Patterns of Small Mammal Species Richness and Abundance on Prairie Dog Colonies of Various Densities

Doniphan Property in Eastern Boulder County-Photo by Marty Moyers

Final Research Project

University of Colorado-Boulder

EPOB 4630

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Spring 2002

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Acknowledgements

Dr. Eric Stone-Professor at University of Colorado at Boulder

-For his assistance with the GPS, GIS, and statistical analyses

Whitney Johnson-Masters candidate EPOB, University of Colorado at Boulder

-For his data and help during an exceptionally busy time

Mark Brennan-Wildlife Biologist, Boulder County Parks and Open Space

-For his prompt assistance in acquiring permits, suggestions, information & maps of trapping sites, and contacts of other critical people

Dr. Dave Armstrong-Professor at University of Colorado at Boulder

-For his suggestions, enthusiasm, and meticulous edits

Amanda Hargis-GIS Coordinator, Boulder County Administrative Services Department

-For the aerial photo CD of Boulder County

Brad Seaman-Senior GIS Specialist for Boulder County Parks and Open Space

-For a CD of historical aerial photos over Boulder County

Acknowledgements

Photo by Marty Moyers

Photo 1-Boulder County Parks and Open Space Permit

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Abstract

Prairie dogs are believed to be keystone species in short- and mixed-grass prairies. Aerial photos confirm the patterns they impress upon the landscape. The results of these patterns affect the other species living there as well. We compared small mammal species richness and abundance on three different prairie dog colonies of various densities. Small mammal community patterns were significantly different between sites. Deer mice (Peromyscus maniculatus) dominated all sites, while house mice (Mus musculus) were found at only one site. We compiled our data with Johnson's (2002) data of small mammals trapped on and off prairie dog colonies. Comparing active burrow densities, visual prairie dog counts, and colony boundedness with small mammals trapped, we discovered patterns these variables had on species richness and abundance.

Introduction

Black-tailed prairie dogs (Cynomys ludovicianus) have been regarded as a 'keystone' species or key component of the mixed-grass prairie ecosystem in western North America due to their influence on biological diversity and ecosystem function (Sharps & Uresk 1990, Kotliar *et al.* 1999, Ceballos et al 1999).


Photo courtesy of U.S. Fish & Wildlife Service

Photo 1-Black-tailed prairie dogs

The integral role of prairie dog colonies of contributing to species diversity of prairie ecosystems has been indicated in numerous studies (Clark et al. 1982). Kotliar *et al.* (1999) believed they support other important ecosystem functions by increasing biological diversity and landscape heterogeneity across prairie and shrub-steppe landscapes. By creating an environment that is inviting to other animals, 64 species of vertebrates have been found on prairie dog colonies (Campbell & Clark 1981).

The objective of this project was to compare small mammal richness and abundance on prairie dog colonies of various densities, looking for emerging patterns. Species richness is a count of the number of species captured on a particular site at a given time, while abundance is calculated as the number of individual animals captured each trap night. Additionally, we determined active burrow densities, performed visual counts of prairie dogs at each site, assigned boundedness levels to each colony, and inserted GPS (Global Positioning System) data into GIS (Geographic Information System) software, producing a map of each prairie dog colony enabling us to calculate its area. Aerial maps were also utilized to confirm our GPS data and boundedness factors.

Our data was then compiled with Johnson's (2002) data of trappings done on and off prairie dog colonies. Our trappings were performed on colonies of higher urbanization rates than those by Johnson, thereby extending the range of data. Calculations were then done to examine the results of the assembled data and test our hypothesis, which is stated below.

We believed we would encounter patterns of lower capture rates of small mammals on the more densely populated prairie dog colonies. Reasons for this may include: changes in specific habitat features, inter-species competition, predation, niche overlap, boundedness, and/or foraging efficiency. Boundedness, as described by Dr. Eric Stone, is the amount and/or intensity of physical barrier surrounding a colony, represented by a scale ranging from 0-5. Zero constitutes a colony with no barriers (i.e. roads, creeks, roads developments, etc.) and five pertains to a colony that is completely surrounded by unsuitable habitat. According to Forman (1995), habitat loss and isolation increase with the five spatial processes of: perforation, dissection, fragmentation, shrinkage, and attrition. Obviously, both natural processes and human activities form patterns, which contribute to the reduction of habitat.

Whicker and Detling (1988) found prairie dogs create large, highly modified patches making it unlikely other animals would remain unaffected by the presence of such patches. Fragmentation and habitat loss are the leading causes of biodiversity loss throughout the United States (Wilcove et al. 1996). Additionally, Schwartz (1997) and Bock et al. (1998) stated that the remaining native grassland patches are embedded in a matrix of agriculture and developed lands, significantly isolating them from other grassland patches.

Ruggles *et al.* (1999) have discovered the following species to be found on or near prairie dog colonies in Boulder County:

- Deer mouse (Peromyscus maniculatus)
- Hispid pocket mouse (Chaetodipus hispidus)
- Western harvest mouse (Reithrodontomys megalotis)
- House mouse (Mus musculus)
- Prairie vole (Microtus ochrogaster)
- 13-lined ground squirrel (Spermophilus tridecemlineatus)

In our trappings and those of Johnson's (2002), only the first four species were encountered. They are briefly described below.

Deer mice are the most common mammals in Colorado, occupying most habitats at all elevations (Fitzgerald *et al.* 1994). This is probably due to their high variability, both externally (Armstrong 1972) and physiologically (Wasserman and Nash 1979). They take advantage of small burrows of other species and eat a wide variety of seeds, insects, and fungi (King 1968), contributing to the ability of these mice to use a great number of different kinds of habitats.

Photo courtesy of Dr. D. Armstrong

Photo 2-Deer mouse

Photo courtesy of Dr. D. Armstrong

Photo 3-Hispid pocket mouse

The Hispid pocket mouse inhabits a variety of shortgrass and midgrass communities, and also disturbed sites like weedy ditch banks, hedge rows, and dry riparian areas (Fitzgerald *et al.* 1994). They are generally solitary with each individual constructing its own burrow and eat a wide variety of seeds (Fitzgerald *et al.* 1994).

In eastern Colorado the Western harvest mouse occurs in riparian communities, weedy disturbed areas margins of wetlands, and relatively dense, tall stands of grasses (Fitzgerald *et al*. 1994). These mice are largely granivorous, feeding on seeds and grasses of forbs. Additionally, feral populations of the house mouse may displace and out compete the western harvest mouse (Fitzgerald *et al*. 1994).

Photo Dr. L.G. Ingles
Photo 4-Western harvest mouse

Photo from http://www.nsrl.ttu.edu/tmot1/mus_musc.htm
Photo 5-House mouse

House mice are often a sign of human habitation and/or disturbance. Their high reproductive rate combined with their adaptability to various habitats, they may displace small native rodents (Ruggles *et al*. 2000, Fitzgerald *et al*. 1994). The opportunistic house mouse has a varied diet and distribution (Fitzgerald *et al*. 1994) reinforcing its adaptability.

Background

Johnson (2002) provides the most recent local data concerning small mammal density, diversity, and evenness on and off prairie dog colonies. His data along with data from this project data will contribute to a 5-year study of prairie dog colonies, with its goals, to understand the ecological factors that influence disease transmission and develop mechanistic models for use in forecasting rates and patterns of disease spread in human-altered landscapes (Collinge *et al.* 2001).

Methods

We trapped at three sites, Doniphan and Bouzarelos-Keller-Knopf properties, described below. At each prairie dog colony, 49 Sherman non-folding live traps were placed in a 35 square meter, 7x7 grid-like fashion, spaced 5-meters apart within the boundaries of the colony. This is the method Johnson (2002) utilized and since we compared our data with his we followed this system in order to be consistent.

Traps were set out in the evening, baited with rolled oats and cotton bedding. The traps were then checked early the next morning for captures.

Photo by Marty Moyers

Photo 7-Data collection

Species, gender, age, and reproductive condition were accounted for on data sheets. Before the animals were released, they were marked with a marker on their belly, ensuring they were not used twice in the data analysis.

Photo by Marty Moyers

Photo 8-Marking a mouse

The traps were reset and re-baited later that same afternoon, if needed. This process continued for three more days at each site, cleaning the dirty traps with a bleach solution between sites.

Additionally, we performed burrow density counts on 10, 50 x 2 meter areas, randomly selected plots, on each colony. Only active burrows were counted and if any part of the burrow fell within the 2-meter width, it was tallied. We used the active burrow entrances per hectare to estimate active burrow entrance density in the colonies.

Burrow Densities

	Doniphan	Bouzarelos-North	Bouzarelos-South
	10	6	9
	9	2	4
	12	4	5
	7	3	8
	8	3	5
	8	4	7
	1	5	6
	10	3	3
	12	5	7
	8	4	5
Total	85	39	59
Average	8.5	3.9	5.9

Table 1: Burrow Densities

Lastly, four 2-hour long visual counts of prairie dogs were done at each site for three consecutive afternoons. A 50-m2 plot was placed around the 35 m^2 trapping area, constituting the zone in which aboveground prairie dogs were counted. This zone was delineated by flags at each corner of the 50-m2 plots, as to clearly outline the boundaries for our visual counts. We counted the prairie dogs at four 10-minute intervals, with 20-minute rest periods in between. At the end of each visual count, the traps were set for the evening. We sat in lawn chairs or in our car, at least 50m away from the test plots to conduct our visual counts (Table 3).

The average maximum count of each grid was used to estimate prairie dog density of each colony. Maximum average is the average of the highest number of prairie dogs counted for each grid for each colony and is the best predictor of actual prairie dog density (Severson & Plumb 1998). Even though black-tailed prairie dogs are diurnal and active above ground year-round, Davis (1966) stated that during periods of inclement cold weather, they might stay below ground for several days, thereby potentially affecting our visual counts.

The weather was not atypical for this time of year, our temperatures ranged from 35-78°, however, the wind was intense during our data collection at our second site and may have affected the prairie dog and small mammal behavior.

Photo by Marty Moyers

Photo 9-Sherman trap with brick, to hold in place due to the wind

Doniphan Property				
Date: April 9th 2002				
Weather: Partly cloudy 70°				
Count:	1	2	3	4
P-Dogs:	1	2	0	3
Date: April 10th 2002				
Weather: Partly cloudy 66°				
Count:	1	2	3	4
P-Dogs:	8	3	4	3
Date: April 11th 2002				
Weather: Cloudy 63°				
Count:	1	2	3	4
P-Dogs:	1	3	3	3

Table 2: Visual prairie dog counts on Doniphan property

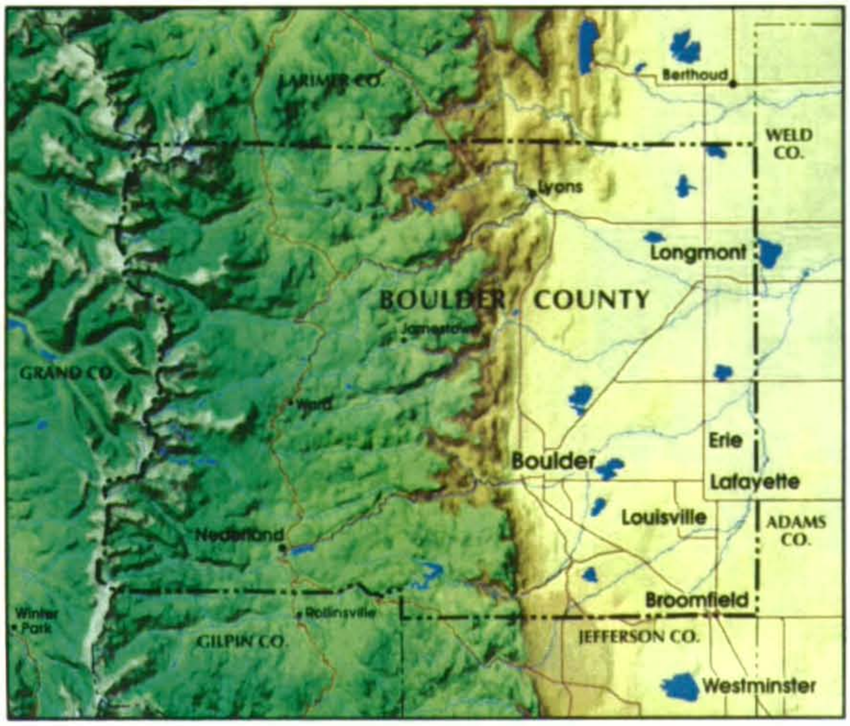
Bouzarelos-Keller-Knopf Properties				
North				
Date: April 22nd 2002				
Weather: Clear, sunny, windy 71°				
Count:	1	2	3	4
P-Dogs:	0	0	0	0
Date: April 23rd 2002				
Weather: Sunny, clear, windy 78°				
Count:	1	2	3	4
P-Dogs:	0	0	0	0
Date: April 24th 2002				
Weather: Clear, sunny, breezy 62°				
Count:	1	2	3	4
P-Dogs:	1	2	1	1

Table 3: Visual prairie dog counts on Bouzarelos-North property

Bouzarelos-Keller-Knopf Properties				
South				
Date: April 22nd 2002				
Weather: Clear, sunny, windy 71°				
Count:	1	2	3	4
P-Dogs:	0	1	3	0
Date: April 23rd 2002				
Weather: Sunny, clear, windy 78°				
Count:	1	2	3	4
P-Dogs:	1	2	3	3
Date: April 24th 2002				
Weather: Clear, sunny, breezy 62°				
Count:	1	2	3	4
P-Dogs:	1	2	3	3

Table 4: Visual prairie dog counts on Bouzarelos-South property

Study Sites



Map from http://www.co.boulder.co.us/openspace/au.openspace.map.htm

Map 1-Boulder County Open Space

Both of our sites were located in the eastern portion of Boulder County. The first, the Doniphan property, was located just outside of Erie, east of 287. The second site was directly north of Niwot, off of the Diagonal Highway and 83rd Street.

Doniphan Property

Photo from http://www.aerialsearch.com

Photo 10-1998 Aerial photo of the Doniphan property

The first site we trapped was the Doniphan property, located off of Lookout Road, east of highway 287. It is bounded by Boulder Creek on the west and north sides, Lookout Rd. to the south, and a farm on the east. This site was given a 3.5 for boundedness. We trapped here 9-12 April 2002.

Bouzarelos-Keller-Knopf Property

Photo from http://Aerialsearch.com

Photo 11-1998 Aerial photo of Bouzarelos-Keller-Knopf property

The second site was the Bouzarelos-Keller-Knopf property, located off highway 119 and 83rd Street-north of Niwot. It is bounded by a private dirt road to the north, private property to the west, south, and east. A substantial irrigation ditch runs through its midsection.

Photo by Marty Moyers

Photo 12-Irrigation ditch bisecting the Bouzarelos-Keller-Knopf property

Because of time constraints, we set up two plot sites on this property, one on either side of the ditch. We labeled them the Bouzarelos-Keller-Knopf north and south sites. This site was given a 2 in boundedness. We collected data on this site 23-26 April 2002.

Data Analysis

The independent variables are the burrow densities and visual counts of prairie dog colonies, while the dependent variables are the small mammal species richness and abundance. Both the independent and dependent variables are categorical, thereby making chi-square tests appropriate.

Table 5. Observed small mammals species richness & abundance

	Doniphan	Bouzarelos-North	Bouzarelos-South	Totals
Pema	13	4	7	24
Mumu	2	0	0	2
Totals	15	4	7	26
S =	2	1	1	

Table 6. Expected small mammals species abundance

	Doniphan	Bouzarelos-North	Bouzarelos-South
Pema	13.85	3.7	6.46
Mumu	1.15	0	0

Table 7. Chi-Square Calculations

Species	Observed-Expected	(Obs-Exp)^2	((Obs-Exp)^2)/Expected
Pema-Doniphan	-0.85	0.7225	0.052166065
Mumu-Doniphan	0.85	0.7225	0.62826087
Pema-Bouz. North	0.3	0.09	0.024324324
Mumu-Bouz. North	0	0	0
Pema-Bouz. South	0.54	0.2916	0.045139319
Mumu-Bouz. South	0	0	0
Total Chi-Square			0.749890578
Degrees of Freedom	2		
Correlating P Value	6		

Because the samples were so small in size, we did not use the 'expected value of less than five rule,' stating those expected values less than five are eliminated from the analysis. However, our Chi-square results imply there is not a statistical significance of our samples being taken from the same population. Johnson's (2002) data was compiled with our data (Table 4) to determine if there was a statistical significance between:

- Species trapped on or off colonies
- Species trapped with increasing burrows/hectare
- Species trapped with size of colony area
- Species trapped with visual counts of prairie dogs/hectare
- Visual counts of prairie dogs/hectare with increasing burrow density
- Species trapped with amount of boundedness
- Burrow density/hectare with amount of boundedness

Ideally, we should have used a rarefaction analysis, but again our sample size was too small to implement this method.

Each of the above analyses is represented in the following graphs.

Table 8. Compilation of colony and non-colony (control) data

COLONY	Colony Area	Prpty Area	Burrows/hectare	PDOGS /hectare	Bound-edness	Treat-ment	PEMA	CHHI	REME	MUMU
Dover/Blacker	0		0	0	0	CONTROL	1	0	0	0
Flatirons Vista	0		0	0	0	CONTROL	1	2	2	0
Mesa Sand & Gravel	0		0	0	0	CONTROL	1	1	3	0
VanVleet/Jeffco	0		0	0	0	CONTROL	0	0	0	0
Waneka/Kelsall	0		0	0	0	CONTROL	4	1	1	0
Zaharias	0		0	0	0	CONTROL	5	1	2	0
Dover/Blacker	8.59		153.33		1	COLONY	2	0	0	0
Flatirons Vista	15.4		160	46.68	0	COLONY	1	1	0	0
Mesa Sand & Gravel	38.95		216.67	32	1	COLONY	5	0	0	0
VanVleet/Jeffco	6.98		216.67	60	1	COLONY	5	0	0	0
Waneka/Kelsall	20.77		142	61	1	COLONY	11	0	0	0
Zaharias	8.19		166.67	63	1	COLONY	1	0	0	0
Doniphan	34.9522	31.262647	850.00	72.00	3.5	COLONY	13	0	0	2
Bouzarelos-N	27.96	32.375556	390.00	20.00	2	COLONY	4	0	0	0
Bouzarelos-S	27.96	32.375556	590.00	36.00	2	COLONY	7	0	0	0

Species: deer mice (Pema), hispid pocket mice (Chhi), western harvest mice (Reme), and house mice (Mumu)

Species trapped on or off colonies

The graph below shows one is more likely to find more hispid pocket and western harvest mice off prairie dog colonies than on.

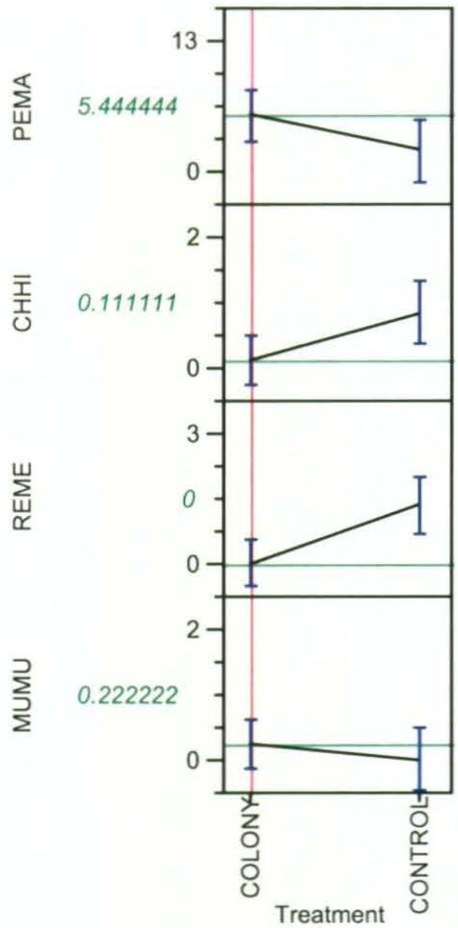


Table 9: Species trapped on or off colonies		
Species	F Ratio	P Value
Pema	3.3811	0.0889
Chhi	6.5582	0.0237
Reme	11.3455	0.005
Mumu	0.65	0.4346

Species trapped with increasing burrows/hectare

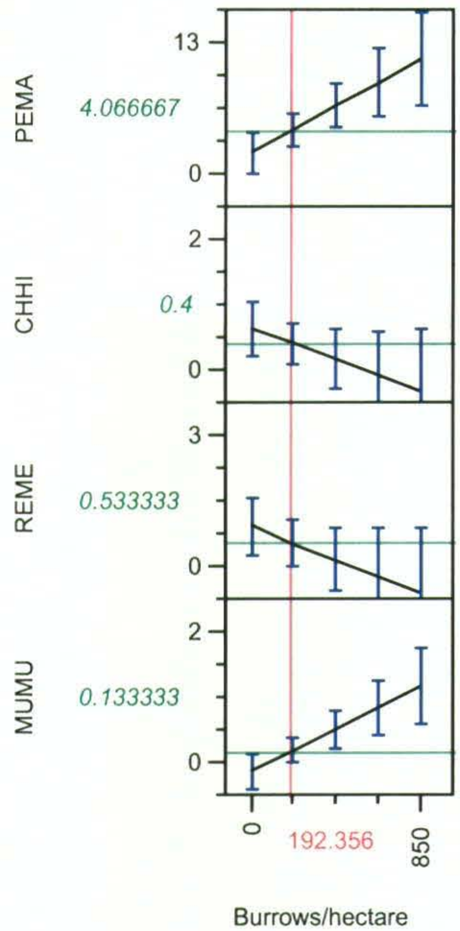


Table 10: Species trapped with increasing burrows/hectare

Species	R Square	F Ratio	P Value
Pema	0.493953	12.6893	0.0035
Chhi	0.20554	3.3633	0.0896
Reme	0.200821	3.2667	0.0939
Mumu	0.539682	15.2413	0.0018

This data disproves our hypothesis. It shows a statistical significance in finding more deer and house mice on colonies of higher densities, not less.

Species trapped with size of colony area

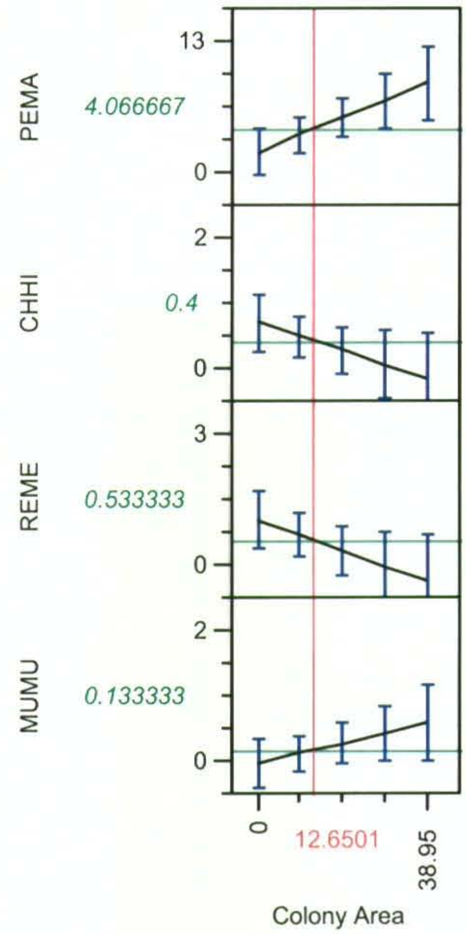


Table 11: Species trapped with size of colony area

Species	R Square	F Ratio	P Value
Pema	0.418963	9.3738	0.0091
Chhi	0.236822	4.034	0.0658
Reme	0.270198	4.813	0.047
Mumu	0.193081	3.1107	0.1013

Deer mice are more likely to be found on larger colonies, while western harvest mice are more likely to be found on colonies with small areas.

Species trapped with visual counts of prairie dogs/hectare

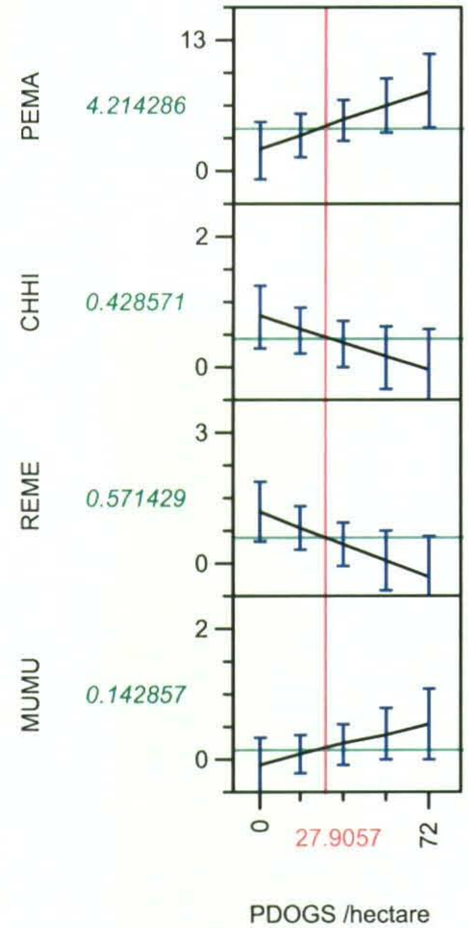


Table 12: Species trapped with visual counts of pdog/hectare

Species	R Square	F Ratio	P Value
Pema	0.350881	6.4866	0.0256
Chhi	0.25653	4.1405	0.0646
Reme	0.354451	6.5888	0.0247
Mumu	0.199972	2.9995	0.1089

This data shows deer mice are found more frequently on colonies where more prairie dogs are sited. While western harvest mice are caught more often where fewer prairie dogs are sited.

Visual counts of prairie dogs/hectare with increasing burrow density

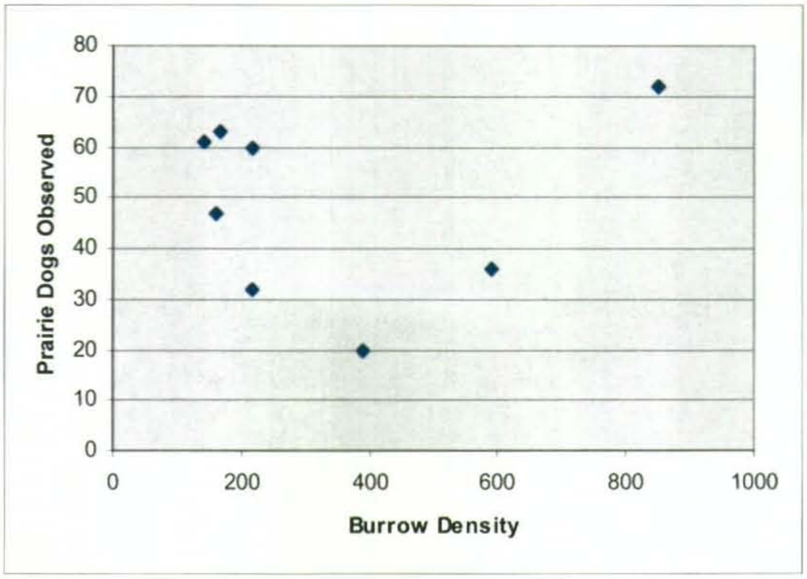


Table 13: Visual counts of pdogs/hectare with increasing burrow density

	R Square	F Ratio	P Value
P-dog	0.00900165	0.0454171	0.839656

This analysis shows there is no statistically significant relationship between visual sightings of prairie dogs with increasing burrow density.

Species trapped with amount of boundedness

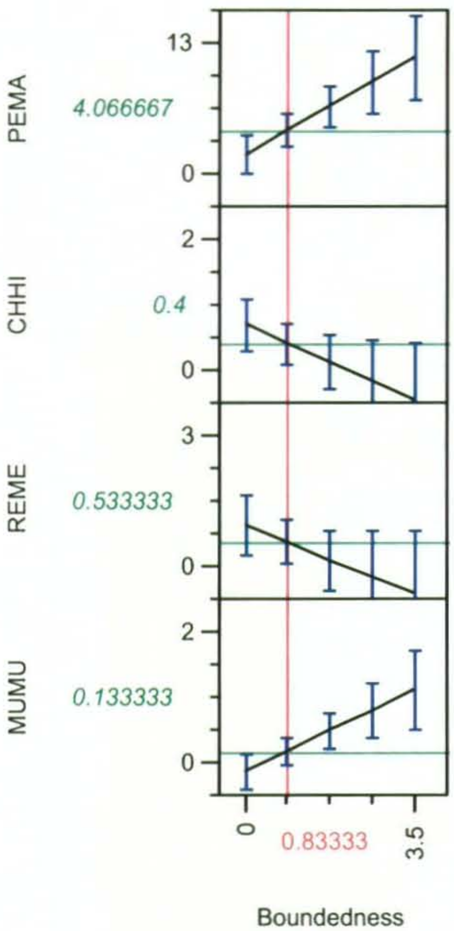


Table 14: Species trapped with amount of boundedness

Species	R Square	F Ratio	P Value
Pema	0.538776	15.1858	0.0018
Chhi	0.300963	5.597	0.0342
Reme	0.218174	3.6277	0.0792
Mumu	0.513644	13.7294	0.0026

Deer and house mice are more likely to be caught on colonies with higher rates of boundedness, while hispid pocket mice are apt to be found on colonies with no physical barriers.

Burrow density/hectare with amount of boundedness

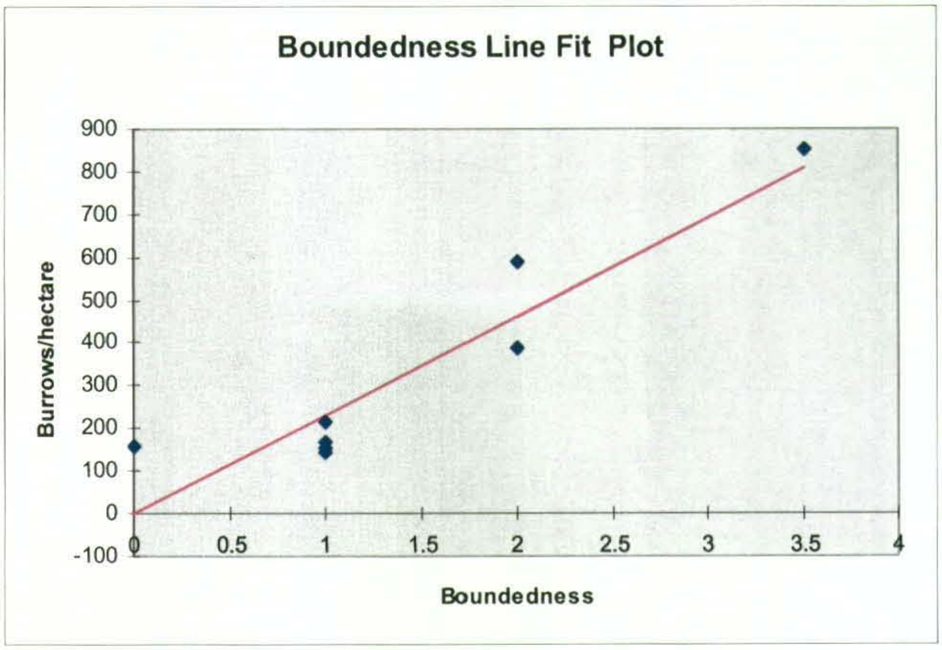


Table 15: Burrow density/hectare with amount of boundedness

	R Square	F Ratio	P Value
P-dog	0.86207725	43.753049	0.0003

This last line-fit plot demonstrates a statistical correlation between burrow density and increasing boundedness.

Conclusion

Of the three sites we trapped, greater small mammal richness and abundance patterns emerged on the more densely urbanized colony, Doniphan. Deer mice was the dominate species while only one other species was encountered, house mice. Another observation we had at this site was almost every mouse we trapped had fleas on it. The house mice were especially infested. Whereas, we did not see any mice with fleas at the Bouzarelos-Keller-Knopf sites. These two trapping areas yielded only deer mice. We also had fewer visual counts of prairie dogs on this property than we did at Doniphan. Our Chi-square values confirmed the mice from these properties came from different populations.

Few ecological studies have solely compared animal species richness and community composition on and off prairie dog colonies, so it is difficult to determine that many animal species truly depend upon prairie dogs (Stapp 1998, Kotliar *et al.* 1999). Johnson's (2002) trappings of small mammals on and off prairie dog colonies, two other species were encountered, Western harvest mice and Hispid pocket mice. A statistically significant pattern emerged, in finding both of these species more frequently off prairie dog colonies than on. There may be several reasons why we did not encounter the Hispid pocket and Western harvest mice at our trapping sites. Prairie dogs reduce grass cover and may have competitively prevented pocket mice and harvest mice from existing on those colonies. Also, due to decreased cover, predators may have increased detection of prey. Additionally, feral populations of House mice may displace and out compete harvest mice (Fitzgerald, 1994). Lastly, it should be pointed out that Johnson (2002) performed his trappings in the months of October and November of 2001, while we completed ours in April 2002.

Other tests showed a pattern between trapping deer and house mice and densely placed burrows/hectare. This could be due to the fact that deer mice take advantage of small burrows of other species and eat a wide variety of seeds, insects, and fungi (King 1968), and the opportunistic house mouse's ability to adapt to various habitats (Ruggles *et al.* 2000, Fitzgerald *et al.* 1994, Fitzgerald *et al.* 1994).

The strong relationship between burrow density/hectare and boundedness, an index of the amount a colony is immediately adjacent to unsuitable habitat, appeared logical. However, the surprise was a deficient connection between visual counts of prairie dogs and burrow density. We can attempt to explain this by the graded-off and filled-in burrows we encountered at the Bouzarelos-north site, in addition to the numerous bullet & shotgun shells casings, and prairie dog bones we found at both the north and south trapping sites (photos 13-15).

Further studies are suggested, performed on and off prairie dog colonies, especially colonies of higher urbanization rates, thereby achieving larger sample sizes and acquiring a better range of data. Conducting this research at approximately the same time of year, is also warranted to attain improved data consistency.

Photo by Marty Moyers

Photo 13-Scraped-off burrow at Bouzarelos-North

Photo by Marty Moyers

Photo 14-Filled-in burrow at Bouzarelos-North

Photo by Marty Moyers

Photo 15-Bullet & shotgun shell casings with prairie dog bones at Bouzarelos site

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