Impacts of recreational shooting on prairie dog colonies

by Timothy Charles Vosburgh

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Fish and Wildlife Management
Montana State University

Abstract:
The BLM has encouraged recreational shooting as a means of controlling prairie dog populations and as a recreational use of public lands. I investigated the impacts of recreational shooting on prairie dog population dynamics, activity patterns, and vegetation conditions in prairie dog towns. I monitored shooting pressure on BLM hunted colonies, measured the strength of association between shooting effort and changes in population size/structure and activity patterns, and compared vegetation between hunted and unhunted colonies. Marked subsamples were used to estimate prairie dog densities during the spring and fall on 10 hunted colonies in 1994 and 9 hunted and 8 non-hunted (control) colonies in 1995. Mean number of prairie dogs killed on colonies open to hunting was 27% in 1994 and 53 in 1995. In 1995, prairie dog density declined 33% on hunted colonies and 15% on non-hunted colonies. The percentage of marked prairie dogs recaptured during the fall was higher on non-hunted colonies (53%) than on hunted colonies (41%). I also found a positive correlation between shooting pressure and change in density on hunted colonies. Although age structure did not change from spring to fall, recreational shooting may have resulted in higher female mortality during 1995. Prairie dogs spent more time in alert postures and less time foraging on hunted than on unhunted towns. Prairie dogs could also be approached more closely on non-hunted colonies than on hunted colonies. Of the 4 approaches I used to monitor prairie dogs: (mark-recapture, burrow counts, vegetation analysis, and counting prairie dogs), above ground counts were the best approach for assessing prairie dog populations.

IMPACTS OF RECREATIONAL SHOOTING
ON PRAIRIE DOG COLONIES

by

Timothy Charles Vosburgh

A thesis submitted in partial fulfillment
of the requirements for the degree

of

Master of Science

in

Fish and Wildlife Management

MONTANA STATE UNIVERSITY-BOZEMAN
Bozeman, Montana

April 1996

APPROVAL

of a thesis submitted by

Timothy Charles Vosburgh

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

Lynn R. Irby — Lynn R. Irby (Signature) — 22 Apr 96 Date

Approved for the Department of Biology

Ernest R. Vyse — E R Vyse (Signature) — 4/22/96 Date

Approved for the College of Graduate Studies

Robert L. Brown — R L Brown (Signature) — 5/2/96 Date

STATEMENT OF PERMISSION TO USE

In presenting this thesis in partial fulfillment of the requirements for a master's degree at Montana State University-Bozeman, I agree that the Library shall make it available to borrowers under rules of the Library.

If I have indicated my intention to copyright this thesis by including a copyright notice page, copying is allowable only for scholarly purposes, consistent with "fair use" as prescribed in the U. S. Copyright Law. Requests for permission for extended quotation from or reproduction of this thesis in whole or in parts may be granted only by the copyright holder.

Signature Timothy Charles Vosburgh

Date April 22, 1996

ACKNOWLEDGMENTS

To the following, I wish to express sincere appreciation for their contributions to this study: Dr. L. Irby for project planning, technical advice, and guidance in preparation of the manuscript; Drs. H. Picton and T. McMahon for critical review of the manuscript; Dr. C. Wambolt for technical advice; W. Hagland of the Charles M. Russell National Wildlife Refuge, R. Stoneberg of Montana Department of Fish Wildlife and Parks, and J. Grensten and M. Williams of the Bureau of Land Management for cooperation and help throughout the study; D. and F. Veseth for providing a place to camp; J. Big Eagle and S. Dinsmore for field assistance and companionship; B. Semmens for help with the figures; and my wife Karan, for her encouragement and support. During the study, I was supported by the Bureau of Land Management, Montana Fish Wildlife and Parks, U. S. Fish and Wildlife Service, and Montana State University-Bozeman.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

The BLM has encouraged recreational shooting as a means of controlling prairie dog populations and as a recreational use of public lands. I investigated the impacts of recreational shooting on prairie dog population dynamics, activity patterns, and vegetation conditions in prairie dog towns. I monitored shooting pressure on BLM hunted colonies, measured the strength of association between shooting effort and changes in population size/structure and activity patterns, and compared vegetation between hunted and unhunted colonies. Marked subsamples were used to estimate prairie dog densities during the spring and fall on 10 hunted colonies in 1994 and 9 hunted and 8 non-hunted (control) colonies in 1995. Mean number of prairie dogs killed on colonies open to hunting was 27% in 1994 and 53 in 1995. In 1995, prairie dog density declined 33% on hunted colonies and 15% on non-hunted colonies. The percentage of marked prairie dogs recaptured during the fall was higher on non-hunted colonies (53%) than on hunted colonies (41%). I also found a positive correlation between shooting pressure and change in density on hunted colonies. Although age structure did not change from spring to fall, recreational shooting may have resulted in higher female mortality during 1995. Prairie dogs spent more time in alert postures and less time foraging on hunted than on unhunted towns. Prairie dogs could also be approached more closely on non-hunted colonies than on hunted colonies. Of the 4 approaches I used to monitor prairie dogs: (mark-recapture, burrow counts, vegetation analysis, and counting prairie dogs), above ground counts were the best approach for assessing prairie dog populations.

INTRODUCTION

Background

Recreational shooting of black-tailed prairie dogs (Cynomys ludovicianus) has occurred in the Missouri Breaks of central Montana for decades. The Bureau of Land Management (BLM) has encouraged recreational shooting as a means of controlling prairie dog populations and as a recreational use of public lands since 1979. The current program in Phillips County includes advertisements in magazines, posting signs to identify legal shooting areas, and distributing maps showing locations of prairie dog colonies (Reading et al. 1989).

The number of prairie dog shooters has apparently increased over the past 6 years throughout their range (BLM, unpubl.), but the impacts of recreational shooting on prairie dog population dynamics and behavior have not been adequately measured; nor has the interaction between recreational shooting and other factors that influence prairie dog populations (poisoning, other herbivore populations, predator populations, drought, and sylvatic plague) been investigated. If shooting effectively reduces prairie dog numbers, it has potential benefits for the livestock industry. If it reduces numbers or distribution, shooting may have detrimental impacts on plants and animals dependent on vegetation disturbances produced by prairie dogs. The recent reintroduction of black-footed ferrets (Mustela nigripes), an endangered species that is dependent on prairie dogs as prey (USFW 1988), in Phillips County adds urgency to the need for information.

Black-tailed prairie dogs are large diurnal ground squirrels which live in large colonies. Colony residents live in contiguous family groups called coteries (King 1955) which typically contain one adult male, 3-4 adult females, and several yearlings and juveniles (Hoogland et al. 1987). The range of the species extends from southern Canada to northern Mexico (Hillman and Clark 1980). They selectively feed on graminoids and have historically been regarded as competitors with livestock (Bonham and Lerwick 1976, Agnew et al. 1986). Although some research questions their impacts on forage (Hansen and Gold 1977, O'Meilia et al. 1982, Collins et al. 1984, Krueger 1986, Uresk and Paulson 1989), the perception of damage has lead, and still leads, to extensive population control efforts. Efforts over the past 100 years have reduced prairie dog colonies to approximately 2% of their original land area (BLM 1982, Campbell and Clark 1982, March 1984, Peterson 1988, Lee and Henderson 1989, Miller et al. 1990) primarily through widespread poisoning programs (Anderson et al. 1986, Dunlap 1988).

Loss of prairie dog populations reduces vertebrate biodiversity in the prairie ecosystem. Over 100 vertebrate species use prairie dog colonies as habitat (Clark et al. 1989, Sharps and Uresk 1990). Prairie dog communities support higher numbers of small mammals and arthropods, more terrestrial predators, higher avian species diversity, and higher avian density than surrounding areas (Hansen and Gold 1977, O'Meilia et al. 1982, Agnew et al. 1986, Krueger 1986, Reading et al. 1989). Prairie dog activity increases nutrient content and digestibility of forage, but may decrease forage production. Despite apparent low biomass of standing vegetation, bison (Bison bison) and domestic cattle preferentially graze on prairie dog colonies. (O'Meilia et al. 1982, Coppock et al. 1983).

Detling and Whicker (1988) concluded that prairie dogs create unique patches of biological diversity in grassland ecosystems.

Reductions in number, size, and distribution of prairie dog colonies increases the risks for all species associated with that community. Small isolated populations of prairie dogs may be more susceptible to disease, inbreeding, and catastrophic events. Sylvatic plague (Yersinia pestis), a disease that is probably exotic to North America (Cully 1993), appeared in Phillips County around 1990 and continues to fragment prairie dog populations. Highly specialized animals like the black-footed ferrets may be more vulnerable to the effects of prairie dog population fragmentation than prairie dogs themselves.

Prairie dog management in central Montana is as much an economic as a biological issue. Local area ranchers worry about the invasion and spread of prairie dog colonies onto their private lands and about the potential competition with cattle for available forage. Managers employed by resource agencies are trying to balance the concerns of ranchers with the need to preserve the unique biological communities associated with prairie dog towns by controlling the distribution and size of colonies rather than completely eliminating them.

Sport shooting can be an effective control mechanism for prairie dogs (Stockrahm 1979, Knowles 1988) that might be more socially acceptable than poisoning. Recreational shooting also has the advantage of potentially limiting prairie dog numbers rather than eliminating colonies. If recreational shooting operates in this manner, it could preserve the positive biological effects of prairie dogs (including maintaining habitat for species such as the black-footed ferret), while reducing damage to livestock interests, and providing public recreational use of BLM lands, and economic benefits to local businesses.

The goal of this study was to determine if current levels of recreational shooting have a detectable impact on prairie dog population dynamics, activity patterns or vegetation condition in prairie dog towns in south Phillips County, Montana. Specific objectives were to:

1. Estimate intensity and seasonal pattern of recreational shooting in colonies advertised (those identified on maps distributed to hunters) and unadvertised to hunters by BLM.

2. Estimate population size, age/sex structure, population turnover, activity patterns, and vegetation composition and cover in hunted and non-hunted colonies.

3. Measure the strength of association between shooting effort and changes in population size/structure, activity patterns, and vegetation for sample colonies.

STUDY AREA AND METHODS

This study was conducted in the southern portion of BLM's Phillips Resource Area and on the adjacent Charles M. Russell National Wildlife Refuge (CMR). The study area covered approximately 130 km^2 north of UL Bend National Wildlife Refuge including adjacent lands on the refuge. The topography of the BLM lands is mostly flat upland plains and rolling hills, whereas the CMR has a more highly eroded "breaks" topography. Elevation in the study area varied from 900-1200m. Soils in this area of central Montana are derived from glacial till, sedimentary bedrock, and alluvium from mixed rock sources, resulting in complex and diverse soil patterns (BLM 1982). Climate is continental with mean annual precipitation of 11-13 in (28-33 cm) and temperature of 40 to 100 degrees F. Grasslands typical of the Northern Great Plains dominate the area, but sage (Artemisia spp.) and greasewood (Sarcobatus vermiculatus) are common. Common grasses found in the study area included blue grama (Bouteloua gracilis), western wheatgrass (Agropyron smithii), needle-and-thread (Stipa comata), Sandberg bluegrass (Poa secunda), and green needlegrass (Stipa viridula). The two primary land uses in the study area were livestock grazing (cattle and sheep) and farming of small grains and hay.

Sampling Procedures

Field work was conducted from June-September 1994 and June-August 1995. Sample colonies were selected from a BLM map of active prairie dog colonies. I selected five prairie dog colonies marked on BLM location maps (advertised colonies), five colonies not identified on maps (unadvertised colonies), and colonies (4 in 1994 and 10 in 1995) in areas closed to hunting (control colonies) for intensive study. Advertised and unadvertised colonies were matched by size, topography, soil type, and habitat type. In 1994, I included 4 non-hunted colonies (control colonies) on the CMR for behavioral, burrow density, and vegetation studies. In 1995, the number of control colonies was increased to 10 but 2 of these colonies were lost to plague during the summer. Study colonies ranged in size from 8 ha to 40 ha on the BLM study area and from 8 ha to 60 ha on the CMR study area.

Hunter activity was determined from hunter questionnaires placed in each hunted colony. Hunters were asked to record the number of rounds fired, number of prairie dogs hit, and time spent shooting on each BLM colony. I also recorded the number and location of hunters seen in the field and interviewed them for additional shooting information. Data from the hunter registers were supplemented with results from BLM and Montana Fish Wildlife and Parks (FWP) prairie dog hunter surveys (unpubl. 1994).

Prairie dog population parameters were estimated using mark-resight techniques (Pollock et al. 1990) on BLM colonies in 1994 and 1995 and on CMR colonies in 1995. I trapped each colony using 25 Tomahawk live traps (Tomahawk Live Trap Co., Tomahawk, Wisconsin) for 3 days, at the beginning and end of the field season. I identified individual prairie dogs by attaching a numbered, self-piercing fingerling tag (National Band and Tag Co., Newport, Kentucky) in each ear. I dyed prairie dogs in the spring with Rodal-D (Lowenstein and Sons, Brooklyn, New York) using different patterns for adult males, adult females, and juveniles. These markings could be easily seen from a distance of 300m. In late summer of 1995, I marked animals with a different color of fur dye so that I could make independent population estimates in the fall.

I calculated burrow density (active and inactive) in mid-summer on all sample colonies. In addition, BLM personnel counted active and inactive burrows along 10 parallel belt transects on 27 colonies in 1994, once in the spring and again in the fall. Ten colonies in the BLM sample were eliminated by plague during 1994, but burrow densities in 17 of the original 27 colonies were sampled in 1995. Fresh diggings, freshly cut vegetation in or around a burrow entrance, and prairie dog droppings near burrow entrances indicated an active burrow.

I observed prairie dog behavior and movements to determine the approximate location of coterie boundaries. This allowed me to select vantage points from which 2-4 contiguous coteries could be observed. The size of these observed areas ranged from 8000 m^2 on smaller colonies to 30,000 m^2 on larger colonies. Colony boundaries were delineated with wooden stakes placed approximately 50 m apart.

After approaching a vantage point by foot, I counted the number of marked and unmarked animals on the study area with the aid of binoculars or a spotting scope. During observations, I recorded 5 categories of prairie dog activities: 1) foraging, 2) standing or alert posture, 3) resting or sitting, 4) interacting, and 5) moving. I made counts at 5-minute intervals for 15 minutes during each observation session. A total of 45 observations on each hunted and 30 on each non-hunted colony were made during the 2 year study. Observations were equally divided among morning, mid-day and evening time periods.

I measured prairie dog behavioral response to disturbance in two ways: 1) number of animals staying above ground when approached within 75 m (1994) and 2) closest approachable distance (1994 and 1995). These measurements were taken on focal individuals or focal animal groups in randomly selected parts of the study colony. I attempted to sample during all time periods on hunted and non-hunted colonies throughout the summer.

Vegetation composition and percentage cover of each plant species were measured in all sample colonies using a 11-category canopy coverage system (<1%, 1-10%, 11-20%, ... 91-100%) based on a modification of Daubenmire's (1970) method. Plants were grouped into 4 categories: 1) grasses, 2) forbs, 3) shrubs, and 4) total cover. I measured vegetation at 5-m intervals along 5 50-m transects inside each colony in 1994 and both inside and outside each colony in 1995. Ten 2x5 dm plots were sampled at 5-m intervals along each line.

Analysis.

Mark-recapture population estimates (White et al. 1982) were used to determine population densities. I used Chapman's (1939) modification of the Lincoln-Peterson index to determine population density based on resightings of marked prairie dogs during the first 3 observation periods following each trapping and marking effort. Mann-Whitney 2-sample tests were employed to compare the change in population density from spring to fall and the proportion of marked animals recaptured in the fall between hunted and non-hunted colonies. I used t-tests to compare active burrow densities on advertised, unadvertised, control colonies and on colonies included in BLM surveys. I used Chi-square analysis of two-way contingency tables to compare seasonal and annual changes in sex ratio and age structure on all sampled colonies.

I compared behavioral patterns between BLM hunted and CMR non-hunted colonies using t-tests. Difference in vegetation on hunted and non-hunted of colonies was tested using Mann-Whitney tests. I also used Mann-Whitney tests to compare vegetation inside with vegetation outside of BLM colonies. The criteria for rejection of a statistical test was $P < 0.10$.

Hunting pressure was assessed by comparing responses to my questionnaires by hunters on advertised and unadvertised colonies. Results from these hunter surveys provided data to test the strength of the association between shooting pressure and estimated changes in population densities and to determine seasonal and annual variation in shooting pressure among colonies. BLM personnel coded and analyzed the BLM and FWP's hunter survey information using the computer program SPSS (Statistical Package for the Social Sciences; BLM-FWP unpubl.).

RESULTS

Hunting Patterns and Hunter Attitudes

I observed substantial differences in summer hunting pressure on BLM colonies during the two years of the study (Table 1). In 1994, thirteen groups of hunters registered on 10 sample colonies, whereas in 1995 33 groups registered on 9 sample colonies, despite a 2 month shorter field season. In addition, the number of hunters, shots fired, prairie dogs hit, and time spent hunting more than doubled from 1994 to 1995.

Resident versus nonresident hunter composition also varied between years. The proportion of Montana residents hunting prairie dogs increased from 10% in 1994 to 50% in 1995. In 1994, most hunters (90%) had hunted prairie dogs previously, but in 1995 I observed a greater proportion of first time hunters (30%).

Shooting pressure varied widely among the colonies. Two of the 10 colonies, B-72 and B-148, received 57% of total shooting pressure during 1994 and 1995 (Table 1). Colony B-148 received a reported 697 shots, the highest shooting intensity of any sample colony. Only 3 colonies: B-72, B-148, and S-07, received more than 100 reported shots during a single summer.

Table 1. Hunting Pressure on 10 BLM Colonies in 1994 and 9 Colonies in 1995.

Town status	# hunters	# shots	# hits	hours hunting
1994				
B-42	5	93	26	3.3
S-07	3	39	19	2.5
B-72	7	151	41	5.5
B-148	4	164	51	5.75
B-90	4	59	21	1.5
B-164	0	0	0	0.0
B-67	6	39	11	1.75
B-156	2	40	12	0.75
B-91	3	44	15	2.25
B-128	2	74	33	3.5
Advertised	24	386	114	12.5
Unadvertised	11	317	115	12.7
Total	**36**	**703**	**229**	**26.8**
1995				
B-42	13	34	21	4.75
S-07	14	290	105	11.0
B-72	17	437	109	20.75
B-148	20	533	172	23.25
B-90	9	41	23	3.75
B-164	0	0	0	0.0
B-67	6	8	3	1.25
B-71	9	75	40	5.5
B-91	7	80	45	6.0
Advertised	52	600	201	36.5
Unadvertised	43	898	317	39.7
Total	**95**	**1498**	**518**	**76.2**

Shooting pressure also varied seasonally and between years (Fig. 1). In 1994, peak shooting pressure occurred during late spring and early summer with a second smaller peak during early fall. In 1995, shooting pressure again peaked in May and June but remained relatively high for the remainder of the summer.

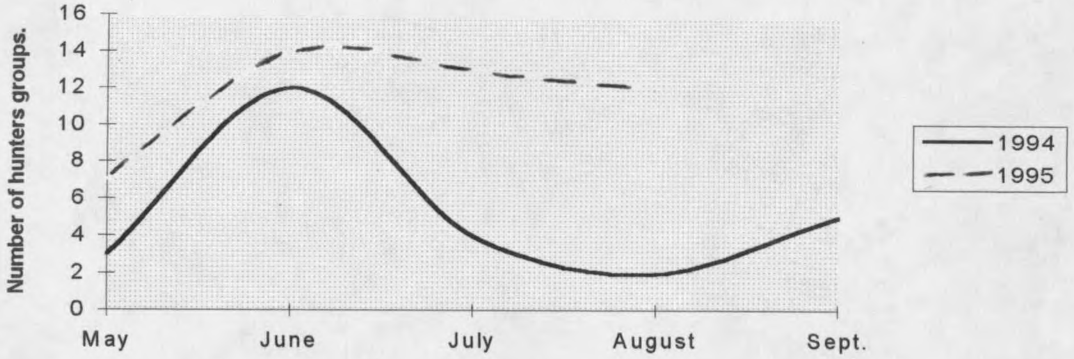

Figure 1. Seasonal pattern of recreational shooting on BLM hunted colonies during the 1994 and 1995 field seasons.

According to hunter register data, shooting pressure also varied between advertised and unadvertised colonies. The total number of shots recorded in 1994 and 1995 was 986 on advertised and 1215 on unadvertised colonies (Table 1). Highest shooting pressure occurred on advertised colonies in 1994 but on unadvertised colonies in 1995. I found strong correlation between the number of shots fired (r = 0.79) and number of hunters (r = 0.86) with the number of prairie dogs reported killed.

The BLM - FWP mail survey in 1994 and my interviews indicated dissatisfaction among prairie dog hunters, especially veteran hunters, with the purported low number of prairie dogs on BLM colonies. Majority of hunters interviewed (>50%) did not feel that recreational shooting was an effective control for prairie dog populations. However, a few groups of hunters claimed that they could reduce or 'shoot out' an average size colony. Despite their perceptions of low prairie dog numbers, most hunters seemed to enjoy their recreational experiences while on BLM lands.

Effects of Hunting

Estimate prairie dog density (animals/ha) in spring 1995 (6/10 to 6/24) varied from 16 to 63 on hunted colonies and 8 to 40 on non-hunted colonies (Table 2). Late summer 1995 (9/1 to 9/15) estimates varied from 13 to 42 on hunted and 9 to 38 on non-hunted colonies. Average density was higher during the spring and fall on hunted colonies (34 prairie dogs/ha) compared to non-hunted colonies (23 prairie dogs/ha). Population density decreased 33% in hunted colonies and 15% in non-hunted colonies over the summer (Table 2). This difference indicated that the decrease in density during the 1995 field season was greater (df = 16, p = 0.06) in hunted than in unhunted colonies.

Proportion of marked prairie dogs recaptured in the fall was 0.45 (1994) and 0.42 (1995) on hunted colonies, and was 0.53 for non-hunted colonies in 1995. In 1995, the proportion recaptured was higher (df = 16; p = 0.038) on colonies closed to hunting than on hunted colonies. Despite the higher shooting pressure in 1995, the proportion of marked animals recaptured on hunted colonies was significantly different (df = 17; p = 0.045).

The average number of prairie dogs reported as killed, based on a 60% compliance on hunter registers and accurate assessments of shooting by hunters, on BLM hunted colonies was 23 per colony in 1994 and 57 per colony in 1995. On hunted colonies, I found a strong correlation between the number of shots (r = -0.72; p = 0.02) and the number of hits (r = -0.79; p = 0.01) (Fig.2) with the estimated change in population density from early to late summer.

Table 2. Prairie dog density estimates and changes in density from spring to fall on portions of study areas in 1995.

BLM 1995 Town #	study area size m^2	number of dogs/ha early	number of dogs/ha late	change in density % change
B 67	10000	16	13	-19
S 07	12500	38	20	-47
B 42	12500	37	27	-27
B 164	11000	40	29	-27
B 90	9000	40	28	-30
B 91	10000	42	31	-26
B 148	12000	47	23	-51
B 72	11000	46	27	-41
B 120	6600	63	42	-33
Mean		**41**	**27**	**-33**
CMR 1995				
UL 1	22725	18	19	+5
UL 2	20000	19	13	-31
UL 3	10000	40	26	-35
UL 4	30000	8	9	+12
C 19	8300	38	32	-16
C 20	20000	21	15	-29
C 25	17500	14	11	-21
C 1	13000	40	38	-5
Mean		**24**	**20**	**-15**

I tested the impacts of sport shooting on age structure and sex ratio by comparing the ratio of adults to juveniles and adult male to adult female prairie dogs between spring and fall estimates (Table 3). Chi-square tests of heterogeneity indicated no significant differences among hunted and non-hunted colonies for spring age ($X^2 = 19.4$; $p = 0.37$) and sex ($X^2 = 17.1$; $p = 0.52$) or fall age ($X^2 = 25.2$; $p = 0.12$) and sex ($X^2 = 11.0$; $p = 0.89$) ratios. Thus, I pooled colonies into 2 categories, hunted and non-hunted. The ratio of adults and juveniles captured in the spring was not different from the ratio captured in the fall during either 1994 or 1995 (Table 3). Similarly, I did not find seasonal differences in the sex structure on hunted and non-hunted colonies in 1995 (Table 3). However, differences in the ratio of females to males captured in the spring compared to the ratio captured in the fall approached significance ($p = 0.06$) on hunted colonies during 1995.

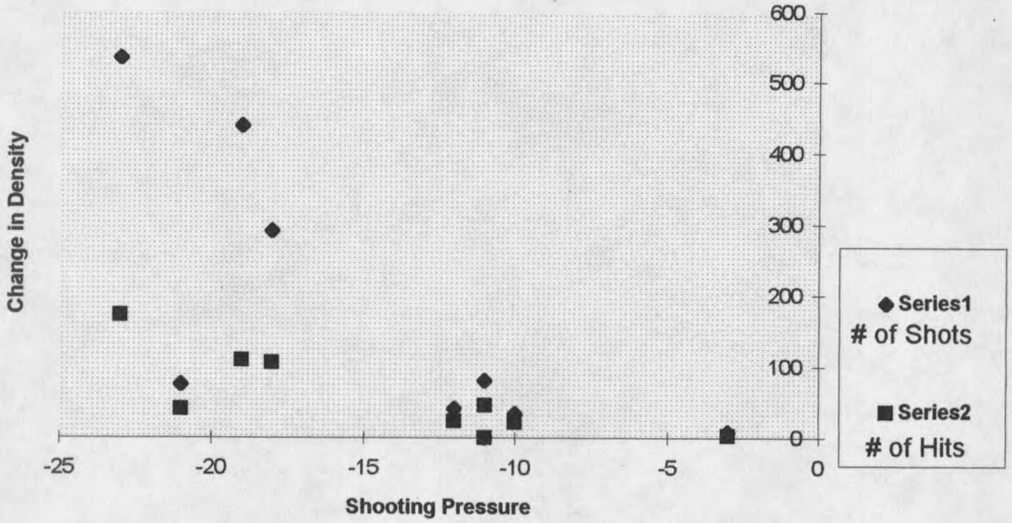

Figure 2. Estimated change in density (no./ha) and reported shooting pressure on hunted colonies in 1995.

Table 3. Comparison of age structure and sex ratios on BLM hunted and CMR non-hunted colonies during 1994 and 1995. Results of Chi-square tests are included.

	BLM 1994		BLM 1995		CMR 1995	
	Adult	Juvenile	Adult	Juvenile	Adult	Juvenile
Spring	88	84	92	53	79	33
Fall	92	88	72	37	67	37
	p= 0.99		p= 0.65		p= 0.34	
	Female	Male	Female	Male	Female	Male
Spring	45	43	48	44	35	44
Fall	48	43	27	45	33	34
	p= 0.83		p= 0.06		p= 0.55	

The percentage of lactating females during early summer captures was also similar between hunted and non-hunted colonies. The percentage of lactating females was 56% on BLM and 65% on CMR colonies (Table 4). Only 8 of the 37 juvenile females marked in 1994 and recaptured during the spring of 1995 were lactating.

Table 4. Total number of prairie dogs marked and ratio of adult females lactating during early summer captures on hunted and non-hunted colonies.

	Year	Total Marked	Adult Females Lactating: Total Number of Adult Females
BLM	1994	172	28 : 45
BLM	1995	145	24 : 48
CMR	1995	112	21 : 35

Active burrow density showed no pattern in relative hunting pressure. Estimated active burrow densities for hunted colonies varied from 40 to 91 burrows/ha on advertised colonies and 10 to 113 burrows/ha on unadvertised colonies. Active burrow density on surveyed colonies closed to hunting varied from 60 to 120 burrows/ha. Mean decrease in active burrow density from spring to fall was -4.6 burrows/ha for 27 colonies open to hunting surveyed in 1994 and -19.7 burrows/ha on 17 hunted colonies surveyed in 1995. Overall, spring burrow density counts decreased 8% in 1994 and 16% in 1995 when compared to fall counts. On hunted colonies sampled by BLM personnel in both years, the density of active burrows counted in spring increased 25%, and the density counted in the fall increased 27%, from 1994 to 1995. Mean change in active burrow density from spring to fall was not different ($t = 0.71$, $df = 42$, $p = 0.48$) between hunted colonies surveyed by BLM personnel in 1994 or 1995.

The range of active burrow densities on study portions of sample colonies I studied intensively was 27-113 burrows/ha on hunted colonies and 48-109 on non-hunted colonies. The mean burrow density for both spring and fall counts was 69 burrows/ha on hunted colonies in 1994. In 1995, the mean count was 82 burrows/ha on hunted and 81 burrows/ha on non-hunted colonies. Mean percent change in active burrow density from spring to fall was not different ($t = 0.77$, $df = 18$, $p = 0.45$) between 1994 and 1995 on intensively studied hunted colonies; nor was the mean change in active burrow density different ($t = 0.61$, $df = 17$, $p = 0.54$) between hunted and non-hunted colonies intensively sampled in 1995 (Table 5). There was no significant correlation ($r = 0.29$; $p = 0.14$) between burrow density and estimated population density using the Lincoln-Peterson index on intensively sampled colonies.

Table 5. Mean percent change, standard deviations, and the range of active burrow density, from spring to fall on BLM hunted and CMR non-hunted colonies during 1994 and 1995.

	% change	standard deviation	range	
Entire colonies:				
Hunted 1994	-8	0.35	-0.82	0.65
Hunted 1995	-16	0.31	-0.61	0.38
Observed areas:				
Hunted 1994	-10	0.20	-0.34	0.31
Hunted 1995	-3	0.21	-0.31	0.37
Non-hunted 1995	3	0.17	-0.27	0.33

Effects of Hunting on Behavior

Observation of marked and unmarked prairie dogs proved an effective means of testing behavioral differences in hunted and unhunted colonies when observations were made at distances or under conditions when prairie dogs were not aware of my presence. Highest counts of animals above ground in areas where marked prairie dogs were present were tightly correlated with Lincoln-Peterson population density estimates for hunted ($r = 0.83$; $p = 0.005$), non-hunted ($r = 0.96$; $p < 0.001$), and all colonies ($r = 0.89$; $p < 0.001$), respectively.

A comparison between hunted and non-hunted colonies indicated consistent differences in prairie dog activity patterns. Of the total number of prairie dogs originally marked during the spring on BLM hunted colonies, the mean percentage of marked animals counted above ground was 26% in 1994 and 31% in 1995. On CMR non-hunted colonies, the mean number that I counted was 43% in 1995. Mann-Whitney tests indicated that the proportion was higher ($df = 17$; $p = 0.009$) on non-hunted than on hunted colonies in 1995.

Prairie dogs also were more alert ($df = 16$, $p = 0.007$) in hunted colonies (66%) versus non-hunted colonies (49%) (Table 6). However, the proportion of prairie dogs that were alert at the close of each 15 minute observation session was similar between hunted and non-hunted colonies ($p = 0.59$).

When colonies were approached on foot with no attempt at concealment, prairie dogs were more than twice as likely to retreat down their burrows in hunted colonies

(48%) than in non-hunted colonies (22%). In 1994, the proportion of prairie dogs that retreated down their burrows was higher (df = 12; p = 0.009) on hunted than on non-hunted colonies.

Table 6. Mean proportion and standard deviations of alert prairie dogs on individual BLM hunted and CMR non-hunted colonies in 1995.

BLM Colonies	mean	standard deviation	range	
B 120	0.72	0.18	0.40	0.99
B 148	0.71	0.22	0.27	0.99
B 164	0.45	0.26	0.15	0.99
B 67	0.77	0.19	0.33	0.99
B 72	0.66	0.28	0	0.99
B 90	0.55	0.25	0.11	0.99
B 91	0.72	0.19	0.36	0.99
B 42	0.75	0.30	0	0.99
S 07	0.68	0.29	0.16	0.99
CMR Colonies				
C 1	0.44	0.24	0.10	0.99
C 19	0.45	0.26	0.14	0.86
C 20	0.47	0.27	0.11	0.93
C 25	0.43	0.27	0	0.99
C 39	0.63	0.33	0.10	0.99
C 35A	0.46	0.21	0.16	0.83
C 41	0.36	0.26	0	0.83
C 46A	0.68	0.25	0.33	0.99

Overall, individual prairie dogs could be approached more closely in 1994 than in 1995 (Fig. 3). Mean approachable distance to focal individuals was 34 m in hunted and 24 m in non-hunted colonies in 1994, and 75 m on hunted and 34 m on non-hunted colonies in 1995 (Fig. 3). The mean approachable distances were significantly different between hunted and non-hunted colonies in 1994 ($t = 5.29$, $df = 98$, $p < 0.001$) and in 1995 ($t = 6.67$, $df = 98$, $p < 0.001$).

Focal individuals tolerated closer approaches by vehicle on CMR colonies than on BLM colonies. I only compared approachable distances using a vehicle in 1995, but the results were similar to those obtained for approaches by foot. Approachable distances were higher (67m) on hunted colonies and lower (23m) on non-hunted colonies (Fig. 3).

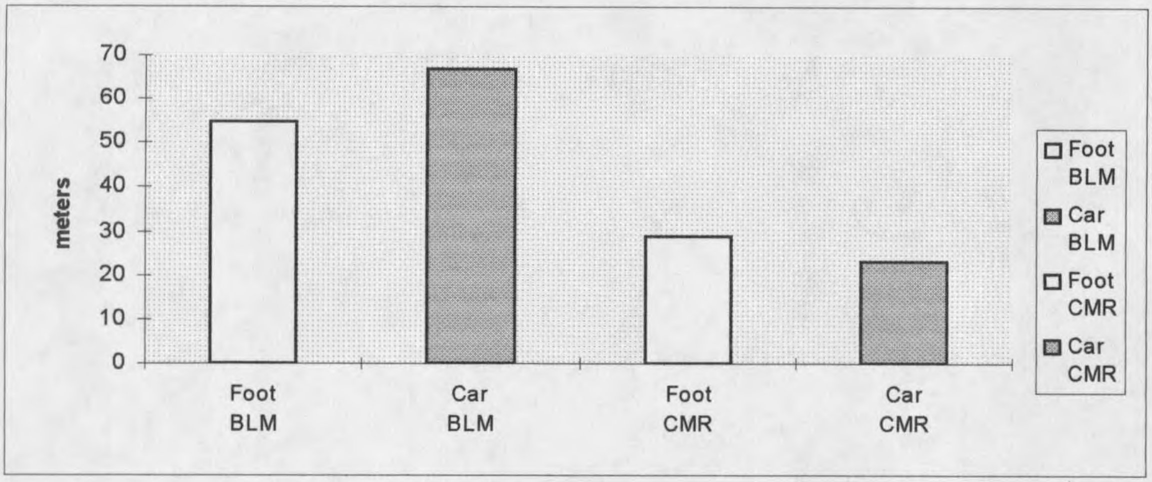

Figure 3. Histogram showing the mean distance that focal individuals could be approached on hunted and non-hunted colonies. Results include data for approaches by foot and by car.

<u>Vegetation</u>

Mann-Whitney 2-sample tests were used to compare vegetation characteristics inside and outside of prairie dog colonies and between hunted and non-hunted colonies. Total plant canopy cover was similar inside (37%) and outside (45%) BLM colonies (df = 17; p = 0.17). However, the mean coverage of grasses was significantly higher (df = 18; p = 0.014) on grasslands adjacent (29%) to prairie dog colonies than on the inside (16%) of colonies. Conversely, mean coverage of forbs was higher (df = 17; p = 0.027) on the inside (10%) than on adjacent prairie (5%). There was not a significant difference (p = 0.96) in shrub cover inside (11%) compared to outside (11%) BLM sampled colonies.

Plant species on hunted and unhunted prairie dog towns were similar with representation of climax communities and species associated with disturbance (Table 7). The mean percentage of canopy cover for the 4 categories I measured (grasses, forbs, shrubs, and total vegetation) was similar during 1994 and 1995 on hunted colonies, and canopy cover for the individual plant categories on hunted colonies was similar to the cover on non-hunted colonies in 1995 (Table 8).

Table 7. Mean canopy coverage (%) for all plant species comprising 1% or more cover inside one or more of 9 hunted and 8 non-hunted prairie dog towns.

Category and Plant Species	BLM Hunted % cover	CMR Non-hunted % cover
Grasses		
Agropyron smithii	6	4
Bouteloua gracilis	7	1
Koeleria macrantha	1	1
Poa pratensis	1	1
Poa secunda	1	1
Stipa comata	T	1
Total	**16**	**9**
Forbs		
Antennaria spp.	1	0
Astragalus spp.	1	T
Dyssodia papposa	0	2
Lapula redowsii	1	2
Lepidium densiflorum	1	1
Lygodesmia juncea	1	T
Monolepis nuttalliana	0	1
Phlox hoodii	1	0
Plantago patagonica	2	3
Psoralea spp.	1	T
Sphaeralcea coccinea	1	1
Total	**10**	**11**
Shrubs		
Artemisia frigida	8	12
Artemisia tridentata	2	3
Ceratoides lanata	1	T
Opuntia polycantha	1	T
Total	**12**	**15**

Table 8. Mean percent cover of grasses, forbs, shrubs and total coverage and standard deviations on hunted and control colonies. Results of Mann-Whitney 2-sample tests are included only for 1995.

		% grasses	% forbs	% shrubs	% total cover
BLM 1994	mean	15.5	11.6	12.6	39.9
	std-dev	10.7	7.2	5.1	14.2
BLM 1995	mean	15.5	9.7	10.3	35.5
	std-dev	10.1	6.9	5.2	22.2
CMR 1995	mean	9.8	11.3	15.1	36.2
	std-dev	6.2	6.7	10.1	23.0
	p-value =	0.26	0.31	0.53	0.85
	df =	16	16	16	16

There was no apparent relationship between density estimates on hunted and unhunted colonies and vegetation cover in colonies. Correlation between prairie dog density and grass, forb, and shrub mean canopy cover were $r = 0.058$ ($p = 0.78$), $r = 0.091$ ($p = 0.66$), and $r = -0.22$ ($p = 0.29$), respectively.

DISCUSSION

Hunting Patterns and Hunters Attitudes

I found substantial annual and seasonal variation in shooting pressure on hunted colonies. Exceptionally wet conditions during late spring likely accounted for the low number of hunters observed in 1994. Shooting pressure increased rapidly once travel conditions improved about the middle of June, but then subsided. This decline in hunter activity coincided with hot and dry conditions that prevailed during July and August in 1994. An increase in hunter activity during the same year, coincided with upland game bird, archery, and antelope hunting seasons in September. These hunting activities probably contributed to the reported increase in sport shooting of prairie dogs during the fall. However, I did not detect an increase in shooting pressure during the first weekend of the antelope hunting season in early October of 1994. In contrast to the seasonal variation in shooting pressure reported in 1994, shooting pressure during 1995 remained relatively constant from mid-May through mid-September. Roads were dry and temperatures were milder in July and August of 1995 than in 1994. I did not sample hunter pressure in October of 1995 or in early spring of either year.

Hunting patterns also appeared to be influenced by advertised shooting opportunities on the Fort Belknap Indian Reservation and by the perception of plague. Hunters had a choice between hunting on BLM lands or on tribal lands and sylvatic plague outbreaks on BLM colonies probably influenced many to select tribal lands. Hunters often blamed the plague for the low number of prairie dogs on BLM colonies. Some hunters even feared contracting the disease themselves. Fear of the plague, whether justified or not, was apparently higher in 1994 than 1995 based on conversations with motel owners and storekeepers in Zortman, Montana.

Although the plague remained active throughout much of Phillips County in 1995, both the number of hunters and shooting intensity on BLM colonies increased during 1995. Higher shooting fees on tribal land probably contributed to this reported increase as fees increased from $30 per season in 1994 to $50 per season in 1995. In contrast, the BLM does not require a fee to hunt prairie dogs.

Results from the BLM - FWP prairie dog shooting questionnaire in 1994 and my surveys were consistent with respect to the amount of time spent hunting each day, but were inconsistent with the reported number of prairie dogs killed. The BLM-FWP survey indicated that in 1994, the average respondent spent about 7 hours per day hunting and shot approximately 200 prairie dogs during their visit. My hunter registers and interviews indicated that about 60 prairie dogs were shot per person during 7 hours of hunting in 1994. The results of the BLM-FWP survey probably included travel time among colonies, whereas my results did not. Regardless of the hunter kill rate, most sport shooters I interviewed and respondents in the BLM-FWP survey felt that shooting was not having a significant impact on prairie dog populations.

My interviews with hunters and the BLM-FWP hunter survey indicated that most hunters traveled from another state to specifically shoot prairie dogs in Montana. About 92% of the hunters that returned a 1994 BLM-FWP hunter survey came from another state to shoot prairie dogs. The BLM-FWP survey indicated that the average distance traveled by recreational shooters was about 1000 miles. Results from the 1995 BLM-FWP were not available in time to compare them with my 1995 survey.

Interviews with hunters may be useful in predicting recreational shooting trends. I found that the number of first-time prairie dog hunters was higher in 1995 than in 1994. An increase in the ratio of first-time versus veteran prairie dog hunters may indicate the potential for higher shooting pressure in future years, particularly if a high proportion of these hunters return to Phillips County to hunt prairie dogs.

Interviews with hunters also indicated their level of satisfaction with their approaches to recreational shooting. Many hunters complained of low number of prairie dogs on BLM colonies. The perceived low population densities relative to previous years have challenged prairie dog hunters to change their hunting techniques. About 50% of the shooters I interviewed preferred the challenge of long range shooting, at distances of at least 200 m, with its requirements for patience, marksmanship, and specialized equipment. The remaining hunters tried to get closer shots or more opportunities to shoot at prairie dogs by stalking the animals. Hunter success varied with hunting techniques, type of equipment, hunter experience, and marksmanship.

Efforts of BLM personnel to distribute shooting pressure via maps advertising specific colonies were not completely successful. I found that the intensity and seasonal pattern of recreational shooting were similar on both advertised and unadvertised colonies. Advertised colonies also had similar densities, age and sex structures, and mortalities as those unadvertised. Sport shooters located all but one of the unadvertised colonies, probably because of its remote location.

Population Consequences of Hunting

Differences in mortality between advertised and unadvertised colonies varied little despite considerable differences in shooting pressure between years. In 1995, a year of relatively high shooting pressure, overall mortality was higher on hunted than on non-hunted colonies. Colonies in hunted and non-hunted areas were of comparable sizes, in similar habitats, had similar vegetation, were in pastures grazed by cattle, and were accessible to the same predator community.

I estimated summer mortality on hunted colonies at 33% compared to 15% on non-hunted colonies and minimum summer survival of marked animals, 53% on non-hunted versus 42% on hunted. Since my estimates of hunting effects were for the period of highest shooting activity, they probably included the bulk of the annual shooting mortality during the summer of 1995. I did not find any estimates of summer mortality in unhunted colonies in the literature, but estimates of annual mortality in prairie dog colonies undisturbed by hunting have been shown to average 23% for adults (19% females, 25% for males) to 44% for yearlings and juveniles (Hanson et al. 1982).

Results of adult/juvenile ratios on both hunted and non-hunted colonies indicated that adult loss (mortality and emigration) from the population was similar to juvenile losses, at least during the summer. Presumably, the ratio of adult:juveniles would be lowest during the spring, shortly after emergence. Thus, a similar ratio of adult to juvenile prairie dogs from spring to fall might indicate a higher loss of adults compared to juveniles on both hunted and non-hunted colonies.

The proportion of lactating females is an indication of the number of females that produced litters but is not necessarily a good indicator of recruitment. However, considering the high percentage of lactating females and the low proportion of juveniles captured during early summer, the female/pup ratio should have been higher than I observed during this study. The low numbers of captured juveniles compared to the higher number of adults captured may have been a direct result of preweaning mortality. However, because the young are born and remain underground until weaned, limited data are available on prenatal and preweaning mortality. Hoogland et al.(1987) suggested that infanticide was the number one cause of juvenile mortality that may contribute to both preweaning and postweaning juvenile deaths, possibly representing more than 50% of these fatalities.

Although male prairie dogs do not begin breeding before 2 years of age, some females breed as yearlings. My estimated reproduction for yearling females (22%) was within the range, from 5-75% for yearlings as compared to 60-100% in adult females, estimated in other studies (King 1955, Koford 1958, Tileston and Lechietner 1966, Knowles 1982, Hoogland 1985, Franklin and Garret 1993). The proportion of yearling females that breed is probably dependent upon their nutritional status and the presence of unrelated or distantly related adult males (Hoogland 1982, Garrett and Franklin 1983). For instance, one way prairie dogs possibly avoid extreme inbreeding is for a young female to be less likely to come into estrous if her father is in her coterie (Hoogland 1982).

Conversations with hunters suggested that juveniles were more vulnerable to shooting mortality than older animals during the spring, but this differential vulnerability persisted only for a short period. King (1955) pointed out that young prairie dogs were quick to learn behaviors from adults. During my behavioral studies, I found that young prairie dogs did not remain above ground longer nor did they allow me to approach closer than did adult animals on BLM hunted colonies. This would suggest that hunters' observations were in error. However, I did not differentiate among shooting mortality for the various age classes of prairie dogs older than 1 year. Thus, it is possible that young adult prairie dogs are more vulnerable to shooting mortality than animals 2 years and older.

The recruitment to emergence on hunted (1.1 and 1.8 pups/adult female in 1994 and 1995, respectively) and on unhunted (0.94 pups/ adult female in 1995) colonies was lower than the potential for this species and lower than ratios in many other studies. Immature prairie dogs generally make up approximately 50% of the population (King 1955, Tileston and Lechleitner 1966). However, Collins et al. (1984) suggested that the most realistic projection for annual prairie dog repopulation was about 30%. In estimating recruitment, I assumed that all pups had emerged from their burrows prior to the first density estimates made in early summer as weaned pups generally emerge in late May and early June (Koford 1958). In support of this, I only witnessed evidence of a late litter on one study colony.

I marked 175 prairie dogs in 1994 and 250 in 1995 with fur dye but I observed prairie dogs outside delineated portions of sample colonies only 4 times. Nonetheless, it is likely that emigration contributed to some of the estimated decrease in density from spring to fall that I measured on both hunted and non-hunted colonies. Emigration is most common during early summer (Koford 1958, Garret et al. 1982, Knowles 1985, Hoogland et al. 1987), and migrating animals may have moved undetected to adjacent coteries, to other colonies within the study area, or from adjacent colonies into the intensive study sites I monitored during this time period.

There were no clear impacts of shooting on sex ratios. Sex ratios were nearly 1 : 1 during both spring and fall on BLM colonies in 1994 and on CMR colonies in 1995. However, I captured nearly 50% fewer females in the fall compared to the spring on BLM hunted colonies in 1995 suggesting a higher summer mortality for females than for males on hunted colonies. In contrast, the female to male ratio of captured prairie dogs on non-hunted colonies remained about constant, suggesting that shooting mortality may have been higher for females than for males.

Sex ratios on hunted and non-hunted towns indicated more adult males than most studies report, but sex ratios of towns are highly variable. King (1955) observed a ward of a town for three years and the overall sex ratios during that time were skewed against males. He suggested that mortality was higher in males than females and that social unrest may drive certain yearling males out of a dog town. Smith (1958) found that both adult and yearling ratios were skewed against males. In another study of unhunted colonies, Tileston and Lecheitner (1966) found adult ratios skewed against females. Garrett and Franklin (1981) reported that dispersal occurred during a limited time period in late spring, resulted in relatively short movements and poor survivorship, occurred in both sexes, but was higher for males than for females. On colonies open to hunting, Tileston and Lecheitner (1966) considered males to be less wary than females thus favoring male shooting mortality over female shooting mortality. Stockrahm (1979) also noted that hunting mortality was higher in yearling males than in older animals. In this study, ratios of male and female prairie dogs did not vary significantly from the number that were originally marked during spring captures, which might indicate equal loss from the population for both sexes.

Other studies have shown that the emigration of males contributes to the skewed sex ratio against males on coteries. Prairie dogs, particularly yearling males, that emigrate from their home coterie have lower survival than do animals that remain at home (Garret and Franklin 1981, Knowles 1985, Hoogland et al. 1987). Most male mortality occurs during the first year rather than in the two-to-three-year age class (King 1955, Koford 1958) because of poor survival associated with emigration. Thus, the number of older adult males should naturally be less than the number of mature females.

Although recruitment appeared to be slightly higher on hunted colonies than on non-hunted colonies, I could not determine whether the difference was due to sport shooting, population density differences, or some other factor. I was also unable to determine the influence of migration on sample colonies. Knowles (1982) monitored the effects of shooting on 2 colonies and thought that shooting mortality was additive on one and compensatory on the other colony. Hoogland et al. (1987) found that the number of weaned juveniles seemed to vary inversely with the number of adults and yearlings on prairie dog colonies.

Even though my data indicated that recreational shooting was additive during summer months, similarity in prairie dog density and burrow density between hunted and non-hunted towns and higher juvenile/adult female ratios on hunted than unhunted colonies could indicate that additive summer mortality was compensated for by decreased mortality or increased reproduction during other periods. A 2 year study is too short to adequately evaluate compensatory responses.

Two previous studies (Stockrahm 1979, Knowles 1988) found that heavy shooting had severe negative impacts on prairie dog colonies, including large population reductions compounded by the disruption of the prairie dog social system. Knowles (1982) speculated that sport shooting probably would not be of much value as a management tool because of the law of diminishing returns (Allen 1947). Although shooting intensity was probably higher in his study than on my study colonies, the results from this study suggests that recreational shooting could be an important management tool for prairie dogs. Additional research is needed to determine the amount of shooting pressure required to control the size and density of prairie dog colonies.

Behavioral Impacts of Hunting

Prairie dogs become habituated when exposed to frequent contact with humans. Adams (1984) reported that prairie dogs from colonies visited frequently by humans were less wary and more tolerant of humans than prairie dogs that were infrequently visited. In contrast, I found that the effects of human contact in the context of recreational shooting in my study resulted in prairie dogs becoming extremely cautious of humans rather than becoming habituated to them. In colonies open to hunting, some prairie dogs appeared to be extremely wary and responded to warning barks of conspecifics by immediately entering burrows. However, on non-hunted colonies, prairie dogs gave warning barks, but few animals ran down their burrows upon hearing the alarm calls as they did on hunted towns. This behavioral response was noted whether I was on foot or in a vehicle.

Prairie dogs are naturally alert and wary animals, as are most mammals that have evolved on the great plains of North America. Individual alertness of prairie dog adults has probably evolved mainly in the context of detecting predators and visual alarms of conspecifics (Hoogland 1979). Those prairie dogs that remained above ground on hunted colonies often remained in alert postures during the entire observation session, whereas prairie dogs on non-hunted colonies would sometimes resume foraging after only a few minutes of being alerted. The increased time allocated to alert behavior on hunted colonies may have reduced time for prairie dogs to partake in other activities.

When hunted colonies which had not detected my presence were observed, few animals were seen in alert postures. I also counted higher numbers and a higher proportion of foraging animals when I was able to approach vantage points undetected. Even though prairie dogs clearly altered their behavior when disturbed by hunters, prairie dogs appeared to resume normal behavioral patterns during the interim between hunter visits. Thus, prairie dog behavior appears to be a conditional response to avoid hunters rather than a permanent change in prairie dog activity patterns. Stockrahm (1979) speculated that disturbance from hunters affected the growth of juveniles by allowing them only short time periods for grazing, and this reduced growth in their first summer which could result in smaller animals that produced fewer pups during the following spring. Although I did not weigh juvenile prairie dogs in this study, it is unlikely that shooting activity significantly reduced growth during the summer months since the average time hunters spent on colonies was only a few hours each week.

Prairie dog alert behavior on hunted colonies probably depended on shooting intensity, duration of shooting, and the frequency of shooting on a colony. Prairie dogs on heavily shot colonies retreated to burrows more readily and were more alert to approaches than on lightly shot colonies. Retreats to burrows and alert time were also higher in seasonal periods with high shooting pressure than with low pressure.

Colony size and/or density also may affect the time individual prairie dogs must be on the look out for signs of danger. Prairie dogs from large colonies or colonies with high densities should be able to devote more time to feeding and other maintenance activities than members of smaller or less populated colonies because each individual needs to spend less time watching for predators or signals from other prairie dogs. Hoogland (1979) found that individual alertness was negatively correlated with increases in ward size and ward density. Stockrahm (1979) thought that extreme wariness in prairie dogs from hunted towns was a result of small size of the town and conditioning to avoid hunters. Because recreational shooting on smaller colonies would tend to concentrate shooting pressure, the behavioral effects of shooting on smaller colonies would presumably be greater than on larger colonies. However, I found no relationship between town size and alert behavior in this study.

Monitoring Prairie Dogs

As concerns for prairie dog communities increases, wildlife managers need to be able to estimate density and changes in density of prairie dogs over time. Proposed techniques for monitoring prairie dog populations are: 1) active burrow density, 2) visual counts of prairie dogs, 3) plugging burrows, and 4) mark-recapture (Menkens and Anderson 1994). I attempted to monitor prairie dog populations using active burrow counts, visual counts, and measurements of vegetation both inside and outside prairie dog colonies. Plugging of burrows and counting the number of reopened burrows is another technique (Tietjen and Matschke 1982) but was too time and labor intensive for this study, and does not have as great a potential as other techniques for a rapid, large scale evaluation of prairie dog populations. The BLM is using Global Positioning System technology to monitor seasonal and annual changes in town size and results of this study will be reported elsewhere.

Burrow Counts

Counts of the total number of burrows in a town may not be a reliable index of population size or density. Houston et al. (1986) considered counts of burrows to be positively correlated with population density. Burrows, however, are persistent, stable structures (Koford 1958), which generally last longer than one season. Thus, short-term fluctuations in the number of prairie dogs probably do not reflect changes in the total number of burrows. While the prairie dogs typically excavate several new burrow systems each year, others disappear from lack of use. Total burrow density can remain relatively constant even though population density changes (Hoogland et al. 1987). Therefore, counts of active burrows in a geographic area are presumably better indicators of prairie dog densities than are counts of total number of burrows.

I measured a change in burrow activity during both summers on BLM colonies, but the changes did not correlate with population estimates using the Lincoln -Peterson index. Presumably, prairie dog mortality early in the summer would have a greater impact on active burrow density than would late season mortality. Nonetheless, changes in density of active burrows did not coincide with our estimated changes in population density on either hunted or non-hunted colonies.

I could not determine if changes in burrow activity were a result of concurrent changes in population density or to seasonal changes in prairie dog activities. Because black-tailed prairie dogs clean out more burrows in the spring than they use (Koford 1958), population density estimates based on spring counts of active burrows would tend to be higher than in other seasons. Furthermore, my observations indicated that prairie dogs apparently concentrated their activities around fewer burrows in late summer compared to earlier in the year. These seasonal shifts in behavior may have been responsible for the decreased density of active burrows measured during the fall relative to spring counts on BLM hunted colonies. On observed portions of study colonies, I also measured a decrease in active burrow density from spring to fall on hunted towns but not on the non-hunted colonies. After comparing maximum above ground counts of prairie dogs with burrow entrance densities, Powell et al. (1994), also concluded that density of active burrow entrances alone may not be a reliable indicator of prairie dog populations.

Annual variation in active burrow density was 25% higher in the spring and 27% higher in the fall in 1994 compared to 1995. Weather conditions, rather than hunting probably explains this unexpected increase in activity. Hot, dry conditions in 1994 resulted in the soil becoming very hard and compact, which in turn, suppressed prairie dog digging activity. In contrast, cooler and wetter weather probably helped to make the soil more conducive for digging because prairie dogs often work the soil around their mounds following rains (Clark 1977).

Counts of Prairie Dogs

Of the three approaches I used to monitor prairie dog populations, my analyses indicated counting prairie dogs has the best chance of being a useful monitoring approach. Visual counts have been used to study the ecology of black-tailed and white-tailed prairie dogs (Fagerstone and Biggins 1986, Knowles 1986, Menkens et al. 1990) and can provide an index of population density (Fagerstone and Biggins 1986, Menkens et al. 1990). In this study, I found a much stronger correlation between maximum counts and mark-recapture estimates of population density than between Lincoln-Peterson density estimates and burrow density ($r = 0.28$) or between Lincoln-Peterson estimates and vegetation parameters ($|r| < 0.22$). Visual counts are quick and easy and would provide managers with a useful technique that would allow them to monitor a large number of towns.

A disadvantage of visual counts on hunted colonies where prairie dogs are conditioned to avoid hunters is the potential difficulty associated with making accurate counts without scaring the prairie dogs down their burrow. This may require some precautionary measures such as selecting vantage points far from colonies being observed. Prairie dogs generally remained above ground during observations made from 300 m or more. The extreme wariness of prairie dogs, particularly on hunted colonies, made approaching a vantage point undetected difficult. A vantage point where an observer can approach undetected and that offers good visibility of the study area would be ideal.

Diurnal activity can also influence population density estimates. Prairie dogs are diurnal with two periods of maximum surface activity that can affect maximum counts and thus, population density estimates. Therefore, counts should be made during periods of highest activity and during seasonably moderate weather conditions (Menkens et al. 1990, Knowles 1982). The number of prairie dogs I counted in the mornings was not significantly different than number of animals counted in the evenings. Koford (1958) recommended that prairie dog population estimates take place 3.0-3.5 hours after sunrise. In Kansas, Powell et al. (1994) found that prairie dogs were most active 2.5

hours after sunrise and 2 hours before sunset, with higher counts being obtained in the evening. Menkens and Anderson (1994) suggested that the same individual perform all counts on an area due to the differences that may exist in the ability of observers to see and count prairie dogs.

Vegetation.

Prairie dogs are often viewed as pests in western rangelands because they utilize forage and change the species composition of grasslands. As a result, recreational shooting of prairie dogs has been popular with local area ranchers in south Phillips County because removal of prairie dogs by shooting is believed to reduce competition for forage with cattle. Prairie dogs may improve the quality of forage for cattle just as they do for other ungulates (Whicker and Detling 1994), but increased quality of forage can come with a sizable reduction in the total standing crop of forage available for cattle (O'Meilia et al. 1982, Uresk 1984, Whicker and Detling 1988). I compared vegetation on and off prairie dog colonies and between hunted and non-hunted colonies to try to determine if recreational shooting indirectly affects vegetation on colonies and if these changes to vegetation could be used as a potential monitoring tool for prairie dog populations.

Cattle are the prevalent livestock on lands in South Phillips County and are grazed under an intensive management system. Study colonies were located within 4 allotments or grazing management units, 2 of which contained pastures on both BLM and CMR lands. Livestock on all of the allotments in 1994 and 1995 was managed under a rotation grazing system in accordance with the BLM Allotment Management Plan. The season of use ranges from May 1 to November 15, annually. Presumably, colonies on both the BLM and CMR lands received similar grazing pressure during the study.

Results from my data were consistent with general observations of prairie dog impacts on vegetation. Since prairie dogs predominately feed on graminoids (Kelso 1939), other plants replace these preferred grasses. Prairie dog-induced changes in vegetation include morphological and physiological (Detling and Whicker 1988), as well as changes in species composition (King 1955, Koford 1958, Bonham and Lerwick 1976). Koford (1958) and Bonham and Lerwick (1974) reported a greater number of plants, primarily forbs, on prairie dog towns than on native shortgrass prairie sites in Colorado. In this study, the canopy cover of forbs was nearly twice as high inside compared to the cover of forbs outside towns. When annual forbs were present (generally in the spring time), total vegetative cover was higher inside of the towns. However, where the species were predominantly perennials, total cover was less inside than outside of colonies. Vegetative cover was lower in my study area during 1994 than in 1995 because fewer annuals survived into mid-summer due to the hot, dry weather conditions.

Knowles (1982) and Agnew et al. (1986) reported that in northern plains shortgrass communities blue grama and western wheatgrass were two grasses with significantly less cover inside than outside colonies. Where they occur, western wheatgrass and blue grama are both important grasses in the diets of prairie dogs (Kelso 1939). Thus, selective grazing pressure and digging activities by prairie dogs may have resulted in the difference that I measured in the cover of these 2 grasses. Boddicker (1978) found that prairie dog activities caused a two-fold decrease in patch size of blue grama by reducing the size of clumps and patches. Prairie dogs tended to break up the blue grama sod by their digging activities, thus enhancing the site for a variety of forbs.

Even though change in the vegetation after prairie dog colonization has been widely noted, the rate of change was seldom documented. In colonies established more than 3 years, shifts in plant dominance and composition had begun (Coppock et al. 1983). Coppock et al. (1983) and Archer et al. (1987) studied the rate of plant species change, replacement, and diversity and found that plant species composition on colonies changes over time and that species diversity is maximized at intermediate time periods. However, on older colonies, species composition appears to decrease to levels similar to uncolonized prairies because of the final dominance by a few species of annual and perennial forbs and dwarf shrubs. Agnew et al. (1986) who may have sampled older towns, found that plant species richness was greater on mixed-grass prairie vegetation types than on prairie dog towns.

Vegetation on colonies destroyed by plague appeared to respond quite rapidly. This was probably due to the lack of disturbance by prairie dogs. Although I did not closely monitor plague-decimated colonies, vegetation on them often resembled the vegetation on nearby grasslands. Vegetation on one colony close to a main road that had a low population density, presumably due to sport shooting rather than plague, also resembled that of the surrounding prairie.

Biotic and abiotic factors such as soil type, topography, grazing pressure, and weather evidently affected plant canopy cover more than the impacts of recreational shooting on prairie dogs. Furthermore, variation in plant species abundance and composition is common in the Missouri Breaks area. During 1994, yellow sweet clover (Melilotus officinalus) was abundant throughout the region, but in 1995, the only evidence was the dead stems from the previous year. Vegetation monitoring, while not as useful for short-term observations, would have some use in long-term studies.

CONCLUSIONS

Continual monitoring of hunting activity is a prerequisite for management objectives related to the impacts of shooting on colonies. I used a relatively simple method of monitoring shooting pressure involving placing hunter registers on colonies that might be a feasible monitoring tool. The BLM-FWP shooting questionnaire can continue to be used for obtaining additional information concerning shooting pressure on colonies of interest.

Even though I measured a significant difference in mortality between hunted and non-hunted colonies, additional research is needed to determine how much shooting pressure would be necessary to control the population size and density of prairie dog colonies open to recreational shooting. My data suggests that shooting pressure is directly related to change in prairie dog density during the summer. This study did not determine whether increased summer mortality was compensated by increased productivity or survivorship.

Any estimate of the impact of recreational shooting on prairie dog colonies must also consider the behavioral effects, since the two are interrelated. Sport shooting clearly resulted in changes in alert behavior of prairie dogs. Individual prairie dogs were more approachable on non-hunted colonies than hunted colonies. Prairie dogs spent more time above ground on non-hunted than on hunted colonies. Prairie dogs also spent more time foraging and resting and less time in alert postures on non-hunted colonies compared to hunted colonies. Apparently, prairie dogs have become conditioned to avoid hunters on BLM colonies.

Mark-recapture techniques provided the most precise data on survival and productions. However, mark-recapture is time-consuming, expensive, and labor-intensive, and would not be appropriate for situations requiring rapid evaluation or monitoring of prairie dog populations impacted by recreational shooting.

Of the 3 techniques I tested for monitoring prairie dog status, counting prairie dogs above ground has the most promise. Although relatively easy to conduct, counts of active burrows may not be a reliable index to black-tailed prairie dog populations in north central Montana. Variations in weather and differences between light and heavy use of an individual burrow entrance are problems associated with using burrow counts to assess short-term population density. Furthermore, some burrows may be a more integral part of the burrow system of a coterie and may remain active longer than other burrows. Another potential problem with counts of burrows is inconsistency in counting active versus inactive burrows. Although we tried to remain consistent by following general guidelines, the large number of people involved in the burrow counts may have contributed to some of the variation observed between years. For consistency, 1 person should determine all burrow entrances as active or inactive.

Overall, this study indicated that vegetation was not as sensitive as other techniques for monitoring short-term changes in prairie dog populations. In comparing differences in the plant canopy cover of grasses, forbs and shrubs on prairie dog colonies that received different levels of shooting pressure, I measured only small differences in the 3 vegetative categories between the BLM hunted and the CMR non-hunted colonies. If recreational shooting had influenced populations over the past decade, the impacts on populations were not reflected in vegetation indices I used.

Visual counts of prairie dogs, during periods of highest aboveground activity, can be used to quickly assess the status of a large number of prairie dog colonies. If counts of prairie dogs are being used on colonies disturbed by hunting, I recommend that observations be made from at least 300m and that vantage points be carefully selected to minimize warning barks from conspecifics that might unnecessarily alarm animals on the count area. Observers should avoid double counting or missing prairie dogs while counting, replicate counts, and conduct at least of 3 counts to minimize inherent variation in number of above ground animals. Observers should also avoid those colonies that hunters had recently visited.

REFERENCES CITED

Adams, R. A., B. J. Lengas, and M. Bekoff. 1984 Variations in the threshold of anti-predatory responses in black-tailed prairie dogs (Cynomys ludovicianus). Amer. Zool. 24:3A.

Agnew, W., D. W. Uresk, and R. M. Hansen. 1986. Flora and fauna associated with prairie dog colonies and adjacent ungrazed mixed grass prairie in western South Dakota. J. Range. Manage. 39:135-139.

Allen, D. L. 1947. Hunting as a limitation to Michigan pheasant population. J. Wild. Manage. 11:232-243.

Althen, C. L. 1975. The interaction of circadian rhythms and thermal stress in controlling activity in the black-tailed prairie dog. Ph.D. Dissert., Univ. Colorado, Boulder. 168pp.

Anderson, E., S. C. Forrest, T. W. Clark, and L. Richardson. 1986. Paleobiology, biogeography, and systematics of the black-footed ferret, Mustela nigripes. Gr. Basin Nat. Memoirs 8:11-62.

Archer, S., M. G. Garret, and J. K. Detling. 1987. Rates of vegetative change associated with prairie dog (Cynomys ludovicianus) grazing in North America mixed grass prairie. Vegetatio 72:159-166.

Beckstead, M. 1977. Digestibility of common forage plants and energetic requirements of the black-tailed prairie dog. M.S. Thesis, South Dakota State Univ., Brookings. 39pp.

BLM., 1982. Black-tailed prairie dog control/management in Phillips Resource Area. Programmatic Environmental Assessment. U. S. Bureau of Land Management, Lewistown District-Phillips Resource Area. 40pp.

_____. 1993. Final Judith-Valley -Phillips resource management plan and environmental impact statement, October 1992. U. S. Bureau of Land Management, Montana State Office, Billings. 750pp.

Boddicker, M. J. 1977. Managing prairie dog populations. Colorado State Univ. Exten. Ser., Ft. Collins, Service in Action, No. 6.506, 2pp.

Bonham, C. D., and A. Lerwick. 1976. Vegetation changes induced by prairie dogs on shortgrass range. J. Range Manage. 29:221-225.

Campbell, T. M., and T. W. Clark. 1982. Colony characteristics and vertebrate associations of white-tailed and black-tailed prairie dogs in Wyoming. Amer. Midl. Nat. 105:269-276.

Clark, T. W. 1977. Ecology and ethology of the white-tailed prairie dog (Cynomys leucurus). Milwaukee public Museum Publ. in Biol. and Geol. No. 3, 97pp.

Clark, T. W., J. Grensten, M. Gorges, R. Crete, and J. Gill. 1987. Analysis of black-footed ferret translocation sites in Montana. Prairie Nat. 19:43-56.

Collins, A. R., J. P. Workman, and U. W. Uresk. 1984. An economic analysis of black-tailed prairie dog (Cynomys ludovicanus) control. J. Range Manage. 37:358-361.

Coppock, J. K., J. E. Detling, and M. I. Dyer. 1983. Plant-herbivore interactions in a North American mixed-grass prairie; I. Effects of black-tailed prairie dogs on intraseasonal above-ground plant biomass and nutrient dynamics and plant species diversity. Oecologia 56:1-9.

Daubenmire, R. 1970. Steppe vegetation of Washington. Wash. Agr. Exp. Tech. Bull. 62.

Detling, J. K., and A D. Whicker. 1988. Control of ecosystem processes by prairie dogs and other grassland herbivores. Pp. 23-29 in Proc. Eighth Great Plains Wildl. Damage Control Workshop. General Technical Report Rm-154. U. S. Dept. of Agriculture, Forest Service.

Dunlap, T. R. 1988. Saving America's wildlife. Princeton University Press, N. J. 222pp.

Fagerstone, K. A., and D. E. Biggins. 1986. Comparison of capture-recapture and visual count indices of prairie dog densities in black-footed ferret habitat. Gr. Basin Nat. Mem. 8:94-98.

Forrest, S. C., T. W. Clark, L. Richardson, and T. M. Campbell. 1985. Black-footed ferret habitat: Some management and reintroduction considerations. Wyo. BLM Wildl. Tech. Bull. No.2, 48pp.

Garrett, M. G., and W. L. Franklin. 1981. Prairie dog dispersal in Wind Cave National Park; possibilities for control. Pp. 185-198 in Proc. Fifth Great Plains Wildl. Damage Control Workshop. Inst. of Agr. and Nat. Res., Univ. of Nebraska, Lincoln.

______, J. L. Hoogland, and W. L. Franklin. 1982. Demographic differences between an old and a new colony of black-tailed prairie dogs (Cynomys ludovicianus). Amer. Midl. Nat. 108:51-59.

______, and W. L. Franklin. 1983. Diethylstilbestrol as a temporary chemosterilant to control black-tailed prairie dog populations. J. Range Manage. 36:753-756.

Hansen, R. M., and I. K. Gold. 1977. Black-tailed prairie dogs, desert cottontails, and cattle trophic relationships on shortgrass range. J. Range Manage. 30:210-214.

______, D. W. Uresk, and R. P. Cincotta. 1982. Prairie dog dispersal and habitat preference in Badlands National Park. Annu. Rept. to Nat. Park Serv. Research Center, Laramie, Wyo. Dept. of Range Science, Colorado State Univ., Ft. Collins. 44pp.

Hillman, C. N., and T. W. Clark. 1980. Mustela nigripes. Mammalian Species 126:1-3.

Hoogland, J. L. 1979. The effect of colony size on individual alertness of prairie dogs (Sciuridae: Cynomys spp.). Animal Behav. 27:394-407.

______. 1981. The evolution of coloniality in white-tailed and black-tailed prairie dogs (Sciuridae: Cynomys leucurus and C. ludovicianus). Ecology 62(1):252-272.

______. 1982. Prairie dogs avoid extreme inbreeding. Science 215:1639-1641.

______. 1985. Infanticide in prairie dogs: lactating females kill offspring of close kin. Science 230:1037-1040.

______, D. K. Angell, J. G. Daley, and M. C. Radcliffe. 1987. Demography and population dynamics of prairie dogs. 8th Great Plains Wildl. Damage Control Workshop. Rapid City, South Dakota.

Houston, B. R., T. W. Clark, and S. C. Minta. 1986. Habitat suitability index model for the black-footed ferret: A method to locate transplant sites. Gr. Basin Nat. Mem. 8:99-114.

Kelso, L. 1939. Food habits of prairie dogs. U. S. Dept. Agric. Circ. 529:1-15.

King, J. A. 1955. Social behavior, social organization and population dynamics in a black-tailed prairie dog town in the Black Hills of South Dakota. Contrib. Lab. Vert. Biol., Univ. Mich., Ann Arbor. 124pp.

Knowles, C. J. 1982. Habitat affinity, populations, and control of black-tailed prairie dogs on the Charles M. Russell National Wildlife Refuge. Ph.D. Dissert., Univ. Montana, Missoula. 171pp.

______. 1985. Some relationships of black-tailed prairie dogs to livestock grazing. Unpub. manuscript.

______. 1986. Some relationships of black-tailed prairie dogs to livestock grazing. Gr. Basin Nat. 46:198-203.

______. 1988. An evaluation of shooting and habitat alteration for control of black-tailed prairie dogs. Proc. 8th Great Plains Wildl. Damage Control Conf. General Technical Report Rm-154. U. S. Dept. of Agriculture, Forest Service.

Koford, C. B. 1958. Prairie dogs, whitefaces and blue grama. Wild. Monogr. 3:1-78.

Krueger, K. 1986. Feeding relationships among bison, pronghorns, and prairie dogs: An experimental analysis. Ecology 67:760-770.

Lee, C. D., and F. R. Henderson. 1989. Kansas attitudes on prairie dog control. USDA For. Serv. Gen. Tech. Rep. RM-171:162-165.

Lerwick, A. C. 1974. The effects of the black-tailed prairie dog on vegetative composition and their diet in relation to cattle. M.S. Thesis, Colorado State Univ. Ft. Collins. 106pp.

Marsh, R. E. 1984. Ground squirrels, prairie dogs and marmots as pests on grassland. Pp. 195-208 in Proc. Conf. Organization and Prac. of Vert. Pest Control. Hampshire, England.

Menkens, G. E., D. E. Biggins, and S. H. Anderson. 1988. White-tailed prairie dog ecology in Wyoming. Proc. 8th Great Plains Wildl. Damage Control Conf. General Technical Report Rm-154. U. S. Dept. of Agriculture, Forest Service.

______, and S. H. Anderson. 1993. Mark-recapture and visual counts for estimating population size of white-tailed prairie dogs. U. S. Fish and Wildl. Service. Biol. Report (13). Pp. 67-72.

Miller, B. J., C. Wemmer, D. E. Biggins, and R. P. Reading. 1990. A proposal to conserve black-footed ferrets and the prairie dog ecosystem. Environ. Manage. 14:763-769.

O'Meilia, M. E., F. L. Knopf, and J. G. Lewis. 1982. Some consequences of competition between prairie dogs and beef cattle. J. Range Manage. 35:580-585.

Peterson, L. 1988. Legislative review of prairie dog status. USDA For. Serv. Gen. Tech. Rep. RM-154:115-116.

Powell, K. L., R. J. Robel, K. E. Kemp, and M. D. Nellis. 1994. Aboveground counts of black-tailed prairie dogs: Temporal nature and relationship to burrow entrance density. J. Wild. Manage. 58(2):361-366.

Reading, R. P., J. J. Grensten, S. R. Beissinger, and T. W. Clark. 1989. Attributes of black-tailed prairie dog colonies in northcentral Montana, with management recommendations for the conservation of biodiversity. Montana BLM Tech. Bull. 2:13-27.

Sharps, J. C., and D. W. Uresk. 1990. Ecological review of black-tailed prairie dogs and associated species in western South Dakota. Gr. Basin Nat. 50:339-345.

Smith, R. E. 1958. Natural history of the prairie dog in Kansas. Univ. Mus. Nat. Hist.Misc. Publ. 49. 39pp.

Stockrahm, D. M. 1979. Comparison of population structure of black-tailed prairie dog towns in southwestern North Dakota. M.S. Thesis, Univ. N. Dakota, Grand Forks. 103pp.

Tietjen, H. P., and G. H. Matschke. 1982. Aerial prebaiting for management of prairie dogs with zinc phosphide. J. Wildl. Manage. 46:1108-1112.

Tileston, J. V., and R. R. Lechleitner. 1966. Some comparisons of the black-tailed and white-tailed prairie dogs in north-central Colorado. Amer. Midl. Nat. 75:292-316.

Uresk, D. W. 1984. Black-tailed prairie dog food habits and forage relationships in western South Dakota. J. Range Manage. 37:325-329.

______. 1985. Effects of controlling black-tailed prairie dogs on plant production. J. Range Manage. 38:466-468.

______, and D. B. Paulson. 1989. Estimated carrying capacity for cattle competing with prairie dogs and forage utilization in western South Dakota. USDA For. Serv. Gen. Tech. Rep. RM-166:387-390.

USFWS. 1988. Black-footed ferret recovery plan. U.S. Fish Wildl. Serv., Denver. 154pp.

White, G. C., D. R. Anderson, K. P. Burnham, D. L. Otis. 1982. Capture-recapture and removal methods for sampling closed populations. Los Alamos National Laboratory Rep. LA-8787-NERP. 235pp.

Whicker, A. D., and J. K. Detling. 1988. Ecological consequences of prairie dog disturbances. Bioscience 38:778-785.

______, and J. K. Detling. 1993. Control of grassland ecosystem processes by prairie dogs. U. S. Fish and Wildl. Service. Biol. Report (13). Pp 18-27.