EFFECT OF THE BLACK-TAILED PRAIRIE DOG ON AVIFAUNAL COMPOSITION IN SOUTHERN SHORTGRASS PRAIRIE

By

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PREFACE

The black-tailed prairie dog (Cynomys ludovicianus) is often referred to as a keystone species of the prairie ecosystem. Studies conducted on the habitat created by prairie dog colonies are contradictive in their findings on the importance of this habitat to associated vertebrate species and vegetation composition. Human activities (cultivation, eradication) and sylvatic plague (Yersinia pestis) are reducing prairie dog densities across the Great Plains. Most colonies now exist as disjunct and fragmented populations. Much controversy surrounds the prairie dog and its role in the prairie ecosystem needs to be fully assessed. We censused avifauna and determined vegetation composition on shortgrass prairie in Cimarron county, Oklahoma. Our main purposes were to compare avifauna on prairie dog-colonized and control sites (native shortgrass prairie without prairie dog colonies) to test for statistically significant differences. This thesis comprises 2 manuscripts formatted for submission to Oklahoma Academy of Science (Chapter I) and American Midland Naturalist (Chapter II). Manuscripts are complete as written and need no supporting material.

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CHAPTER 1

HISTORY AND POLICY OF THE BLACK-TAILED PRAIRIE DOG: A REVIEW

The black-tailed prairie dog (*Cynomys ludovicianus*) is a large burrowing rodent found in western American grasslands (1). The prairie dog was first described in the early 1800's and was named the Louisiana Marmot (*Arctomys ludovivianus*) by Ord in 1815. The genus *Cynomys* was proposed in 1817 by Rafinesque. In 1858, J.A. Allen recognized two species of prairie dogs, the black-tailed and white-tailed (*C. leucurus*) (2). When Europeans colonized North America, many of their activities, such as planting crops and killing mammalian predators (e.g., coyote [*Canis latrans*], badger [*Taxidea taxaus*], and prairie rattlesnake [*Crotalus viridus*]), allowed the black-tailed prairie dog to colonize new areas.

In this paper I will discuss: (1) historic distribution and range of the black-tailed prairie dog, (2) history of federal poisoning campaigns, (3) prairie dog impacts on rangelands, (4) the prairie dog "ecosystem," and (5) sylvatic plague (*Yersinia pestis*) and its impacts on prairie dog colonies. Parts of this information have been published in conjunction with scientific results, but a published in conjunction with scientific results, but a comprehensive review on the history and policies surrounding the black-tailed prairie dog is needed, especially because this species has been petitioned to be listed under the Endangered species Act.

HISTORICAL DISTRIBUTION AND RANGE

The black-tailed prairie dog once ranged throughout the Great Plains from the Rocky Mountains, east to the Mississippi Valley, and from Montana and South Dakota south to Texas and Mexico (2,3,4). The black-tailed prairie dog was once the most numerous and widespread herbivore in the Great Plains. It was distributed over ca. 40 million ha during pre-settlement times, which comprised more than 20% of the natural shortgrass and mixed prairie (5,6). Merriam (3) estimated that prairie dogs (all species included) ranged over 283 million ha during the late 1800's and colonies were often 32-48 km in length with an average of 10 prairie dogs per ha. This area was reduced to 40.5 million ha by 1919 (1), 600,000 ha by 1960 (7,9) and 566,000 ha by 1971 (1). A single colony in Texas was reported to cover 6.5 million ha at the turn of the century (3,8).

HISTORY OF THE FEDERAL POISONING CAMPAIGN

Merriam (3) reported that forage production was reduced by 25-75% due to prairie dog activities and quoted a Texas newspaper editorial:

> No man who has gone through the portions of Texas infested by prairie dogs can conceive the enormous ravages they have committed. Millions of acres of land once covered with nutritious grasses have been eaten off by these animals, until the land is naked and worthless, and will remain so as long as the prairie dog remains. They invade the farms and eat down the growing crops. Here and there individual effort has been made to destroy them, without avail, and their numbers steadily increase, until they are a menace to the prosperity of the land.

This estimated loss in forage production was based on a formula developed by Professor W.W. Cooke for determining relative quantities of food consumed by animals of different sizes in the early 1900's (3). He reported that 32 prairie dogs consume as much grass as 1 sheep, and 256 prairie dogs consume as much as 1 cow. Therefore, it was reported that the large Texas colony could support ca. 1,562,500 cattle annually if no prairie dogs were present (3). This estimate by Merriam (3) was accepted and was used to justify poisoning campaigns that were implemented and carried out during most of the 20th century.

Merriam had many supporters. Lantz (4) stated that prairie dogs greatly decreased the carrying capacity of land for livestock and claimed half of the pasturage. Bell (10) stressed that eradication campaigns must be a cooperation between farmers, county, state, local organizations, and federal officials. He also wanted legal provision for the extermination of pests on neglected lands. Bell (11) stated that rodents, including the black-tailed prairie dog, caused an annual crop production loss of $500 million each year and that federal officials, state officials, and landowners needed to combat rodents.

Prairie dog eradication became a federal issue in 1915, whereas before, programs were implemented by counties, states, and local land-owners. In 1917 the Cooperative Campaigns for the control of ground squirrels (*Citellus* sp.), prairie dogs, and jack rabbits (*Lepus townsendii*) began under the Department of Agriculture. At least 7.3 million ha of prairie dogs and ground squirrels were poisoned and most were re-poisoned (8,11). Farmers reported a crop return of $15 to $20 for each dollar invested in eradication and improved range conditions (11). By 1920, the Biological Survey began poisoning millions of ha of prairie dog colonies, and the federal government paid for the poisoning (9). In 1929, the Division of Predatory Animal and Rodent Control (PARC), which was supervised by National Biological Survey (9), was formed. In 1939, PARC was transferred to the Bureau of Sport Fisheries and Wildlife, when U.S. Fish and Wildlife was formed, and remained there until 1986 (9). During this time, it was renamed the Federal Animal Damage Control Program (ADC), and the Animal Damage Control Act of 1931 was passed, which gave federal government permission to develop techniques to control "problem" animals on both public and private lands (12). In 1986, ADC was transferred to the U.S. Department of Agriculture's Animal and Plant Health Inspection Service (APHIS) (9,12).

Federal poisoning ceased in 1972 with the Presidential Executive Order II 11643 that stated the toxicant Compound 1080 could not be used on federal lands, in federal programs, or on private lands (1,11). In February 1973, the Wildlife Services Division of the Fish and Wildlife Service began selling strychnine treated grain at cost to interested parties with demonstrations of poisoning techniques available (11). In 1976, zinc phosphide was approved for poisoning (1). Prairie dogs on federal lands are still poisoned today by persons with grazing leases (9).

POISONING TECHNIQUES

After 1900, both small- and large-scale extermination procedures were in use. The most common small-scale methods were trapping, drowning, destruction by domestic ferrets, and capture in sand or straw barrels placed over holes (3). The large-scale methods were poisoning and fumigation. The most common poisons were strychnine and cyanide of potassium; bisulfide of carbon was the most common fumigator (3). Today, zinc phosphide, diethylstilbestrol, strychnine, aluminum phosphide, shooting, habitat alteration, and visual barriers are used commonly (13). Treated colonies often are rapidly invaded by immigrant prairie dogs. Recolonized populations can reach pre-poisoning size in 1 to 3 years. Therefore, it is suggested that potential immigrants, located in nearby colonies, be eliminated before a prairie dog control program is implemented (14,15).

IMPACTS ON RANGELAND

Many studies have been conducted to assess the impacts prairie dogs have on vegetation, especially whether the impacts are positive or negative, and these studies have yielded conflicting results.

Although shorter vegetation prevails on prairie dog colonies, it is more succulent and has higher nutrient content, digestibility, and productivity than uncolonized prairie (17). Because prairie dog colonies support quality forage, domestic cattle, bison *(Bison bison)*, and other herbivores prefer to graze on these areas (6,18,19). Hassien (20) found that the mean number of cattle droppings was higher on 122 of 123 prairie dog colonies compared to uncolonized areas in the Oklahoma Panhandle. There were no significant differences in weight gain between cattle that fed in prairie dog colonies vs. prairie without colonies, and plant productivity did not improve when prairie dogs were removed from an overgrazed cattle range (5,17).

Alternatively, Garrett et al. (21) found that grazing pressure from prairie dogs, in Wind Cave National Park, South Dakota, limited species diversity and nutrient quality and permitted unpalatable vegetation to dominate the colony. Grazing pressure by prairie dogs also has been reported to reduce both mulch cover and maximum height of vegetation

(22).

Hassien (20) found that forage quality was lower on prairie dog colonies than on surrounding areas. Contemporary expansion of prairie dog colonies is related to livestock grazing. Prairie dogs colonize grazed rangelands and are often blamed for their deterioration. Prairie dogs can be used as bio-indicators of overgrazed grasslands that are loosing productivity because these are areas that they most frequently colonize (23,24). Prairie dogs are ecosystem regulators; i.e. they disturb soil structure and chemical composition by burrowing, depositing excretement, increasing plant and animal diversity, and decreasing primary production of the area in their colony (19,22,23,25). 200-225 kg of soil are mixed per burrow system if it has 50-300 entrances per ha (17). Hassien (20) found that prairie dogs increase the organic nutrients in soil, particularly potassium, phosphorus, and calcium. Concentric vegetation rings are often formed around colonies due to prairie dog activities, and forbs often increase disturbed areas and become dominant (21,26). Whicker and Detling (6) stated that ecosystem processes in prairie dog colonies may proceed at different rates due to the patchy microhabitats that they create within a grassland.

PRAIRIE DOG ECOSYSTEM

It has been estimated that over the past century, prairie dogs have sustained a 98% decline throughout their range due to eradication programs (3,6,9). Prairie dogs create an important "habitat" for many wildlife species (23) and provide a larger prey abundance, especially for carnivores and granivores (22). Clark et al. (27) reported that there are 107 vertebrate species and subspecies associated with colonies of prairie dogs (all prairie dog species included). These species include: the black-footed ferret (*Mustela nigripes*), swift fox *(Vulpes velox)*, snowy owl *(Nyctea scandiaca)*, bald eagle (*Haliaeetus leucocephalus*), golden eagle *(Aquila chrysaetos)*, ferruginous hawk *(Buteo regalis)*, red-tailed hawk (*B. jamaicensis*), kestrel (*Falco sparverius*), short-eared owl *(Asio flammeus)*, and burrowing owl (*Speotyto cunicularia*). Agnew et al. (22) found a greater density of all rodents and greater avifaunal richness and abundance on prairie dog colonies throughout the growing season compared to surrounding areas.

Burrowing owls use abandoned prairie dog burrows for cover and nest sites (28). These owls are declining throughout their range due to the loss of nest sites and prairie dog colonies (28). The mountain plover (*Charadrius montanus*) often relies on prairie dog colonies for nesting. Mountain plovers also feed on prairie dog colonies because insects are more visible and abundant (9,29). Knowles et al. (30) reported that the decline in mountain plovers may be directly related to the near extermination of prairie dogs.

Many carnivorous birds and mammals are attracted to prairie dog colonies due to the presence of a large prey-base (23). Swift foxes den in and near prairie dog colonies and prey on them (31).

SYLVATIC PLAGUE

Sylvatic plague was first introduced into the United States from Asia in ca. 1899. It has spread throughout the United States west of the 100th meridan and has been found in 5 mammalian orders: Rodentia, Lagomorpha, Insectivora, Artiodactyla, and Primates (32,33). About 340 mammal species, which include 220 rodent species, can be infected with plague (33). Many carnivorous mammals, such as the coyote and black-footed ferret, are unaffected by sylvatic plague (34).

Sylvatic plague is caused by a small ovoid bacillus, and it survives by using fleas as vectors (33). About 33 of 3,000 known species of fleas transmit plague. This bacterium may persist in reservoir species, in soil, or fleas and their eggs (32,35,36). This bacterium affects the flea by a method called blocking. A sticky mass is created by the bacterium that glues the spines of the bulbous together. When the flea feeds, none of the sucked blood reaches the stomach due to the blockage, and is driven back into the wound with infectious sylvatic plague bacterium. Eventually, the flea will feed more frequently and infect more host organisms, since it is in a state of dehydration and starvation (33).

This is a devistating disease to prairie dogs and they are highly susceptible. The mortality rate is near 99% (32,35,36,37). The first reported case of plague in black-tailed prairie dogs was in Lubbock, Texas, in 1946.

The black-tailed prairie dog is found in various geographic regions across the United States where different reservoir species may be present. This must be considered when discussing plague ecology, because general statements may not be applicable to all prairie dog populations (32).

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CHAPTER II

EFFECT OF BLACK-TAILED PRAIRIE DOG COLONIES ON PRAIRIE AVIFAUNA

ABSTRACT--Five black-tailed prairie dog (*Cynomys ludovivianus*) colonies were paired with five reference sites having similar topography and soil structure in Cimarron County, Oklahoma. Objectives were to: (1) test for differences in avifauna abundance between site types, (2) assess scale effects on avifauna, and (3) census Category 2 avian species usage of each site type. The Category 2 avian species found in Oklahoma include: ferruginous hawk (*Buteo regalis*), loggerhead shrike (*Lanius ludovicianus*), long-billed curlew (*Numenius americanus*), mountain plover (*Charadrius montanus*), and swainson's hawk (*Buteo swainsoni*).

Data were collected by walking permanent line transects with fixed radius points placed 250 m apart. Avifaunal abundances and species richness were determined for each site. We censused avifauna during 4 separate periods, from April-July in 1995 and 1996, and observed 38 species.

We found avifaunal abundance to be significantly higher on prairie dog colonized sites during the growing season and a correlation ($r_s = 0.70$) between increased colony size and

increased avifaunal abundance, albut sample size was small.

INTRODUCTION

Populations of black-tailed prairie dogs (*Cynomys ludovicianus*) in the Panhandle of Oklahoma have been instable because of sylvatic plague (*Yersinia pestis*) and eradication programs (Shaw *et al*., 1993; Hassien, 1976). Recent literature suggests the black-tailed prairie dog is important to many vertebrate species (Clark and Campbell, 1981; Agnew *et al*., 1986; Sharps and Uresk, 1990; Miller *et al*., 1994), and it has been petitioned to be listed under the Endangered Species Act (Biological Legal Foundation, 1994).

Our objectives were to: (1) test for differences in avifauna abundance between site types, (2)assess the effect of colony size on avifauna, and (3) census Category 2 avian species usage of each site type. Our overall goal was to test the null hypothesis that there is no difference in avifaunal abundance between prairie dog-colonized and reference sites.

STUDY AREA AND METHODS

We studied avifaunal communities within Cimarron County, Oklahoma, which is located in the Great Plains Province and the Short-grass Plains District of Oklahoma (Blair and Hubbel, 1938; Murphy *et al*., 1960). Cimarron County is comprised primarily of irrigated cropland and shortgrass prairie. Average annual rainfall ranges from 380 to 890 mm, with most of the precipitation falling from early spring to fall. It is not uncommon for one-third of the annual precipitation to fall in one rainevent. Average annual temperatures range from 10 to 15 C (Austin, 1965). Average annual wind velocity is 10 km per hour at 0800 hours and 26 km per hour at 1500 hours (Murphy et al., 1960).

Ten study sites, 5 black-tailed prairie dog colonies and 5 reference (all native shortgrass prairie) sites were located in June 1995 from Shackford et al.(1990) and communication with local ranchers (Table 1). Various sized colonies were sought to assess effects of colony size on avifauna. Colonies were chosen as study sites if they were not being poisoned and a suitable pairedreference site could be established. The criteria for establishing reference sites included: majority of soil type same as colony, similar topography to colony, shortgrass prairie, equal to size of colony, and > 0.4 km from any colony but ≤ 5 km from the paired colony. The minimum distance requirement was established to prevent the colonization of the control site by prairie dogs, and the maximum distance requirement was established to maximize the similarity of the colony to its paired reference site.

The five prairie dog colonies were surveyed on foot and mapped on 7.5 minute USGS topographic maps. Colony maps were then digitized using Sigma Scan v.3.9 to estimate area. Burrow density was determined by counting burrows in strip transects, 0.3 ha in size, spaced 60 m apart, over each colony (Biggins et al., 1989).

Avifauna were censused along two permanent transects established, size permitting, at each study location. Transect lengths varied and were based on colony size. The first transect was established parallel to the longest length of the colony and divided the colony into halves. The second transect was established perpendicular to the center of the first transect (M. Palmer pers. comm.). The goal was to make sampling intensity as equal as possible from site to site. Point counts with a 125-m radius were used to estimate bird abundance, and were spaced 250 m apart along each transect (Hutto et al., 1986). Counts began immediately upon arrival to the point, included sight and call identifications, and lasted 6 minutes. If a bird was flushed upon arrival to a point, it was recorded only if it fell in the 125-m radius of the upcoming point (Hutto et al., 1986; Saab and Petit, 1992). Only birds using the site (i.e., foraging, nesting, hunting, etc.) were recorded. Sampling began 30 minutes after sunrise and ended 4 hours after sunrise (Cable et al., 1992; McCoy and Mushinsky, 1994). Transects were sampled in July 1995 and during the breeding season (April, May, and June) in 1996 because all five Category 2 avian species are present in the Oklahoma Panhandle during these time periods (Tyler, 1968; Grzybowski, 1986).

Chi-square tests were performed on avifauna abundances (total number) to test for differences ($\underline{P} \leq 0.05$) between each set of paired sites (Steel and Torrie, 1980). Spearman rank correlation was used to evaluate the effect of colony size on avifaunal richness (i.e. the number of species encountered per site) and abundance (i.e. the total number of birds).

Avifaunal abundance and richness were compared across season (sampling period) and sites (prairie dog colonies) using a Multiplicative Interaction Model (Milliken and Johnson, 1989). This model was applied to the data preceeding the ANOVA because season/site combinations were not replicated and a test for interaction of season and site using ANOVA techniques could not be done (Milliken and Johnson, 1989). When the Multiplicative Model did not show significant interactions, an ANOVA was applied (Steel and Torrie, 1980). If the main effects were significant ($\underline{P} \leq 0.05$), the ANOVA was followed by pairwise comparisons among sites and seasons using Fisher's Least Significant Difference (Steel and Torrie, 1980). All statistical analysis were performed using SAS for windows, version 6 (SAS, 1989). No statistical analyses were performed on Category 2 species abundance and richness because of their rarity.

RESULTS AND DISCUSSION

Collectively, we tallied 2,139 individual sightings of birds, representing 38 species, with 30 species associated with colony sites and 27 species associated with control sites (Appendix 1). Twenty of these species were common to both prairie dog colonies and control sites (Table 2). These numbers are comparable to other studies conducted on black-tailed prairie dog colonies and associated vertebrate species. Clark et al. (1982) found 9 avian species, Campbell and Clark (1981) found 29 avian species, and Tyler (1968) found 40 avian species associated with black-tailed prairie dog colonies.

Chi-square tests were used to compare avifauna abundance between paired sites (Table 3). In July 1995, all of the colony sites had a significantly higher avifauna abundance than their paired control sites, with one exception. When sites of the same type (colony and reference) were combined, avifaunal abundance was significantly higher on the colony sites ($X^2 = 21.9$, $P \leq 0.005$) than on reference sites. In April 1996, 1 colony was highly significant and 1 reference was highly significant. The combination of sites produced no significant differences. The lack of significance in April 1996 was probably a result of vegetation that was still in winter condition because the growing season had not begun. Agnew et al.(1986) found that avifaunal abundance was higher on prairie dog colonies during the growing season. In May and June 1996, one colony had a higher avifaunal abundance but the other sites showed no differences. This lack of difference in abundance was probably the result of drought condtions that effected the Oklahoma Panhandle in which little or no vegetation growth occurred during this time. When sites of the same type were combined across all dates, avifaunal abundance was significantly higher on prairie dog colonies than native shortgrass prairie ($X^2 = 10.4$, $P \leq 0.005$). It appears that prairie dog colonies were the most important to avifauna during the months of June and July. Agnew et al. (1986), Cincotta et al. (1987), and Sharps and Uresk (1990) concluded that avifaunal richness and abundance tends to be higher on prairie dog colonies because colonies provide heterogeneous plant cover, concentrated prey species, increased seed production, and lower vegetation height which creates greater visibility of prey.

During our study, horned larks (Eremophila alpestris) were the most abundant species observed on both colony and reference sites. This was probably the result of the grazing pressure exerted on both colony and reference sites by cattle, to which horned larks respond favorably (Wein, 1973). Grzybowski (1980) compared avifaunal abundances between grazed and lightly grazed grasslands in the Oklahoma Panhandle and found avifaunal abundances to be higher on the grazed grasslands. Other abundant species associated with colony sites during our study were western meadowlark (Sturnella neglecta, mourning dove (Zenaida macroura), burrowing owl (Speotyto cunicularia), and cliff swallow (Hirundo pyrrhonota). Common birds we observed on reference sites were western meadowlark, mourning dove, lark sparrow

(Chondestes grammacus), and grasshopper sparrow (Ammodramus savannarum). Agnew et al. (1986) found horn larks to be the most abundant on black-tailed prairie dog colonies and western meadowlarks to be the most common on mixed-grass prairie.

An interaction for avifaunal abundance was found between season and site ($U1_{7,12} = 0.93$, $P \leq 0.05$), with site 5 and April sampling responsible for the interaction. In April 1996, abundance on site 5 declined more than on any of the other sites. A relatively high Spearman Rank Correlation Coefficient ($r_s = 0.70$) suggests a correlation between avifaunal abundance and colony size (Fig. 1). Similarly, Clark et al. (1982) found a strong correlation between increased vertebrate abundance and increased colony size ($r_s = 0.81$).

Species richness varied among sites and season ($F_{7,12} = 4.91$, $P \leq 0.05$). The interaction between site and sampling session was not significant ($U1_{7,12} = 0.59$, $P > 0.10$). There was no differences between the May, June, and July samples, and no significant difference between the July and April samples (Table 4). There was a significant difference between site 5 and the remaining four sites (Table 4). There was a slight correlation ($r_s = 0.44$) between avifaunal richness and colony size, albut sample size was small (Fig. 2). In contrast, Reading et al. (1989) found avifaunal richness to increase significantly with increased colony size. The low association between richness and colony size in our study may be the result of the lack of large colonies in our study.

All 5 of the Category 2 avian species were observed associated with our study sites; however, three species (ferruginous hawk, long-billed curlew, and swainson's hawk) were associated with prairie dog colonies and three species (loggerhead shrike, mountain plover, and swainson's hawk) were associated with reference sites (Table 5). Data collected on areas that were not our study sites or when we were not walking transects are recorded as "other." When these "other" data are considered, all five species were found on shortgrass prairie, while the same three species occurred on prairie dog colonies. Tyler (1968) found all five species were associated with prairie dog colonies in Oklahoma. Campbell and Clark (1981) found all five species, except long-billed curlew, associated with black-tailed prairie dog colonies.

In conclusion, it appears black-tailed prairie dog colonies produce a positive community response for prairie avifauna which differs from the surrounding shortgrass prairie during certain months of the year. It appears that this response is strongest during times of vegetation growth during the summer growing season.

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Table 1. Descriptions of Prairie Dog Colonies used in a Study Conducted in Cimarron County Oklahoma from April - July, 1995 and 1996.

Colony Number	Colony Size (ha)	Primary Soil Type[1]	Slope (%)	Burrows/ ha[2]
1	21	Mansker loam	0-3%	83
2	4	Portales Clay loam	0-1%	141
3	3	Mansker loam	0-3%	173
4	5	Mansker loam	0-3%	113
5	302	Mansker loam	3-5%	90

[1] Obtained from Murphy et al. 1960. Soil Survey of Cimarron County, Oklahoma. U.S. Government Printing Office, Washington, D.C. 53 p.

[2] Obtained from Bigging et al. 1989. A system for evaluating black-footed ferret habitat. Interstate Coordinating Committee, Reintroduction Site Group, U.S. Fish and Wildlife Service, Fort Collins, CO. 25 p.

Table 2. Avian Species Observed on Each Site Type (Control and Reference) Using Line Transects and Point Counts.

Reference	Colony
American Kestrel	American Crow *
Brownheaded Cowbird *	American Kestrel
Cassin's Kingbird	Barn Swallow *
Cassin's Sparrow	Burrowing Owl *
Cliff Swallow	Cassin's Kingbird
Common Nighthawk	Cassin's Sparrow
Eastern Kingbird	Chihuahuan Raven *
Ferruginous Hawk *	Cliff Swallow
Grasshopper Sparrow	Common Grackle
Horned Lark	Common Nighthawk
Killdeer	Curve-billed
Lark Bunting	Thrasher
Lark Sparrow	Eastern Kingbird
Loggerhead Shrike *	Golden Eagle
Long-billed Curlew	Grasshopper Sparrow
Mountain Plover *	Horned Lark
Mourning Dove	Killdeer
Northern Mockingbird	Lark Bunting
Red-winged Blackbird	Lark Sparrow
Rock Dove	Long-billed Curlew
Savannah Sparrow *	Merlin *
Scaled Quail	Mississippi Kite *
Swainson's Hawk	Mourning Dove

Table 2. Continued.

Reference	Colony
Upland Sandpiper	Northern Harrier *
Vesper Sparrow	Northern Mockingbird
Western Kingbird	Red-winged Blackbird
Western Meadowlark	Scaled Quail
	Turkey Vulture *
	Vesper Sparrow
	Western Kingbird
	Western Meadowlark

*= species observed on only 1 site type.

Table 3. Chi-square Test Results Comparing Avifaunal Abundances Between Each Site Type (Colony vs.Reference).

Date	Site	Chi-square	P-value	Colony	Control
Jul95	1	16.3 *	<0.005	83	24
Jul95	2	12.3 *	<0.005	33	10
Jul95	3	6.3 *	<0.010	38	19
Jul95	4	8.5 *	<0.005	22	46
Jul95	5	5.3 *	<0.010	249	200
Combined	Jul95	21.9 *	<0.005	425	299
Apr96	1	0.1	<0.950	14	13
Apr96	2	6.2 *	<0.005	11	2
Apr96	3	0.0	------	5	5
Apr96	4	9.0 *	<0.005	2	14
Apr96	5	2.0	<0.100	35	48
Combined	Apr96	0.8	<0.500	67	82
May96	1	1.3	<0.250	47	59
May96	2	6.9 *	<0.010	39	19
May96	3	3.5	<0.100	23	12
May96	4	1.1	<0.500	22	38
May96	5	0.0	<0.995	195	194
Combined	May96	0.01	<0.900	326	322
Jun96	1	8.4 *	<0.005	90	55
Jun96	2	3.2	<0.100	38	24

Table 3. Continued.

Date	Site	Chi-square	P-value	Colony	Control
Jun96	3	0.3	<0.750	25	21
June96	4	0.1	<0.750	27	25
Jun96	5	1.4	<0.250	146	167
Combined Jun96		0.9	<0.900	326	292
All Dates Combined		10.4 *	<0.005	1144	995

* = values that are significant.

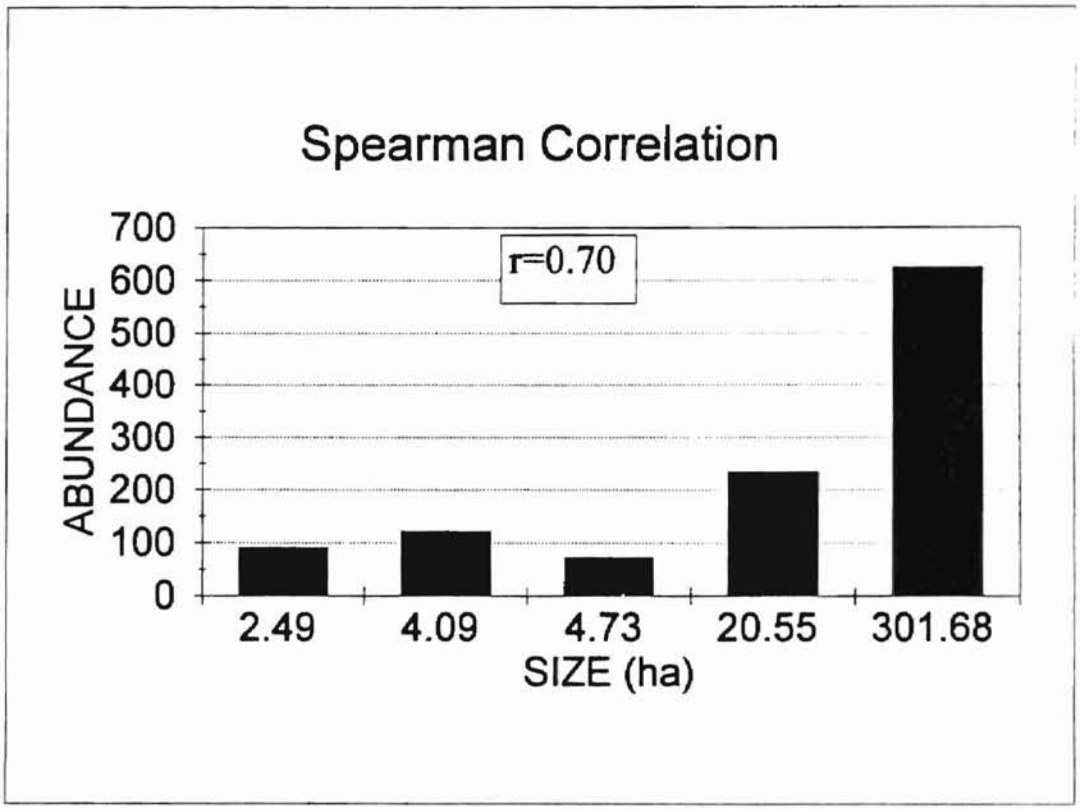
Table 4. Means of Prairie Dog Colony Sites and Sampling Session. Means are from 5 sites and 4 sampling periods. Means (within column) followed by different letters are different ($P < 0.05$); determined by ANOVA followed by Fisher's Least Significant Difference mean separation procedure.

	Mean
Site	
1[b]	6.75
2[b]	6.25
3[b]	6.50
4[b]	4.25
5[a]	12.50
Sampling Session	
July 1995[ab]	7.20
April 1996[b]	3.40
May 1996[a]	8.00
June 1996[a]	10.40

Table 5. Category 2 Avian Species Observed on Each Site Type (Colony and Reference). Roadside Observations are not Included.

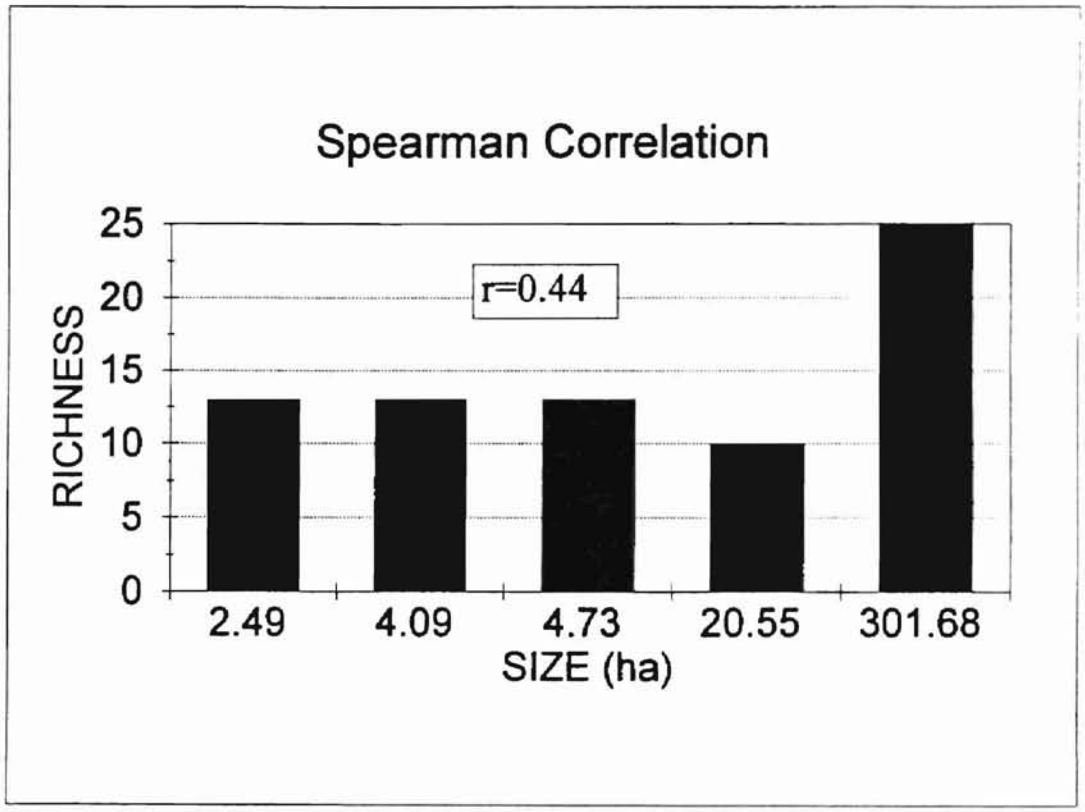
Species	Prairie-dog colony		Reference	
	Site	Other	Site	Other
Ferruginous Hawk	2	4	0	3
Long-billed Curlew	4	1	0	11
Loggerhead Shrike	0	0	2	0
Mountain Plover	0	0	1	2
Swainson's Hawk	1	0	1	3
Totals	7	5	4	19

Fig. 1. Spearman Rank Correlation of Avifaunal Abundance and Prairie Dog Colony Size.



Spearman Correlation
r=0.70
ABUNDANCE
700
600
500
400
300
200
100
0
2.49
4.09
4.73
20.55
301.68
SIZE (ha)

Fig. 2. Spearman Rank Correlation of Avifaunal Richness and Prairie Dog Colony Size.


Spearman Correlation
r=0.44
RICHNESS
0
5
10
15
20
25
2.49
4.09
4.73
20.55
301.68
SIZE (ha)

Appendix 1. Observations of avian species by month on each site type (colony and reference).

Species	Jul95	Apr96	May96	Jun96	Total (%)
American Crow (*Corvus brachyrhynchos*)					
Colony	0	1	0	0	1 (0.1)
Reference	0	0	0	0	0 (0.0)
American Kestrel (*Falco sparverius*)					
Colony	2	0	3	6	11 (0.5)
Reference	0	5	1	1	7 (0.3)
Barn Swallow (*Hirundo rustica*)					
Colony	0	0	1	0	1 (0.1)
Reference	0	0	0	0	0 (0.0)
Brownheaded Cowbird (*Molothrus ater*)					
Colony	0	0	0	0	0 (0.0)
Reference	3	0	0	0	3 (0.1)
Burrowing Owl (*Speotyto cunicularia*)					
Colony	49	5	22	13	89 (4.1)
Reference	0	0	0	0	0 (0.0)
Cassin's Kingbird (*Tyrannus vociferans*)					
Colony	0	0	0	1	1 (0.1)
Reference	0	0	1	2	3 (0.1)
Cassin's Sparrow (*Aimophila cassinii*)					
Colony	0	0	0	1	1 (0.1)
Reference	0	0	0	9	9 (0.4)
Chihuahuan Raven (*Corvus cryptoleucus*)					
Colony	0	0	1	1	2 (0.1)
Reference	0	0	1	0	1 (0.1)
Cliff Swallow (*Hirundo pyrrhonota*)					
Colony	0	0	22	1	23 (1.0)
Reference	2	0	6	0	8 (0.3)

Appendix 1. Continued

Species	Jul95	Apr96	May96	Jun96	Total (%)
Common Grackle (*Quiscalus quiscula*)					
Colony	0	0	0	2	2 (0.1)
Reference	0	0	0	0	0 (0.0)
Common Nighthawk (*Chordeiles minor*)					
Colony	2	0	0	0	2 (0.1)
Reference	1	0	0	1	2 (0.1)
Curve-billed Thrasher (*Toxostoma curbirostre*)					
Colony	1	0	3	2	6 (0.2)
Reference	0	0	0	0	0 (0.0)
Eastern Kingbird (*Tyrannus tyrannus*)					
Colony	0	0	1	5	6 (0.2)
Reference	1	0	0	3	4 (0.2)
Ferruginous Hawk (*Buteo regalis*)					
Colony	0	0	0	0	0 (0.0)
Reference	0	0	0	1	1 (0.1)
Golden Eagle (*Aquila chrysaetos*)					
Colony	0	0	0	1	1 (0.1)
Reference	0	0	0	0	0 (0.0)
Grasshopper Sparrow (*Ammodramus savannarum*)					
Colony	2	0	1	5	8 (0.3)
Reference	4	0	1	1	6 (0.2)
Horned Lark (*Eremophila alpestris*)					
Colony	243	43	169	179	634 (29.7)
Reference	180	55	186	166	587 (27.5)
Killdeer (*Charadrius vociferus*)					
Colony	1	0	3	2	6 (0.2)
Reference	1	0	1	0	2 (0.1)

Appendix 1. Continued

Species	Jul95	Apr96	May96	Jun96	Total	(%)
Lark Bunting (Calamospiza melanocorys)						
Colony	0	1	7	0	8	(0.3)
Reference	0	0	2	1	3	(0.1)
Lark Sparrow (Chondestes grammacus)						
Colony	6	0	0	2	8	(0.3)
Reference	21	0	23	31	75	(3.5)
Loggerhead Shrike (Lanius ludovicianus)						
Colony	0	0	0	0	0	(0.0)
Reference	0	0	2	1	3	(0.1)
Long-billed Curlew (Numenius americanus)						
Colony	1	2	0	3	6	(0.2)
Reference	0	0	0	2	2	(0.1)
Merlin (Falco columbarius)						
Colony	0	0	0	1	1	(0.1)
Reference	0	0	0	0	0	(0.0)
Mississippi Kite (Ictinia mississippiensis)						
Colony	1	0	0	0	1	(0.1)
Reference	0	0	0	0	0	(0.0)
Mountain Plover (Charadrius montanus)						
Colony	0	0	0	0	0	(0.0)
Reference	0	0	1	2	3	(0.1)
Mourning Dove (Zenaida macroura)						
Colony	37	0	27	35	99	(4.6)
Reference	9	0	33	17	59	(2.8)
Northern Harrier (Circus cyaneus)						
Colony	1	0	0	0	1	(0.1)
Reference	0	0	0	0	0	(0.0)

Appendix 1. Continued

Species	Jul95	Apr96	May96	Jun96	Total	(%)
Northern Mockingbird (*Nimus polyglottos*)						
Colony	4	0	5	3	12	(0.5)
Reference	4	0	3	6	13	(0.6)
Red-winged Blackbird (*Agelaius phoeniceus*)						
Colony	0	0	0	1	1	(0.1)
Reference	5	0	0	0	5	(0.2)
Rock Dove	0	0	2	5	7	(0.3)
(*Columba livia*)						
Colony	0	0	2	4	6	(0.2)
Reference	0	0	0	1	1	(0.1)
Savannah Sparrow (*Passerculus sandwichensis*)						
Colony	0	0	0	0	0	(0.0)
Reference	2	0	0	0	2	(0.1)
Scaled Quail (*Callipepla squamata*)						
Colony	4	0	3	0	7	(0.3)
Reference	0	0	1	0	1	(0.1)
Swainson's Hawk (*Buteo swainsoni*)						
Colony	0	0	0	1	1	(0.1)
Reference	1	0	0	0	1	(0.1)
Turkey Vulture (*Cathartes aura*)						
Colony	2	0	0	0	2	(0.1)
Reference	0	0	0	0	0	(0.0)
Unidentified Blackbird						
Colony	0	0	0	1	1	(0.1)
Reference	0	0	1	0	1	(0.1)
Unidentified Kingbird (*Tyrannus* sp.)						
Colony	0	0	0	1	1	(0.1)
Reference	0	0	5	2	7	(0.3)

Appendix 1. Continued

Species	Jul95	Apr96	May96	Jun96	Total	(%)
Unidentified Sparrow						
Colony	0	0	0	4	4	(0.2)
Reference	0	0	2	3	5	(0.2)
Unidentified						
Colony	11	1	2	5	19	(0.8)
Reference	19	3	3	4	29	(1.3)
Upland Sandpiper (Bartramia longicauda)						
Colony	0	0	0	0	0	(0.0)
Reference	1	0	0	0	1	(0.1)
Vesper Sparrow (Pooecetes gramineus)						
Colony	0	0	0	1	1	(0.1)
Reference	1	0	0	0	1	(0.1)
Western Kingbird (Tyrannus verticalis)						
Colony	8	0	11	2	21	(0.9)
Reference	3	0	7	1	11	(0.5)
Western Meadowlark (Sturnella neglecta)						
Colony	50	11	38	46	145	(6.7)
Reference	41	22	47	43	153	(7.1)
Totals	724	149	648	618	2139	(100.0)

Common and scientific names follow the *American Ornithologist's Union Checklist of North American Birds*, sixth edition (1983), with supplements through 1993.

VITA

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