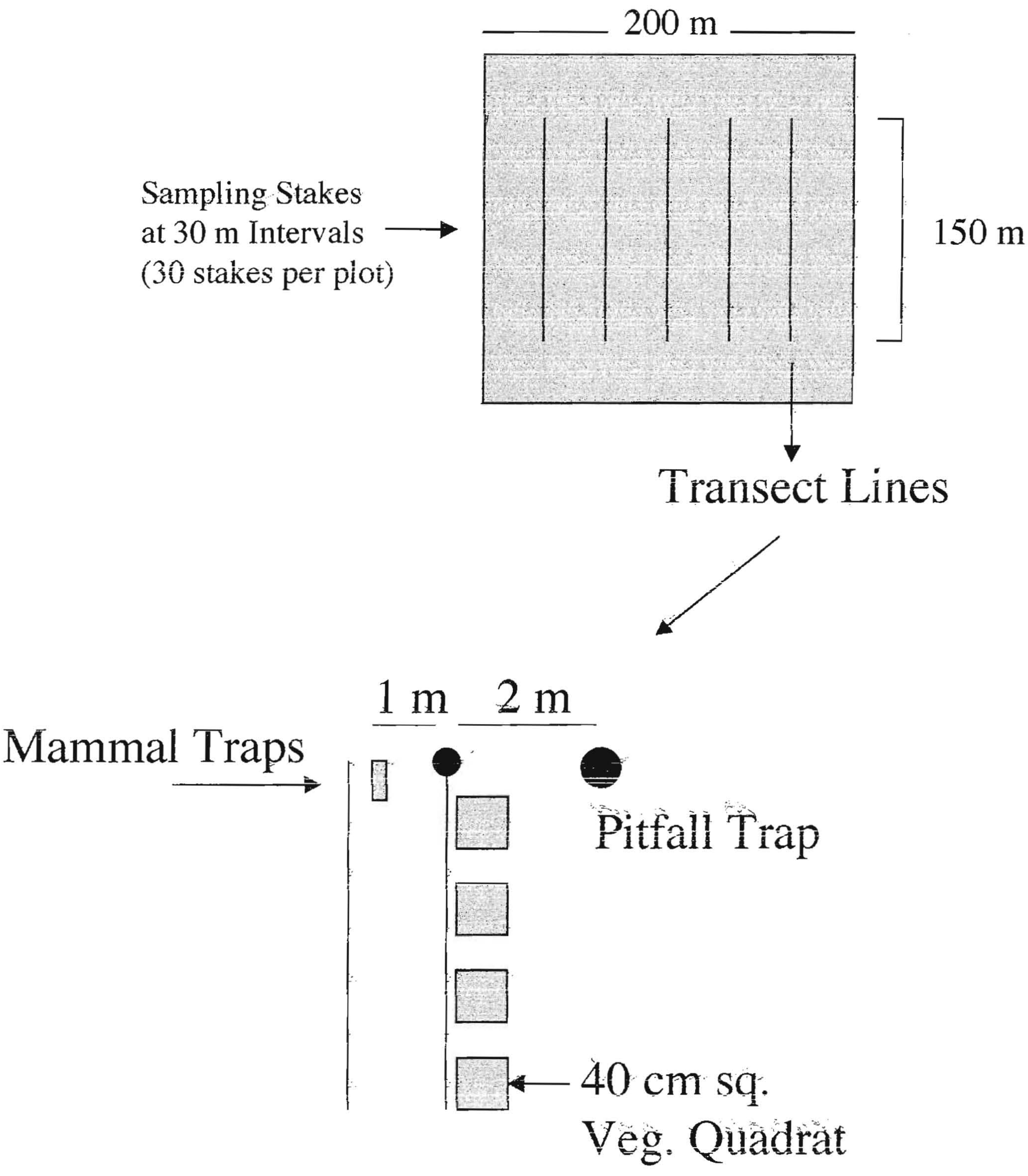
Figure 3. Observations from the literature (Weltzin et al. 1997) and existing prairie dog towns 50 km south of our sites near Janos, Chihuahua, Mexico indicate that prairie dogs are extremely effective at removing woody shrubs in desert grasslands (a). Following reintroduction of prairie dogs to our experimental colonies, prairie dogs immediately began girdling Mesquite (Prosopis spp.)(b). It is not clear if the effects of shrub removal are limited to above ground action, or also include the root systems.

Figure 4. Prairie dogs at a local level (> 1 hectare) had a mixed impact on biomass and diversity. This indicates that at the local level prairie dogs do not have an intrinsically

positive effect on alpha diversity. At the same time, at the landscape level (< hectares) prairie dogs have a significant impact on the beta diversity of landscape sites, with movement by herbivores resulting in a considerable redistribution of resources across the landscape.

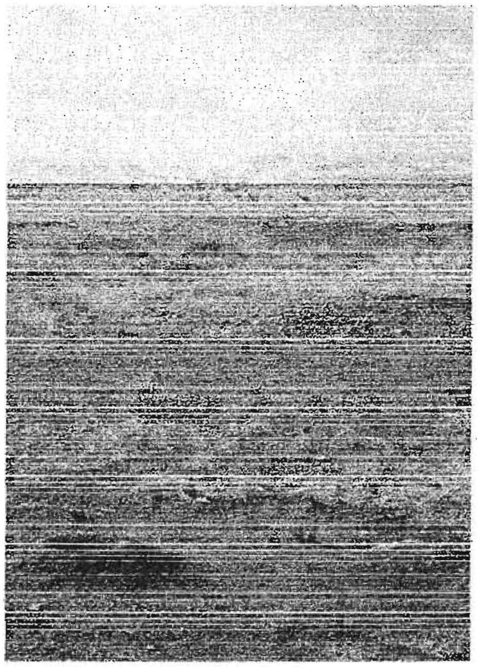
Figure 5. Much of the diversity ascribed to prairie dogs appears to often be the result of interaction between prairie dog and large grazers (including cattle). Grazing removes cover that can hide predators, while prairie dogs can increase forage biomass and nutrient content. This creates a positive feedback loop in which the interaction between prairie dog and large grazers increase habitat and forage for both. Our results indicate that rather being fundamentally in conflict, that prairie dogs and cattle ranching are compatible and complementary.

SAMPLING DESIGN



INTERACTION OF PRAIRIE DOGS AND SHRUBS

(A) Natural Colonies Chihuahua, México.



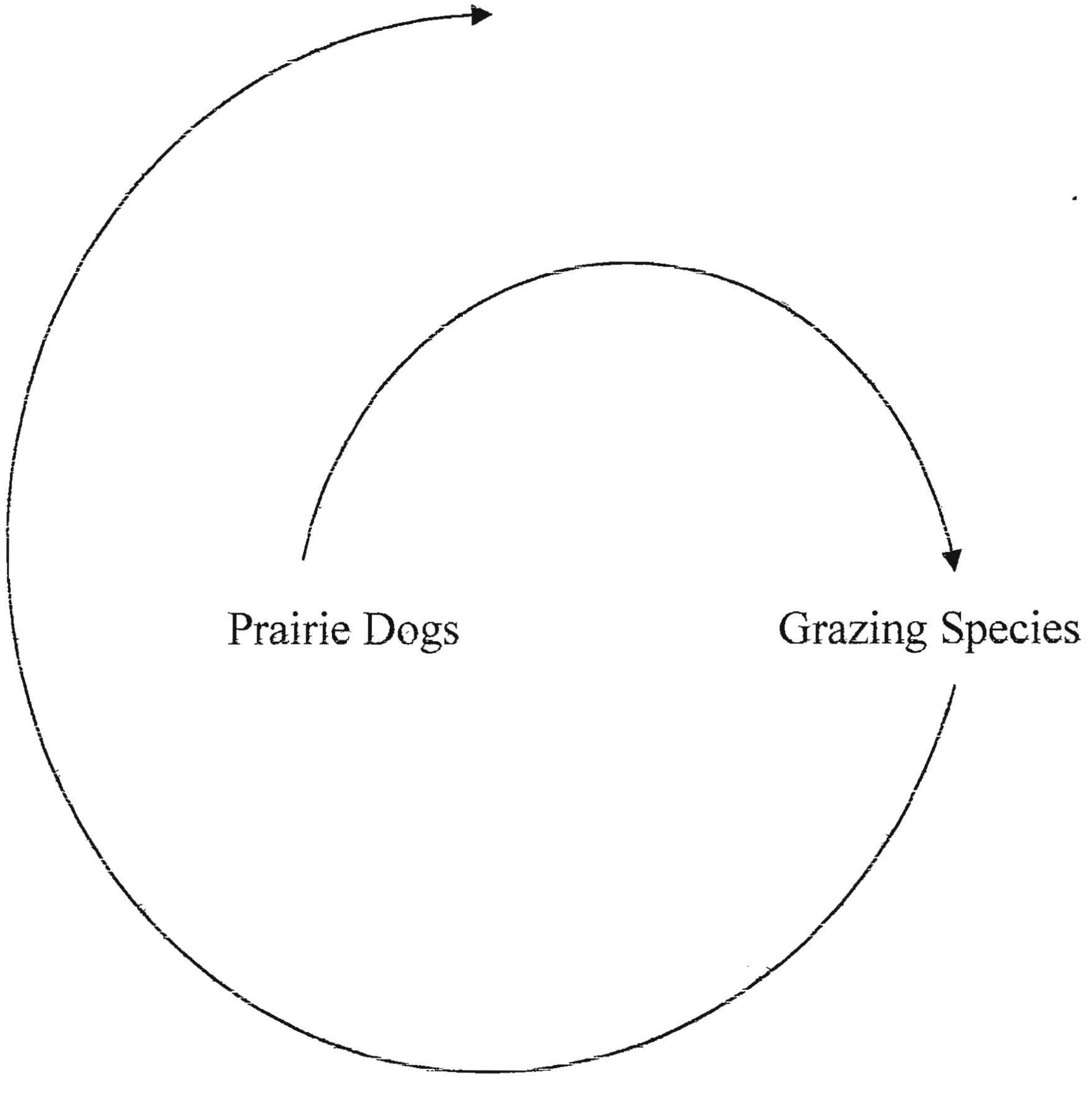
(B) Reintroduced Colony, Gray Ranch, New Mexico.

ECOLOGICAL IMPLICATIONS OF PRAIRIE DOGS

	G/PD	G
Plant Biomass	+	-
Plant Diversity	-	+
Lizard	+	-
Mammal	-	+

DYNAMIC INTERACTIONS

POSITIVE INTERACTIONS BETWEEN EXOTIC AND NATIVE GRAZERS



PLOT DIAGRAM
MCKINNEY FLATS PROJECT