DIETARY PREFERENCES OF BLACK-TAILED PRAIRIE DOGS

REINTRODUCED INTO A CHIHUAHUAN DESERT

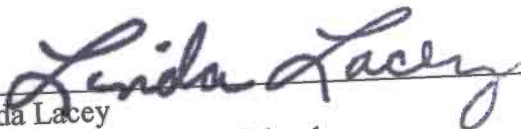GRASSLAND

BY

MATTHEW JASON HARTSOUGH, B.S.

A thesis submitted to the Graduate School

in partial fulfillment of the requirements
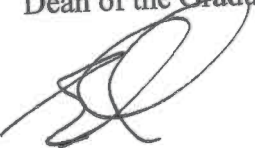
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"Dietary Preferences of Black-tailed Prairie Dogs Reintroduced into a Chihuahuan Desert Grassland," a thesis prepared by Matthew Jason Hartsough in partial fulfillment of the requirements for the degree, Master of Science, has been approved and accepted by the following:

_____

Linda Lacey
Dean of the Graduate School

_____

Ed Fredrickson
Co-Chair of the Examining Committee

_____

Reldon Beck
Co-Chair of the Examining Committee

8-13-02
_____
Date

Committee in charge:

       Dr. Ed Fredrickson, Co-Chair

       Dr. Reldon Beck, Co-Chair

       Dr. Martha Desmond

       Dr. Gary Donart

       Dr. Marta Remmenga

ACKNOWLEDGMENTS

VITA

November 20, 1969	Born at River Falls, Wisconsin
1988	Graduated from Eden Prairie High School, Eden Prairie, Minnesota
1995	B.S. Wildlife Management & Biology, University of Wisconsin – Stevens Point Stevens Point, Wisconsin
1996 & 1997	Wolf biologist intern, Yellowstone National Park Wolf Reintroduction Project
1997-1999	Conservation biologist, Turner Endangered Species Fund, Caballo, New Mexico
2000-2002	Master's Student, Department of Animal and Range Science, New Mexico State University Las Cruces, New Mexico

PROFESSIONAL AND HONORARY SOCIETIES

The Wildlife Society
Member 1999-present

Conservation Biology
Member 1997-1999

Society for Range Management
Member 2002-present

Gamma Sigma Delta
Member 2000

PAPERS PRESENTED

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ABSTRACT

DIETARY PREFERENCES OF BLACK-TAILED PRAIRIE DOGS

REINTRODUCED INTO A CHIHUAHUAN DESERT

GRASSLAND

BY

MATTHEW JASON HARTSOUGH, B.S.

Master of Science

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Dr. Ed Fredrickson, Co-Chair

Dr. Reldon Beck, Co-Chair

Dietary preferences of black-tailed prairie dogs (*Cynomys ludovicianus*)

reintroduced into a Chihuahuan Desert grassland in New Mexico were investigated.

Three prairie dog colonies were sampled during each of the four seasons for one year.

Within each colony fecal samples and vegetation measurements were collected from

at least 10 active study burrows. Alkali sacaton (*Sporobolus airoides*) and burrograss

(*Scleropogon brevifoilius*) were the dominant species on each colony. Tobosa

(*Pleuraphis mutica*) and vine mesquite (*Panicum obtusum*) were also common on the

sites. Wrinkled globemallow (*Sphaeralcea hastulata*), Dakota vervain (*Glandularia

bipinnatifida*), Fendler's bladderpod (*Lesquerella fendleri*), and scurfy sida (*Malvella

sagittaefolia*) were the most common forbs encountered on the colonies. Seasonal

dietary preferences were determined through microhistological analysis of fecal

material collected at 10 randomly selected burrows. Overall, prairie dog diets

primarily consisted of graminoids (85%). Forbs and shrubs were minor components

of the overall diets comprising just 2% and 0.3% respectively. Significant differences

between seasonal diets within and among colonies were observed ($P < 0.05$). The

most important graminoids found in the diets of prairie dog were alkali sacaton (53%)

and burrograss (37%). Vine mesquite and tobosa were seasonally important in the

prairie dog diets during spring and summer. Consumption of burrograss increased

significantly during the fall and summer seasons. Relative preference indices for

burrograss were typically higher throughout the year than akali sacaton. Areas

containing alkali sacaton, burrograss, vine mesquite, and tobosa should be considered

suitable sites for reintroducing prairie dogs. Selection and high relative preference

indices for burrograss suggest that sites containing a large component of this species

may be better suited for prairie dogs than previously thought.

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INTRODUCTION

Prairie dog (*Cynomys spp.*) activities have a substantial impact on the distribution, abundance, and composition of vegetation within colonies (Bonham and Coppock et al. 1983; Lerwick 1976; Weltzin et al. 1997b). Prairie dog herbivory increases plant species diversity (Archer et al. 1987; Bonham and Lerwick 1976; Coppock et al. 1983). Increased diversity within colonies is generally attributed to a decline in grass cover and an increase in forb composition within colonies (Archer et al. 1987; Bonham and Lerwick 1976; Coppock et al. 1983). In addition to changing vegetation composition, prairie dogs may also assist in maintaining grassland ecosystems by preventing woody species from establishing and attaining dominance (Weltzin et al. 1997a).

Understanding prairie dog impacts on grassland vegetation dynamics will assist in understanding historic vegetation transitions. One such transition is the conversion of desert grasslands to desert scrub in the northern Chihuahuan Desert. The loss of black-tailed prairie dogs from southwestern grasslands corresponds with the period prior to a significant transition from grassland to desert scrub (Buffington and Herbel 1965). During the 1917 drought, livestock numbers were greater than any other time in New Mexico (Fredrickson et al. 1998). This coincided with intensive efforts to control small mammals including the black-tailed prairie dog (*C. ludovicianus arizonensis*) and kangaroo rat (*Dipodomys merriami*). While livestock numbers are implicated in this transition (Grover and Musick 1990; Schlesinger et al. 1990) the potential role of eradication programs as a causative factor in this transition have not been elucidated. Studies designed to understand the ecological role of

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prairie dogs in desert grasslands may assist in understanding this transition, and lead to the development of low cost remedial technologies for the restoration of desert grasslands.

The pervasive influence of prairie dogs on grassland habitat community dynamics has led to their classification as keystone species and ecosystem engineers (Jones et al. 1994; Kotliar et al. 1999; Miller et al. 1994; Miller et al. 1999). As a keystone species, prairie dogs significantly influence grassland ecosystem structure, composition, and function through their activities (Kotliar et al. 1999; Miller et al. 1999; Mills et al.1993; Power et al.1996). However, Stapp (1998) cautions against labeling prairie dogs as keystone species, because evaluation of the existing scientific evidence reveals that the effects of prairie dogs on grasslands and other grassland animals are poorly understood and less definitive than suggested. Kotliar et al. (1999) also evaluated the role of prairie dogs in grassland ecosystems and felt their role is overstated in the literature, yet they agree with previous conclusions that the direct and indirect impacts of prairie dog grazing and burrowing have pronounced effects on ecosystem processes and patterns. Thus, labeling prairie dogs as keystone species is justified and therefore should be targeted for conservation.

As prairie dog restoration efforts increase, thought should be given to ecological factors that ensure survival of reintroduced prairie dogs and provide insight on their subsequent impact on desert grassland ecosystems. One of the most important ecological factors to consider is the impact that prairie dog dietary preferences have on plant dynamics, including effects of vegetative manipulation on forage quality for grassland herbivores. Dietary information is essential to assess the

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role of the prairie dog in the prairie ecosystem (Uresk 1984). Diet-forage

relationships will vary from region to region even though major categories of forage

consumed by prairie dogs are similar. Management of rangelands must be based on

plant species consumed by herbivores in the area of interest (Uresk 1984). A basic

understanding of prairie dog dietary preferences will facilitate restoration and

management efforts in the Chihuahuan Desert.

This study will contribute to the basic ecological information pertaining to

dietary preferences of black-tailed prairie dogs reintroduced into areas of known

historical occurrence in the northern Chihuahuan Desert. The two main objectives for

this study were 1) to determine the food habits of prairie dogs reintroduced into

Chihuahuan Desert grasslands; and 2) to relate food habits to forage availability.

LITERATURE REVIEW

Taxonomy

Prairie dogs are diurnal, burrowing Sciurids belonging to the genus *Cynomys*.
Five species of prairie dogs reside in North America: Utah prairie dog (*Cynomys
parvidens*), Gunnison's prairie dog (*Cynomys gunnisoni*), Mexican prairie dog
(*Cynomys mexicanus*), white-tailed prairie dog (*Cynomys leucurus*), and the black-
tailed prairie dog (*Cynomys ludovicianus*). Two subspecies of prairie dog have been
differentiated from the nominate forms, Arizona black-tailed prairie dog (*C.
ludovicianus arizonensis*), and Zuni prairie dog (*C. gunnisoni zuniensis*) (Mearns
1890; Hall 1981). Although several researchers acknowledge the need to distinguish
these subspecies from the nominate forms, the validity of distinguishing subspecies
within these prairie dog populations has been questioned (Chesser 1983; Pizzimenti
1975).

Currently, the Utah prairie dog and the Mexican prairie dog are listed under
the Endangered Species Act of 1973, respectively, as threatened and endangered
(Hoogland 1995). Recently the United States Fish and Wildlife Service (USFWS)
considered the black-tailed prairie dog for protection under the endangered species
act. Although listing was considered warranted, it was precluded due to numerous
other higher priority species taking precedence (USFWS 2000). However, the status
of this species is reviewed on a yearly basis.

General Biology

Black-tailed prairie dogs are generally the largest *Cynomys* species
(Pizzimenti 1975). Body mass of adult prairie dogs range from 525-1350 g, with

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males typically being 5-15% heavier than females (Hoogland 1995). Juvenile's body mass at first emergence from burrows typically ranges from 60-288 g with an average weight of 144 g (Hoogland 1995). Juvenile males are typically 6 g heavier than juvenile females (Hoogland 1995). Adult total body length ranges from 347-410 mm (Tiletston and Lechleitner 1966). Average lifespan of male prairie dogs is 3-4 years and 5-6 years for females (Hoogland 1995).

Black-tailed prairie dogs inhabit relatively flat, low elevation, short and mixed-grass prairies in the western U.S, typically occurring at elevations ranging from 700-1800 m (Hoogland 1995; Proctor et al. 1998). Colonies are located in fine-textured soils with slopes less than 10% (Proctor et al. 1998; Reading and Matchett 1997; Tiletston and Lechleitner 1966). Koford (1958) rarely observed colonies in level or low ground, presumably to avoid occasional flooding or for a lack of preferred forage.

Prairie dogs typically breed in late January to mid-February producing one litter per year (Hoogland 1995; Koford 1958). After a 34-35 day gestation period, pups are born blind and furless (Hoogland1995; Johnson 1927). Emergent litter sizes range from 1-6 pups with an average of 3 (Hoogland 1995). Post parturition, juveniles do not appear aboveground for approximately six weeks at which time it is presumed that they have been weaned (Hoogland 1995).

Unlike white-tailed prairie dogs, black-tailed prairie dogs remain active throughout the year and are not believed to hibernate (Bakko et al. 1988; Hoogland 1995; Tiletston and Lechleitner 1966). However, periods of inactivity in black-tailed prairie dog colonies during winter months have been observed (Anthony 1955;

Harlow and Menkins 1986; Harlow and Frank 2001; Hoogland 1995; Lehmer et al. 2001). Black-tailed prairie dogs are capable of exhibiting a sporadic, non-continuous state of facultative torpor (Anthony 1955; Harlow and Menkins 1986; Harlow and Frank 2001; Lehmer et al. 2001). Along with winter conditions, food and water stress were determined to be the most important factors for inducing torpor in black-tailed prairie dogs (Harlow and Menkins 1986; Harlow and Frank 2001). Since prairie dogs are incapable of synthesizing polyunsaturated fatty acids required for torpor, it has been concluded that diet selection must play an important role in supplying prairie dogs with the essential linoleic and α-linoleic acids required to maintain intermittent states of facultative torpor during winter (Harlow and Frank 2001; Lehmer and Van Horne 2001). Although prairie dogs are capable of torpor, Bakko (1977) suggests that they rely on increased renal efficiency to adapt to times of water stress during harsh winter months.

Black-tailed prairie dogs are more gregarious than other species of *Cynomys*. They exhibit a well-organized social hierarchy with an advanced system of communication (Hoogland 1995; King 1959; Smith et al. 1977; Waring 1970). At least twelve different vocalization patterns have been identified in black-tailed prairie dogs (Hoogland 1995; Smith et al. 1977; Waring 1970). Prairie dogs are polygynous and maintain social family units, called coteries, within prairie dog colonies. Inhabitants of a coterie typically consist of a single breeding male, 3-4 breeding females, and several nonbreeding yearlings and juveniles (Hoogland 1995; King 1959). Larger coteries may contain two or more breeding males that are commonly brothers (Hoogland 1995).

Prairie dogs create extensive burrow systems within colonies. Black-tailed prairie dog colonies contain higher densities of burrows per acre than white-tailed prairie dog colonies. This may be a function of a more developed social hierarchy in *C. ludovicianus*. A typical prairie dog burrow system has two entrances, 1 to 3-m deep, 5-15-m long, and is 10-13 cm in diameter (Hoogland 1995; Whicker and Detling 1993). Excavated soil around the burrow system entrance is usually constructed into one of two shapes: dome or rim craters (Hoogland 1995; Tiletston and Lechleitner 1966). Dome craters tend to be wide, rounded, unstructured mounds, 2-3 m in diameter and less than 30 cm in height (Hoogland 1995). Rim craters are volcano-like in appearance, 1-1.5 m in diameter and can be up to 1 m in height. Rim mounds are constructed through forming soil, vegetative matter, and feces into an adobe-like texture and packing it into shape (Hoogland 1995; Tiletston and Lechleitner 1966). These mounds facilitate daily prairie dog activities in three ways. They protect the burrow systems from flooding in the event of a severe rainstorm (Hoogland 1995; King 1959; Koford 1958). Elevated mounds serve as vantage points from which prairie dogs can scan for predators (Hoogland 1995; King 1959). Finally, these mounds may improve ventilation through the burrow system through the action of the Bernoulli principle (Hoogland 1995; Vogel et al. 1973).

Historic Range

Black-tailed prairie dogs were historically a common and important component of many western grasslands. It has been estimated that prairie dogs occupied between 40-100 million ha of native short and mixed grass prairie from southern Canada to northern Mexico and from the Rocky Mountains east to the tall

grass prairie (Anderson et al. 1986; Nelson 1919). However, due to perceived competition for forage between prairie dogs and livestock, extensive eradication campaigns suggested by Merriam (1902) were initiated by private, state, and federal agencies in the early 20th century and continue today. Conversion of prairie dog habitat into agricultural cropland has also led to the decline of prairie dogs in western grasslands (Mulhern and Knowles 1995). The U.S. Geological Survey estimates that black-tailed prairie dogs may currently occupy less than 0.5% of their original range in the short and mixed-grass prairies (Mac et al. 1998). Remaining prairie dog populations have become increasingly fragmented and isolated throughout their historic range. Remaining small, widely dispersed populations have become increasingly susceptible to extirpation by environmental and genetic stochasticity and natural catastrophes (Shaffer 1981). Currently, sylvatic plague may be the largest threat to the persistence of prairie dog populations in western grasslands (Hubbard and Schmitt 1983; Mulhern and Knowles 1995). This dramatic decrease in black-tailed prairie dog populations led the National Wildlife Federation to petition the United States Fish and Wildlife Service (USFWS) to list the black-tailed prairie dog as a threatened species under the Endangered Species Act (United States Fish and Wildlife Service 2000). The USFWS has concluded that the petition for listing is warranted, but has precluded listing prairie dogs due to numerous other higher priority species that need more immediate protection. Dwindling populations of black-tailed prairie dogs throughout the west has evoked interest in reintroducing these animals to areas of historic occurrence in the Great Plains and the Chihuahuan

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Desert (Carpenter and Martin 1969; Davidson et al. 1999; Robinette et al. 1995; Truett and Savage 1998; Truett et al. 2001).

Prairie dogs were a major component of New Mexico fauna in the early 1900's (Bailey 1931; Findley, 1975;). Two of the five species of prairie dog are found in New Mexico. Black-tail prairie dogs (*C. ludovicianus arizonensis* and *C. l. ludovicianus*) were the more numerous of the two species and occupied extensive areas in the eastern and southern parts of the state. *C. l. ludovicianus* occupied areas in the east and northeastern areas of New Mexico. The historic range of the subspecies *C.l. arizonensis* extended throughout the southern portion of New Mexico west of the Pecos valley to northwest Chihuahua, and southeastern Arizona. Hubbard and Schmitt (1983) estimate that black-tailed prairie dog populations in New Mexico were reduced by approximately 25% by 1983. Gunnison's prairie dog (*Cynomys gunnisoni*) occupied higher elevation grasslands in the northwestern and central regions of New Mexico (Bailey 1931; Hall 1981).

Observations by Bailey (1931), Findley (1975), and Mearns (1890) indicate that black-tailed prairie dogs were a major component of the northern Chihuahuan Desert grasslands. Oakes (2000) found early references to the existence of prairie dog colonies on the Pedro Armendaris land grant, in the northern Chihuahuan Desert, dating back to Spanish colonial times. Prairie dogs occupied sites on the Pedro Armendaris land grant as recently as 1965, before being eradicated to protect livestock interests (Oakes 2000). Bailey (1931) observed that the *C. l. arizonensis* subspecies found in desert grasslands, exhibited "peculiarities of habit" not shared by the better-fed relatives of the short and mixed grass prairies. Bailey (1931) has

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implied that this desert dwelling subspecies adjusted to the more arid conditions by adapting to "unusual" food items such as cactus and the bark of mesquite. Despite observations of "peculiarities" between desert prairie dogs and those found in mixed grass prairies, no studies were found that quantify these differences, especially those differences related to diet-forage relationships in desert grasslands.

Ecological Role

Disappearance of prairie dogs from western grasslands may have significant negative impacts on the ecological processes of this ecosystem. Prairie dogs impact grassland faunal and floral biodiversity, nutrient cycling, hydrology, and vegetative composition and structure through frequent and intense vegetation defoliation and burrowing activities (Bonham and Lerwick 1976; Ceballos et al. 1999; Coppock et al. 1983; Weltzin et al. 1997a,b). Prairie dogs influence grassland vegetative composition, structure, biomass, productivity, and may suppress the invasion of mesquite (*Prosopis spp.*) and other shrubs, helping to slow desertification processes in the southwest (Archer et al. 1987; Weltzin et al. 1997 a,b; Whicker and Detling 1988). Prairie dogs also enhance forage quality for other herbivores through improved nutrient cycling within colonies. Improved nutrient cycling results from several mechanisms: repeated defoliation of vegetation, changes in microclimate, and through biopedturbation (Coppock et al. 1983; Holland and Detling 1990; Whicker and Detling 1988).

Although, not all vegetation on prairie dog colonies is consumed, prairie dogs do maintain vegetation by clipping in order to facilitate communication and predator detection. Through this intense grazing and clipping of range plants, large distinct

patches of vegetation are created across the landscape (Archer et al. 1987; Kotliar et al. 1999; Whicker and Detling 1988). Vegetation structure, composition, and quality differ within and among these patches and contribute to overall gamma diversity (Archer et al. 1987; Kotliar et al. 1999). Patch heterogeneity varies across the grassland ecosystem with prairie dog colonization history (Archer et al. 1987).

Prairie dogs alter the vegetational structure of a patch by maintaining vegetation to less than half that of uncolonized areas of adjacent grassland (Archer et al. 1987). Detling and Painter (1983) and Detling et al. (1986) have found that prairie dogs may affect the genetic structure of plant populations within colonies. Plants surviving repeated grazing by prairie dogs tend to exhibit shorter, more prostrate growth forms with more tillers, which show a greater tolerance for repeated defoliation (Detling and Painter 1983; Detling et al. 1986). Compared to plants from ungrazed areas, those subjected to continuous prairie dog grazing produced approximately 35% more tillers per plant, but had 15% fewer leaves per tiller (Detling and Painter 1983). Detling and Painter (1983) also found that the leaves of plants subjected to heavy grazing were only about 60% as long and wide as leaves from plants that were not grazed. Finally, non-grazed plants were nearly five times as tall, and considerably more erect than plants found on prairie dog colonies (Detling and Painter 1983). Detling et al. (1986) and Detling and Painter (1983) concluded that, although heavily grazed plants are less productive, they might be better able to withstand repeated defoliation than non-grazed forms.

Prairie dog grazing affects plant species richness and distribution within colonies. Selective grazing of range vegetation and modification of the microhabitat

by prairie dogs may change the competitive dynamics among species of plants within the colony and subsequently alter the plant community (Whicker and Detling 1988; Whicker and Detling 1993). Archer and Detling (1984) concluded that preferences for one set of plants may give less preferred or more grazing resistant plants a competitive advantage and an opportunity to replace stressed plants. Thus, overtime, plant population dynamics and distribution patterns are altered.

Plant species composition within prairie dog colonies varies with the extent of herbivore disturbance and reflects the overall impacts of grazing intensity, duration, edaphic properties, and climate (Archer et al. 1987; Coppock et al. 1983; Detling 1998; Osborn and Allen 1949; Whicker and Detling 1988). The consequence of different prairie dog grazing intensities and duration results in heterogeneous vegetative types within prairie dog colonies. Terms describing different zonations of vegetative types within colonies are based on the length of time that an area has been occupied. The area of the colony that has been occupied by prairie dogs the longest, where the dominant grasses have been replaced by forbs and dwarf shrubs, and has experienced an increase in bare ground is referred to as the "old colony" (Allen 1949; Archer et al. 1987; Coppock et al. 1983; Detling 1998; Osborn and Garrett et al. 1982; Whicker and Detling 1988). The term "young colony" describes those areas that have been colonized for shorter periods of time, where vegetation is still dominated by perennial grasses, and the presence of forbs have begun to increase (Archer et al. 1987; Coppock et al. 1983; Detling 1998; Garrett et al. 1982; Whicker and Detling 1988). Colony edges pertain to those areas that have been recently

colonized or have received light use by prairie dogs (Archer et al. 1987; Coppock et al. 1983; Detling 1998; Whicker and Detling 1998).

Vegetative differences can be seen as concentric zones of varying species richness that increase from the old colony, peaks in the young colony, and then decreases at the colony edge. Bare ground areas, mat forming forbs, and shrubs characterize colony centers, which have been subjected to grazing for the longest amount of time (Archer et al. 1987; Coppock et al. 1983; Osborn and Allen 1949; Whicker and Detling 1988). Areas inhabited for intermediate lengths of time, "young colonies," show the highest species richness. The greater plant species diversity in these parts of the prairie dog colony is attributed to an increase in forbs as a result of preferential prairie dog grazing of graminoids. This supports the intermediate disturbance hypothesis, which suggests that species diversity is maximized under intermediate disturbance regimes (Collins and Barber 1989).

An implication of increased plant species diversity within prairie dog colonies is that these patches provide habitat and seed sources for plant species that may only be able to disperse and become established under spatially and temporally variable circumstances (Whicker and Detling 1988). Habitat and forage availability is also enhanced for other grassland species through an increase in plant heterogeneity on prairie dog colonies. However, prairie dogs alone cannot be considered responsible for changes in vegetation dynamics and distribution since their activities are known to modify the grazing patterns of other herbivores (Archer et al. 1987). Coppock et al. (1983) and Krueger (1986) have concluded that bison and antelope preferentially select prairie dog colonies for grazing.

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Prairie dogs can significantly alter above- and belowground productivity and biomass. Whicker and Detling (1988) estimate that grass dominated areas of prairie dog colonies typically lose 60-80% of aboveground net primary production (ANPP) to consumption and wastage by prairie dogs and other herbivores. Consumption rates by herbivores on surrounding uncolonized areas reduce ANPP by 5-30% (Whicker and Detling 1988). Due to heavy grazing intensities on prairie dog colonies, aboveground plant biomass is typically maintained at one-third to two thirds of the aboveground biomass on adjacent uncolonized areas (Coppock et al. 1983). However, the standing live to dead biomass ratio is 2-4 times higher on prairie dog colonies (Coppock et al. 1983).

Prairie dog grazing also influences belowground net primary production, biomass, and nutrient cycling. Several studies have demonstrated a pattern of decreased root biomass that corresponds to a sequence of increased grazing pressure (Detling 1998; Holland and Detling 1990; Ingham and Detling 1984; Jaramillo and Detling 1988; Whicker and Detling 1988). Lower root biomass on prairie dog colonies are attributed to reduced leaf area and, hence, lower photosynthetic production relative to uncolonized areas (Detling 1998). Root growth, following defoliation, essentially ceases because the plant preferentially allocates photosynthetically fixed carbon to aboveground structures (Detling 1998). Ingham and Detling (1984) estimated that root production on prairie dog colonies was only 50-60% of the root production from uncolonized areas. Such intensive grazing pressure by prairie dogs and other herbivores can have profound effects on ecosystem processes such as NPP and nutrient cycling.

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Prairie dogs influence nutrient cycling through grazing, clipping vegetation, and burrowing activities (Holland and Detling 1990; Whicker and Detling 1988). Several studies indicate that prairie dog grazing results in higher plant shoot nitrogen concentration on prairie dog colonies than in those of the same species in adjacent uncolonized areas (Coppock et al. 1983; Detling 1998; Krueger 1986; Whicker and Detling 1988; Whicker and Detling 1993). Increased nitrogen concentrations in recently defoliated plant shoots may be a result of a combination of several ecological factors. Higher shoot nitrogen concentrations may be a function of leaf age structure (Coppock et al. 1983; Whicker and Detling 1988). Since repeated defoliation and growth of new leaves throughout the growing season maintains leaves at a lower average leaf age and because leaf nitrogen concentration declines with age, shoot nitrogen concentrations were higher on prairie dog colonies (Whicker and Detling 1988).

Higher nitrogen concentrations may also result from an increase in plant nitrogen uptake and translocation to aboveground tissue (Coppock et al. 1983; Detling 1998; Krueger 1986; Whicker and Detling 1988; Whicker and Detling 1993). Studies have shown that plants allocate a higher proportion of current photosynthates to regrowth or synthesis of new leaf blades at the expense of other parts in defoliated plants (Detling et al. 1980; Ingham and Detling 1984). This response permits the rapid restoration of plant photosynthetic capacity following grazing. Higher shoot nitrogen concentrations may also result from the potentially greater inputs of nitrogen in available forms from excretion products of herbivores that graze preferentially on

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prairie dog colonies (Coppock et al. 1983; Jaramillo and Detling 1988; Whicker and Detling 1988).

Microclimate changes on prairie dog colonies, as a result of heavy grazing, also may influence nitrogen cycling. Changes in the soil-water balance may influence changes in nitrogen availability through a variety of ways (Whicker and Detling 1988). As prairie dog grazing reduces live and dead shoot biomass, root biomass, and litter, the amount of moisture added to the soil may be reduced (Whicker and Detling 1988). An increase in the amount of bare soil, as a result of grazing, increases soil temperature and soil evaporative losses (Whicker and Detling 1988). Therefore, the combination of less moisture within the soil and increased temperature and evaporative moisture loss from the soil would lead to increased rates of nitrogen mineralization and a greater nitrogen availability on prairie dog colonies (Whicker and Detling 1988).

Prairie dog grazing also influences the competitive interactions between soil microorganisms and plants for available nutrients. Increased soil nitrogen availability may result from more rapid mineralization of other sources of organic nitrogen in soils (McNaughton et al. 1997). Holland and Detling (1990) determined that less carbon is translocated below ground to the roots because photosynthetic production is lower in heavily grazed areas and those photosynthates are preferentially allocated to defoliated shoots. Therefore, soil microbes receive less carbon inputs from roots and surface litter in heavily grazed areas (Detling 1998; Holland and Detling 1990; Whicker and Detling 1988). As carbon inputs decrease, microbes become carbon limited and are unable to use as much nitrogen (Holland and Detling 1990). As a

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result, nitrogen immobilization by microbes is reduced and net mineralization is enhanced, making more nitrogen available for plant uptake (Holland and Detling 1990).

Burrowing Ecology

Burrowing activities of prairie dogs have a profound influence on grassland nutrient cycles. The activities of burrowing mammals may be the most important mechanism in the ecosystem for supplying soluble nutrients from deep soil layers to the surface and may be the only mechanism for bringing insoluble materials to the surface for weathering (Abaturov 1972). Prairie dog activity results in the aeration, pulverization, granulation, and transfer of considerable quantities of subsoil to the soil surface (Sharps and Uresk 1990). Whicker and Detling (1993) calculated that prairie dogs mix approximately 200 to 225-kg of soil per burrow system. Ceballos et al. (1999) calculated that prairie dogs are capable of moving 4759 to 9731 kg of soil/ha in a desert grassland prairie dog colony. However caution should be used when interpreting these results, because Ceballos et al. (1999) are using methods developed for one particular soil type and then applying it to a vastly different soil association. Using techniques to determine soil removal in one type of soil and applying those same techniques to a different type of soil may result in inaccuracies. Frequent soil pedturbation tends to elevate quantities of carbon, nitrogen, soil minerals, and organic materials and also modifies pH levels in soils associated with small mammal burrows and burrow mounds (Abaturov 1972; Carlson and White 1987,1988). Elevated mineral concentrations may result from decomposition of animal bones, fecal material, and urine or minerals brought to the surface from the subsurface (Carlson

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and White 1988; Koford 1958). Carlson and White (1987, 1988) found that the pH of prairie dog mound soil was generally higher than off-mound soils. This apparently was the result of prairie dogs moving calcareous soils to the surface (Carlson and White 1987, 1988). Elevated phosphorus levels have also been observed on prairie dog mounds. Carlson and White (1988) attribute the increased mound soil levels of phosphorus to an accumulation of subsurface soil, prairie dog skeletal material, and fecal material that has been brought to the surface. Rates of litter decomposition, mineral concentration, and rates of mineralization also tend to increase in small mammal pedturbated soils (Carlson and White 1987,1988; Holland and Detling 1990; Munn 1993). Munn (1993) also found that rate of soil mixing on prairie dog colonies exceed the normal rate of soil formation of non-colony areas.

Dietary Preferences

Research on the dietary preferences of black-tailed prairie dogs has been conducted in South Dakota, Colorado, Montana, and the shortgrass region of southeastern New Mexico (Bonham and Lerwick 1976; Fagerstone et al. 1977; Fagerstone and Williams 1982; Hansen and Gold 1977; Kelso 1939; Koford 1958; Stinnett 1981; Summers and Linder 1978; Tiletston and Lechleitner 1966; Uresk 1984). However, no research exploring the dietary preferences of prairie dogs in Chihuahuan Desert grasslands could be found. Research has demonstrated that prairie dogs are selective feeders and do not consume forage species in the order which they occur on the range. Prairie dogs prefer green and growing graminoids over forbs or shrubs, however forage species consumed and their relative amounts vary throughout the year (Fagerstone et al. 1981; Kelso 1939).

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Uresk (1984) found that graminoids constituted 87% of total prairie dog diets.

The most preferred forage species consumed were ring muhly (*Muhlenbergia torreyi*), sand dropseed (*Sporobolus cryptandrus*), and green needlegrass (*Stipa virdula*) (Uresk 1984). Kelso (1939) and Summers and Linder (1978) found that grasses constituted 62% and 65%, respectively, of the annual diets of prairie dogs with western wheatgrass (*Agropyron smithii*) as the most important forage species. Tiletston and Lechleitner (1966) also found western wheatgrass to be an important forage species for prairie dogs. Fagerstone et al. (1981) found that grasses comprised 71% of the prairie dog's annual diet with wheatgrass, buffalograss (*Buchloe dactyloides*), and blue grama *(Bouteloua gracilis)* being the important grasses. Bonham and Lerwick (1976) found that blue grama, sand dropseed, and needleleaf sedge (*Carex eleocharis*) to be important forage species. Stinnett (1981) also found blue grama and sand dropseed to be important dietary components along with tobosa (*Pleuraphis mutica*). Lehmer and Van Horne (2001) found that blue grama was the most common and abundant species in prairie dog diets throughout the year. Fagerstone and Williams (1982) found that prairie dogs selected for C_4 grasses over C_3 grasses. The C_4 species that were preferred were blue grama, red three-awn (*Aristida longiseta*), and tumblegrass (*Schedonnardus paniculatus*). Important C_3 species found in the annual diets of prairie dogs were wheatgrass, brome (*Bromus spp.*), and six-weeks fescue (*Vulpia octoflora*). Although, C_4 grasses were preferred over C_3 grasses, a seasonal trend was evident. C_3 grasses were preferred during the early part of the year when they were abundant and more digestible. As C_3 grasses matured and C_4 grasses become more abundant and nutritious, prairie dog preferences

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turned towards this group of grasses. Typically grass consumption increased during summer months and decreased after the growing season (Bonham and Lerwick 1976; Fagerstone et al. 1981; Hansen and Gold 1977; Kelso 1939; Uresk 1984).

Sedges have been identified as an important component of prairie dog diets. Hansen and Gold (1977) found that sedges constituted 36% of the annual diet and were the most abundant plant in the diets of prairie dogs. Summers and Linder (1978) and Bonham and Lerwick (1976) found that prairie dogs preferentially selected for threadleaf sedge (*Carex filifolia*) and needleleaf sedge, respectively. Lehmer and Van Horne (2001) found that needle-leaf sedge comprised a large portion of the diet during spring (26%) and summer (31.3%). Sedge consumption rates were observed to be highest in the spring, fall, and winter months (Bonham and Lerwick 1976; Hansen and Gold 1977). This trend of sedge consumption is presumably inversely correlated with the availability of graminoids.

Prairie dogs preferentially select graminoids throughout the year, but also will consume forbs and shrubs (Fagerstone et al. 1981; Hansen and Gold 1977; Koford 1958; Lehmer and Van Horne 2001; Summers and Linder 1978). Forbs constituted 12-34% of prairie dog diets with scarlet globemallow (*Sphaeralcea coccinea*) as the most important species (Bonham and Lerwick 1977; Fagerstone et al. 1981; Hansen and Gold 1977; Kelso 1939; Stinnett 1981; Summers and Linder 1978; Uresk 1984). Russian thistle (*Salsola kali*) also was identified as an important diet species (Kelso 1939; Koford 1958; Tiletston and Lechleitner 1966). Forb consumption rates vary annually and may correspond with the availability of preferred grasses, geographic location, and time of growth. Uresk (1984) found consumption rates of forbs to be

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lowest in June (5% of the diet) and highest in September (25% of the diet). Tiletston and Lechleitner (1966) observed forb consumption rates to be much higher in late spring into early summer. Kelso (1939) found forbs to be an important diet component early and late in the year. Stinnett (1981) found that forb consumption was greatest from May to July and declined in September. Several studies have shown that prickly pear (*Oputia spp.*) becomes an important forage species during winter (Fagerstone et al. 1981; Kelso 1939; Koford 1958; Lehmer and Van Horne 2001; Summer and Linder 1978). Kelso (1939), Koford (1958), and Tiletston and Lechleitner (1966) noted that prairie dogs made use of grass and forb roots during late fall, winter, and early spring when water availability was lowest. However, Summers and Linder (1978) did not notice an increase in root-stem material in prairie dog diets during late summer and into winter.

Shrub species such as broom snakeweed (*Gutierrezia sarothrae*), sage (*Artemisia spp.*), fourwing saltbush (*A. canescens*), and rabbitbrush (*Chrysothamus nauseosus*) have been identified in prairie dog diets (Koford 1958; Stinnett 1981). Koford (1958) found that shrubs became important food items during the fall and winter months after other preferred forage species matured and dried up.

Studies have shown that prairie dogs will consume insects and meat in their diets (Fagerstone et al. 1981; Hoogland 1995; Koford 1958; Stinnett 1981; Uresk 1984; Whitehead 1925). Uresk (1984), Fagerstone et al. (1981), and Stinnett (1981) have found that insects may constitute < 0.1% to 3% of prairie dog diets. However, Summers and Linder (1978) found no evidence of prairie dogs consuming insects. Hoogland (1998) has observed the phenomenon of cannibalism among prairie dogs.

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Cannibalism usually occurred in the spring after lactating females kill unweaned juveniles of other adult females. Hoogland (1995) concludes that a possible reason for cannibalism may be to supplement additional nutrients to lactating females to help meet nutritional requirements during this physiologically stressful time of year.

Diet and Demography

Knowledge of wildlife nutrition, as a component of both wildlife ecology and management, is central to understanding the survival and productivity of all wildlife populations, whether free-ranging or captive. (Robbins 1993, pp.1)

Understanding the role of prairie dog diet-forage relationships in the Chihuahuan Desert and how they influence population demographics can facilitate the implementation of effective management strategies between domesticated herbivores and reintroduced prairie dogs. Body fat reserves, which reflect nutritional status, are commonly used as a body condition index for mammals (Hanks 1981). Generally the heavier the animal, the higher the body condition index (Dobson 1992). Increased body weight is largely determined by habitat quality, and more specifically nutrient availability (Garrett et al. 1982; Rayor 1985; Robbins 1993). It has been shown that mammals with higher body mass, or better body condition, have increased reproductive productivity and better overwinter survival rates (Bennett 1999; Garrett et al. 1982; Hoogland 1995; Rayor 1985; Todd and Keith 1983). Studies of ground dwelling sciurids have shown that individuals which are at the upper range of body mass for their species typically reach sexual maturity quicker, have larger litters, wean more litters successfully, and have higher

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overwinter survival rates (Garrett et al. 1982; Murie and Boag 1984; Rayor 1985).

Garrett et al. (1982) and Rayor (1985) found juvenile prairie dogs that gained more weight through the summer and fall were more likely to reach sexual maturity in their first year. Garrett et al. (1982) found that yearling male black-tailed prairie dogs are more likely to disperse and breed in colonies containing more available resources. Rayor (1985) found that yearling female white-tailed prairie dogs are more likely to breed when they have access to a higher quality forage base. Female sciurids having higher body weights are more likely to produce larger litters (Garrett et al. 1982; Rayor 1985). Female prairie dogs having access to higher quality forage were in better overall condition had significantly larger litters than less fit prairie dogs (Garrett et al. 1982; Rayor 1985). Body weight also has a substantial influence on weaning rates. Heavier adult female prairie dogs weaned more litters successfully than lighter females. (Garrett et al. 1982; Rayor 1985).

Overwinter survival of juvenile and yearling sciurids is positively correlated with heavier body mass, which is determined by the growth rate through the summer and fall (Bennett 1999). Body weights of juvenile white and black-tailed prairie dogs, and columbian ground squirrels (*Spermophilus columbianus*) at first emergence between colonies of high and poor quality resources showed no significant differences (Garrett et al. 1982; Rayor 1985). However, juvenile body weights in habitats with better forage quality were significantly higher in late summer and fall than juveniles at colonies

containing poorer quality habitat (Garrett et al. 1982; Rayor 1985). The increased survival rates attained by individuals with higher body mass can be attributed to adequate fat reserves needed for successful hibernation or torpor (Harlow and Menkins 1986; Harlow and Frank 2001). Garrett et al. (1982) and Rayor (1985) found that prairie dogs with access to better forage conditions had higher overall body mass, and therefore had increased annual survival rates than individuals with lower overall body mass.

STUDY AREA

Research was conducted on three black-tailed prairie dog colonies reintroduced onto the Pedro Armendaris Land Grant (Fig.1). The Armendaris ranch is located approximately 20 km east of Truth or Consequences, NM in Sierra County. The ranch occupies 145,750 ha in the Jornada Del Muerto basin, most of which is centered between the Rio Grande River and the San Andreas mountains in the northern region of the Chihuahuan Desert. Vegetation in this area has been classified as semidesert grassland and Chihuahuan desertscrub (Brown 1994).

Historically, prairie dogs occupied sites on the land grant as recently as 1965, after which they were poisoned to protect livestock interests (Oakes 1998). A prairie dog reintroduction program was initiated on the Armendaris ranch in 1995 utilizing techniques described in Truett and Savage (1998) and Truett et al. (2001). Currently 11 colonies have been reintroduced onto the Armendaris ranch. Prairie dogs were reintroduced into areas historically occupied by *C. l. arizonensis*. Therefore, black-tailed prairie dogs known to be of the subspecies *C.l. arizonensis* from a colony in the Tularosa basin were used in the initial reintroductions. Due to the limited supply of *C.l. arizonensis*, the *C.l. ludovicianus* subspecies was used in the most recent reintroductions. Prairie dogs used in the present study are of the *C.l. ludovicianus* subspecies. Currently there are eleven reintroduced colonies on the Armendaris Ranch. Three colonies were used in the study: Red Lake South colony (RLC) (UTM 312247.05 E, 3695962.36 N) (Fig. A1), Deep Well colony (DWC) (UTM 313701.40 E, 3690308.21 N) (Fig. A2), and S-Curve colony (SCC) (UTM 315200.50 E,
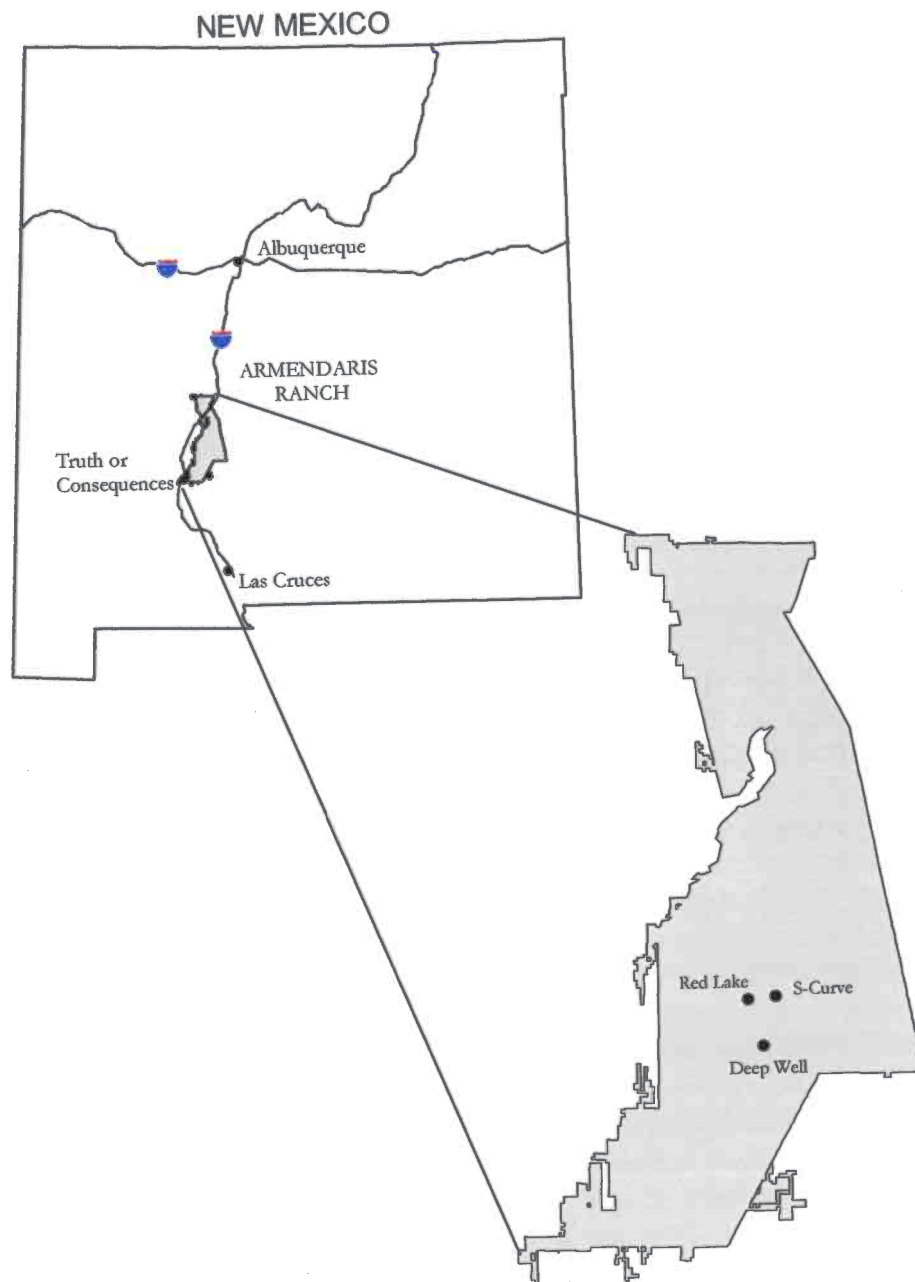
Figure 1. Location of Pedro Armendaris Land Grant (Armendaris ranch) and study colonies

369201.86 N) (Fig. A3). The Red Lake South colony was established in July 1998 and the Deep Well and S-Curve colonies were established in July 1999.

The RLC is approximately 8 ha in size and is enclosed by a seven-wire electric fence used to deter mammalian predators. Elevation at this site is 1369 m. The colony is located on a Mimbres silt-loam soil association, which is characterized by deep, well-drained Typic Camborthids, fine-silty, mixed, thermic soil (Soil Conservation Service 1984). Slope for this area is 0% - 5%. The dominant grass within the colony is alkali sacaton (*Sporobulus airoides*). Burrograss (*Scleropogon brevifolius*) patches are distributed throughout the colony. Honey mesquite (*Prosopis glandulosa*) can be found on the colony.

The Deep Well colony is approximately 1.27 ha and is also located in the Mimbres silt-loam soil association (Soil Conservation Service 1984). Elevation at this colony is 1378m. Dominant grasses in this colony include alkali sacaton, tobosa (*Pleuraphis mutica*), vine mesquite (*Panicum obtusum*), and burrograss.

The S-Curve colony is approximately 2.17 ha in size and is located on a Reakor-Dona Ana soil association characterized by deep, well drained, Typic Calciothids, fine-silty, mixed, thermic soils (Soil Conservation Service 1984). Slope for this area is 1%-5%. Elevation at this colony is 1410m. Dominant grasses include burrograss, alkali sacaton, and vine mesquite. Three-awn (*Aristida spp.*) and black grama are also present in the colony.

Several herbivores have been observed grazing on or near the study colonies. In 1993, cattle were removed from the ranch and replaced with approximately 2200 head of bison (*Bison bison*). Within the last few years the herd has been reduced to

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approximately 1200 head. Other large herbivores observed within and around the colonies include oryx (*Oryx gazella*), pronghorn antelope (*Antilocapra americana*), and mule deer (*Odocoileus hemionus*). Several small mammals also found at the study sites include: black-tailed jackrabbits (*Lepus californicus*), desert cottontail (*Sylvilagus audubonii*), and various small rodents.

Precipitation data were obtained from National Oceanic and Atmospheric Administration recording stations at the Bosque Del Apache Wildlife Refuge and Elephant Butte Dam and a Campbell Scientific weather station located at the RLC site that was installed at the end of July 2000 (Table 1). Average annual precipitation for this area is 203 mm to 254 mm (Soil Conservation Service 1984). Average temperature for this area is 14.27 ^{0}C (Table 2).

Table 1. Monthly precipitation totals for 2000 & 20001 at 3 locations near the Pedro Armendaris Land Grant in southern New Mexico

Precipitation Total for 2000 (mm)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Bosque Del Apache	0.00	1.02	46.99	3.30	0.00	28.70	41.40	57.15	1.02	70.87	44.45	20.57	315.47
Elephant Butte Dam	0.00	0.00	43.69	2.79	0.00	56.64	21.34	46.48	M[1]	74.68	41.40	1.52	
Red Lake Colony	-	-	-	-	-	-	-	16.26	0.00	61.72	40.64	3.81	

Precipitation Total for 2001 (mm)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Bosque Del Apache	50.80	0.51	16.76	0.76	18.54	2.54	48.01	49.02	23.11	1.02	16.76	0.05	227.89
Elephant Butte Dam	29.72	20.07	5.33	0.00	M	M	36.83	41.91	44.70	2.29	6.10	0.05	
Red Lake Colony	22.61	17.02	10.92	1.27	9.91	5.84	37.34	37.59	25.15	5.08	11.68	5.84	190.25

M denotes missing data

[1] M

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Table 2. Average monthly air temperature for 2000 & 2001 at 3 locations near the Pedro Armendais Land Grant in southern New Mexico

		Average Monthly Temperature for 2000 (°C)										
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Bosque Del Apache												
Min Temp	-18.33	-10.56	-8.89	-3.33	M[1]	M	13.89	11.67	2.78	0.56	-5.22	-6.89
Max Temp	26.11	27.22	28.33	35.56	M	M	41.67	40.56	38.89	37.22	15.89	15.89
Avg Temp	5.17	8.28	10.44	16.11	22.00	25.39	27.50	26.17	22.67	14.72	5.33	4.50
Elephant Butte Dam												
Min Temp	-7.22	-3.33	-3.33	0.56	16.11	M	M	14.44	1.11	3.89	0.33	-0.78
Max Temp	23.33	22.78	22.22	32.78	36.67	M	M	36.67	33.33	33.33	12.56	13.22
Avg Temp	8.17	9.28	9.56	17.56	22.89	25.56	26.78	26.17	M	15.50	6.44	6.22
Red Lake Colony												
Min Temp	-	-	-	-	-	-	-	9.80	2.92	1.46	-9.86	-12.28
Max Temp	-	-	-	-	-	-	-	37.31	37.08	34.30	20.92	18.07
Avg Temp	-	-	-	-	-	-	-	25.21	22.93	14.01	4.00	3.16

[1] M denotes missing data

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Table 2 (continued)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
						Average Monthly Temperature for 2001 (°C)						
Bosque Del Apache												
Min Temp	-13.33	-11.67	-6.11	-3.89	-0.56	5.00	8.89	10.56	3.33	-2.78	-10.00	-8.50
Max Temp	18.33	23.89	29.44	32.22	37.78	41.67	41.11	40.00	37.78	32.22	30.00	15.00
Avg Temp	2.28	6.11	9.83	14.44	20.17	24.28	26.44	24.94	21.17	15.67	M	3.28
Elephant Butte Dam												
Min Temp	-10.00	-5.56	-1.11	1.11	M	M	17.22	17.22	12.22	6.11	-6.67	-2.22
Max Temp	16.11	22.22	26.67	28.89	M	M	36.67	37.22	35.00	31.11	25.56	12.50
Avg Temp	3.33	7.78	11.11	15.56	M	M	26.72	25.56	23.39	18.67	9.94	5.17
Red Lake Colony												
Min Temp	-14.25	-11.51	-7.81	-4.22	-1.22	5.25	13.70	10.32	4.57	-2.81	-10.71	-15.24
Max Temp	17.67	22.65	28.59	33.00	37.43	38.24	39.29	37.33	35.52	30.08	27.06	19.73
Avg Temp	0.50	6.12	10.35	15.70	21.14	25.73	26.35	24.52	21.26	15.27	8.26	1.41

[1] M denotes missing data

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METHODS AND MATERIALS

Study Burrows

Prairie dog burrows in all three study colonies were physically described and

identified as being active or inactive according to methods employed by Biggens et

al. (1993). Each burrow was marked with a numbered stake and its location was

mapped with hand held geographical positioning system (GPS) equipment (Trimble

Pro XL receiver with DGPS accuracy) and Arcinfo geographical information system

(GIS) software. Ten active burrows were randomly selected to serve as data

collection points within each study colony. Study burrows were sampled four times

during the year: summer (August 2000), fall (November 2000), winter (February

2001), and spring (April 2001). If a study burrow became inactive from one data

collection period to another, the next closest active burrow to the original study

burrow was then used as the data collection point for that sampling period. An

attempt was made to utilize the original study burrow each field season.

Vegetation Measurements

Prairie dog colony vegetation composition and forage availability were

determined using 2 20-m line-point transects radiating from the center of each study

burrow for a minimum of 20 transects per season. Transect directions from $1-360^0$

were randomly selected utilizing a random number generator. Transects were marked

with stakes and numbered aluminum tags. If a study burrow became inactive from

one field season to another the next closest active burrow was then used as the study

burrow. Line point transects at each alternate study burrow were established in the

same manner as the original study burrows. If an alternative study burrow was used,

transects at the original study burrow were also read and incorporated into the vegetation data for that season. Therefore it was possible to have more than 20 transects contributing to vegetation analysis for a given season. Line points were read at 10-cm intervals and species composition and canopy and basal cover were recorded for each species encountered. If a point fell on dung, litter, or bare soil it was recorded as such. Canopy cover was then determined for all species found on the prairie dog colonies. Vegetation data was entered into a Microsoft Excel® database.

Fecal Collection

Study burrows were used as fecal collection points. All fresh fecal material within a 2-m radius of the burrow entrance was collected each time a study-burrow was sampled. Fecal pellets were considered fresh if they were not dried hard and were greenish, black, or dark brown in appearance (Biggens et al. 1993; Desmond et al. 2000). Fecal pellets collected from each study-burrow were kept separate from other study-burrow samples. Fecal samples and reference plant material were oven dried at 40^0C for 24 hours and ground through a 1-mm screen in a Cyclotec sample mill (Vavra and Holechek 1980).

Slide Preparation

Fecal and reference plant material were mounted on microscope slides using an Aqueous Kaiser glycerine jelly mounting medium (Joseph 1995). Reference plant specimens were collected from each colony and identified with assistance of Dr. Kelly Allred, NMSU Department of Animal and Range Science and Allred (2000). Five slides from each fecal collection and reference plants were mounted according to methods described by Joseph (1995). Reference slides were made from the above

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ground portion of each plant species that was found growing on the study sites. Photographs of reference plant cells were taken with a JVC digital camera using Automontage and Adobe photoshop (6.0) software.

Diet Analysis

Diet composition was determined through microhistological analysis of fecal material as described by Sparks and Malechek (1960) and modified by Joseph (1995). A Zeiss axioskop compound microscope was used to examine fecal and plant material. Fecal samples were examined at 100x magnification following procedures described by Sparks and Malechek (1960). Each fecal sample was represented by five slides and twenty locations were observed on each slide for a total of 100 microscope fields for each fecal sample. Higher magnification (200x & 400x) was used when necessary to ensure positive identification of cells for the different plant species. The first location on a slide was randomly chosen and subsequent locations were determined systematically. A location was considered as an area delineated by the microscope field at 100x magnification. Only those fragments that were positively identified by epidermal characteristics were recorded as evidence for the presence of a plant species (Sparks and Malechek 1960). Diet composition for a species was determined on a frequency basis. Epidermal characteristics used in the identification of forage species included: size, number, shape, and arrangement of stomatal guard and subsidiary cells, orientation of long and short cells, shape of silica cells, absence or presence of epidermal hairs, size and shape of hairs, trichomes, and leaf venation patterns (Fahn1982; Metcalfe 1960; Sparks and Malechek 1960).

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Dietary preferences were determined by using a relative preference index (RPI) developed by Krueger (1972). Relative preference for a forage plant was calculated as:

RPI = % fd x D / % fr x C

Where fd = % diet frequency
    D = % diet composition
    fr = % range frequency
    C = % range composition

Diet frequency is the number of microscope fields out of 100 that a plant species was found in. Diet composition is the overall percentage that a plant species comprises based on the sum of all frequencies for plant species found in the diet. Range frequency is the number of hits out of 400 points read along the transects. Range composition is the overall percentage that a plant species comprises based on the sum of all hits for a plant species found on the range.

Species of plants not sampled in the field, but identified in prairie dog diets, were assigned a species frequency of .1% to determine a relative preference indice for that species (Uresk 1984). A value of 0 was used for diet frequency and composition when a plant species not found in prairie dog diets. This value was then divided into the percent frequency and composition a plant species was found on the range. The result is an RPI of 0, which suggests there was no preference for that plant species.

Statistical results were computed using the GLM procedures of SAS. Although each colony was observed in every season, not all plant species were found in the diet or in the study colonies every season resulting in an incomplete factorial in many cases. Because of this, seasonal colony measurements were analyzed in a one

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factor analysis of variance, and mean separation among colony means within each season and among season means within each colony were performed using pair wise contrasts. Seasonal colony means were identified as one-way factors and analyzed by linear contrasts for all 12 means. Differences between means were significant when $p < 0.05$.

RESULTS

Colony Vegetation

Forty-two plant species were identified in and around the study colonies (Table 3). For the purpose of this study ear muhly (*Muhlenbergia arenacea*) and burrograss (*Scleropogon brevifolius*) were combined because they are similar in appearance, occupy essentially the same niche, and they share microhistologic similarities. Burrograss was encountered substantially more often (90%) along vegetation transects than ear muhly (10%). Rattlesnake weed (*Chamaesyce albomarginata*) and thymeleaf spurge (*Chamaesyce serpyllifolia*) were also pooled due to similarities in microhistological appearance. Graminoids provided the greatest amount of botanical composition throughout the year and ranged from 72% to 100% (Table 3). Alkali sacaton (*Sporobolus airoides*), burrograss, tobosa (*Pleuraphis mutica*) and vine mesquite (*Panicum obtusum*) comprised 99% of the total graminoid cover. Forbs provided 1% to 26% of overall canopy cover of which most were annual species (Table 3).

Alkali sacaton was the most common grass species at the Red Lake Colony (RLC) site. This site had significantly higher average composition of alkali sacaton throughout the year than either the Deep Well Colony (DWC) or the S-Curve Colony (SCC) (Table 3). Burrograss contributed 7% to 22% of the seasonal botanical composition while tobosa was negligible at less than 1%. Few forb species were found on this site and therefore, forb composition contributed minimally to overall vegetative colony composition (Table 3). Overall canopy cover at RLC was highest during summer, decreased significantly during the fall and winter, and increased

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Table 3. Average botanical composition (%) throughout the year on black-tailed prairie dog study colonies on t

n^h =	Red Lake Colony					Dee	
	Fall	Winter	Spring	Summer	Yr. Avg.	Fall	Win
	12	13	11	10		12	1
Grasses							
Alkali sacaton	87.13[e]	76.85[e]	84.77[e]	81.92[e]	82.67	44.93[f]	43.
Black grama							
Burrograss	12.04[f]	22.94[f]	7.08[f]	7.85[f]	12.48	3.96[f]	8.9
Purple threeawn							
Tobosa				0.43	0.43	14.15	14.
Vine mesquite						28.30[ae]	29.3
Total Grasses	99.17	99.79	91.85	90.20		91.34	96.
Forbs							
Perennial							
Buffalo-gourd				0.08	0.08		
Desert Holly			4.69	1.17	2.93	0.79	
Fendler's bladderpod							
Hog potato			1.91	5.96[e]	3.94		
Longleaf ephedra							
Prostrate pigweed				0.57	0.57		
Scurfy sida			0.48[f]	0.88[f]	0.68		
Shortcrown milkweed							
Wrinkled globemallow						4.73[be]	1.5
Yellowspine thistle							
Total Perennial Forbs			7.08	8.09		5.52	1.!
Annual							
Abert's dome				0.40	0.40		
Dakota vervain						2.53[ab]	1.9
Faintcrown							
Green violet							
Hairy carpetweed							
Miniature wooly-star							
Pale globemallow							
Prairie evening primrose						0.45	
Purslane							
Russian thistle						0.18	
Scarlet creeper							
Silver-leaf nightshade							
Spruge spp.				0.82[e]	0.82		
Strapleaf spine-aster							
Tansy mustard			0.24[f]		0.24		0.3
Thicksepal cryptantha							
Townsendia							
Warty carpetweed							
Wooly indian-wheat							
Total Annual Forbs			0.24	1.22		3.16	2.:
Shrub							
Broom snakeweed							
Honey mesquite	0.83				0.83		
Total Shrubs	0.83						
Total Composition	100.00	99.79	99.17	99.51		100.02	10

[a,b,c,d] seasonal botanical composition means within colony with different letters are significantly different (p < 0.
[e,f,g] seasonal botanical composition means among colonies with different letters are significantly different (p < 0
[h] n = number of study-burrows sampled

	Well Colony				S-Curve Colony			
r	Spring	Summer	Yr. Avg.	Fall	Winter	Spring	Summer	Yr. Avg.
	11	10		15	14	13	10	
f	33.86[f]	37.49[f]	40.05	35.46[bf]	10.72[ag]	36.15[bf]	41.31[bf]	30.91
				0.19	2.27		0.38	0.95
	6.30[f]	2.30[f]	5.37	52.49[be]	72.35[ae]	43.99[be]	46.65[be]	53.87
				0.87	0.09			0.48
	21.28[e]	9.43	14.74	3.52	8.31	6.43[f]	3.00	5.32
e	17.32[be]	23.44[abe]	24.60	0.90[f]	0.83[f]	0.53[f]	1.22[f]	0.87
	78.76	**72.66**		**92.56**	**95.35**	**87.19**	**94.45**	
	2.34	1.35	1.49				0.37	0.37
				7.05[a]	3.36[ab]	7.13[a]		5.85
	2.25	2.36[f]	2.31				0.09[f]	0.09
					0.23			0.23
		1.02	1.02					
	3.32[be]	5.11[ae]	4.22				0.09[f]	0.09
		1.15	1.15					
	6.43[be]	5.13[b]	4.45			0.09[f]		0.09
		0.29	0.29					
	14.34	**16.41**		**7.05**	**3.59**	**7.22**	**0.55**	
		0.55	0.55					
)	3.82[a]	0.41[ab]	2.17		0.11	0.15		0.13
	0.62	0.20	0.41					
							0.19	0.19
						0.12		0.12
		0.75	0.75					
	0.19		0.32			1.09		1.09
		3.53	3.53					
			0.18			0.08	0.13	0.11
		0.40	0.40				0.09	0.09
		0.07	0.07					
		4.95[f]	4.95				6.46[f]	6.46
						0.20	0.20	0.20
	2.26[ae]		1.3			0.26[f]		0.26
						0.43		0.43
						0.69		0.69
							0.19	0.19
					0.34[b]	2.29[a]		1.32
	6.89	**10.86**			**0.45**	**5.31**	**7.26**	
				0.39	0.34	0.17		0.30
				0.39	0.34	0.17		
00	99.99	99.83		100.00	99.39	99.89	100.37	

)
5)

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Table 4. Average Canopy cover, bare soil, crown, and litter(%) by canopy cover throughout the year on black-taile

	n[h] =	Red Lake Colony					Deep Well Co		
		Fall	Winter	Spring	Summer	Yr. Avg.	Fall	Winter	Sp
		12	13	11	10		12	13	
Bare ground		36.29[be]	47.62[af]	46.13[af]	37.55[bf]	41.90	32.00[be]	50.10[af]	54
Canopy cover		11.18[bef]	4.23[c]	10.42[b]	17.28[af]	10.78	15.40[be]	5.37[c]	9
Crown		7.84[ae]	7.73[a]	9.77[ae]	5.40[bf]	7.69	4.81[bf]	6.50[b]	5.
Litter		51.73[ae]	43.21[be]	37.50[be]	53.83[ae]	46.57	56.52[ae]	39.54[ce]	32
Total		**107.04**	**102.79**	**103.82**	**114.06**		**108.73**	**101.51**	**10**

[a,b,c,d] seasonal means within colony with different letters are significantly different ($p < 0.05$)

[e,f,g] seasonal means among colonies with different letters are significantly different ($p < 0.05$)

[h] number of study-burrows sampled

...rairie dog study colonies on the Pedro Armendaris land Grant

...ny			S-Curve Colony				
...ng	Summer	Yr. Avg.	Fall	Winter	Spring	Summer	Yr. Avg.
	10		15	14	13	10	
3^{af}	34.40^{bf}	42.68	65.08^{ab}	71.98^{ae}	70.92^{ae}	58.56^{be}	66.63
)^{c}	39.83^{ae}	17.60	10.63^{bf}	7.07^{c}	12.60^{b}	17.63^{af}	11.98
}^{bf}	1.73^{ae}	4.63	6.23^{bef}	7.30^{a}	6.58^{abf}	4.50^{bf}	6.15
3^{ce}	48.18^{be}	44.23	22.00^{ab}	16.20^{bcf}	12.69^{cf}	25.13^{af}	19.00
19	124.14		103.94	102..55	102.79	105.82	

during spring (table 4). The percentage of bare ground at the RLC significantly increased from approximately 37% and 36% in the summer and fall respectively, to more than 46% in the winter and spring (Table 4). The amount of litter at the RLC decreased from summer and fall to winter and spring (Table 4). Crown cover within the colony was lowest during the summer than at any other time throughout the year (Table4).

Alkali sacaton and vine mesquite were the dominant grasses found at the DWC throughout the year and accounted for 76 ± 8.17% of the total graminoid composition within the colony. Tobosa contributed 9% to 21% to the overall colony composition. Burrograss was common on the site, but contributed little to overall colony composition (Table 3). The major forbs found at this site include wrinkled globemallow (*Sphaeralcea hastulata*), scurfy sida (*Malvella sagittaefolia*), Dakota vervain (*Glandularia bipinnatifida*), hog potato (*Hoffmanseggia densiflora*), purslane (*Portulaca oleracea*), and desert holly (*Acourtia nana*). Forb composition was highest in the spring and summer field seasons and ranged from 21% to 26%, respectively. Overall canopy cover was highest in the summer, decreasing during fall, and lowest in winter and spring (Table 4). The amount of bare ground did not differ significantly from the RLC and percentages increased from summer and fall to winter and spring (Table 4). The amount of litter found on this site varied from a high of 46% in the fall to 25% in the summer (Table 4). Crown cover followed the same trend as RLC, with the highest percentages in fall, winter, and spring (Table4).

The most abundant graminoids at SCC were burrograss and alkali sacaton (Table 3). These grasses made up 91 ± 3.36% of the total graminoid composition,

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with burrograss providing the majority of the cover. Other species common on the site, but contributing little to overall graminoid composition include: vine mesquite, tobosa, black grama, and purple threeawn (*Aristida purpurea*). The major forb found on this site was fendler's bladderpod (*Lesquerella fenderii*) (Table 3). Broom snakeweed (*Gutierrezia sarothrae*) added little to colony botanical composition. Overall canopy cover was highest during summer, decreased during fall and winter, and thes increased during the spring (Table 4). The percentage of bare ground at the SCC site was significantly greater than any of the other colonies (Table 4). This colony had significantly lower percentages of litter than the other study colonies, with the exception of the DWC in the summer field season (Table 4). Crown cover was lowest during the summer and highest during fall, winter, and spring (Table 4).

Diet Analysis

Twenty-three plant species were identified in black-tailed prairie dog fecal pellets (Table 5). Grasses constituted $85 \pm 9.60\%$ of the total diets of prairie dogs on these Chihuahuan Desert grassland sites. Major grasses consumed by prairie dogs were alkali sacaton and burrograss (Table 5). These species accounted for $89 \pm 16.08\%$ of the graminoid species found in fecal samples. Other grasses found in prairie dog diets include vine mesquite, tobosa, black grama, and purple threeawn. Annual and perennial forbs contributed $8 \pm 6.92\%$ to overall prairie dog diets. Major forbs found in fecal samples include wrinkled globemallow, fendler's bladderpod, wooly Indian-wheat, spurge, and scarlet creeper (Table 5). The subshrub, broom snakeweed, was found in fecal samples, but was not a major forage component.

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Table 5. Average dietary composition (%)

	Colony			
	Fall	Spring	Summer	Yr. Avg.
$n^h =$	1	10	10	
Grasses				
Alkali sacaton	53.2	28.73[abf]	36.71[bg]	39.52
Black grama			0.84	0.84
Burrograss	44.2	29.65[be]	29.14[be]	33.04
Purple threeawn		0.07	0.29	0.15
Tobosa		0.94[f]	3.93[f]	1.43
Vine mesquite		4.13[bf]	9.80[ae]	4.66
Total Grasses	**97.7**	**73.52**	**80.71**	
Forbs				
Perennial				
Fendler's bladderpod		3.76[a]	0.03[b]	3.21
Frog-fruit	0.?			
Hog potato			1.36	1.36
Scurfy sida		0.04[f]	0.51[f]	0.28
Wooly locoweed		0.65		0.66
Wrinkled globemallow	0.1	0.17[bf]	0.33[b]	0.84
Total Perennial Forbs	**0.?**	**4.62**	**2.23**	
Annual				
Dakota vervain			0.23	0.42
Faintcrown		0.09		0.09
Prostrate pigweed				
Russian thistle				
Scarlet creeper				
Smooth umbrella-wort		1.80[a]	0.04[b]	0.92
Spurge spp.			8.25[e]	8.25
Tansy mustard				
Thicksepal cyptantha				0.39
Wooly inian-wheat		11.32[a]		4.63
Total Annual Forbs		**13.21**	**8.52**	
Shrubs				
Broom snakeweed	0.2	0.14[b]	0.11[b]	2.19
Total Shrubs	**0.?**	**0.14**	**0.11**	
Unknown	1.7	8.51	8.44	8.47
Total Diet Composition	**100**	**100.00**	**100.01**	

[a,b,c,d] seasonal diet composition means with
[e,f,g] seasonal diet composition means amon
[h] n = number of study-burrows sampled

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Grasses constituted 95 ± 4.78% of the overall prairie dog diets at RLC. Alkali sacaton comprised the largest percentage of graminoids, 65 ± 12.13%, found in prairie dog diets throughout the year. Consumption of alkali sacaton was significantly higher in the spring than summer. However, selection of alkali sacaton dropped off significantly from spring and summer to fall and winter (Table 5). Alkali sacaton consumption at RLC was higher throughout the year than at DWC and SCC. Burrograss comprised 33 ± 14.34% of the grasses found in prairie dog diets. Selection was significantly higher in the fall and winter than in spring and summer (Table 5). Burrograss was found in fecal samples in the similar percentages as DWC throughout the year, but differed from quantities found in diets at SCC. Vine mesquite composed 2% to almost 5% of prairie dog diets during the spring and summer, respectively. Consumption of vine mesquite was less for DWC and SCC during the summer.

Forb and shrub use at RLC was negligible and contributed 2% and 0.3%, respectively to the overall diet. A greater number of forb species were found in prairie dog diets during the spring and summer seasons of the year (Table 5). The most common forbs found in fecal samples include scurfy sida and spurge. Wrinkled globemallow was the only forb found in prairie dog diets in each field season, however it comprised less than 1% of the diet in each season. Broom snakeweed was the only shrub found in fecal material and contributed less than 1% to the diet throughout each season.

Grasses comprised 81 ± 9.08% of the overall diet at the DWC. Alkali sacaton comprised 42 ±6.07% of the graminoids found in prairie dog diets. Consumption of

sacaton was significantly lower in summer than the other three seasons (Table 5). Percentages of sacaton found in the diets at DWC did not differ significantly from percentages found in diets at the SCC, except for the summer season. Burrograss contributed $34 \pm 17.99\%$ of the graminoid composition found in prairie dog diets at DWC. Consumption of burrograss was significantly higher during the fall and winter than spring and summer (Table 5). Vine mesquite comprised 14 to 23% of the diets in summer and spring, respectively. Consumption of vine mesquite at DWC was significantly higher in spring than at SCC. Tobosa was eaten throughout the year, but consumption was significantly higher in summer than spring. Consumption of tobosa was also higher in spring than in fall and winter (Table 5). Tobosa was consumed in greater quantities at DWC than at any of the other study colonies.

Forbs comprised $10 \pm 8.56\%$ of the overall diets at DWC. Consumption of forbs was greatest during the summer and fall. Species contributing the most to diet composition include wrinkled globemallow, scarlet creeper, spurge and scurfy sida (Table 5). Wrinkled globemallow was the most abundant forb found in fecal samples throughout the year, and was highest in fall (8%) and lowest in summer (0.7%). Wrinkled globemallow was consumed significantly more during fall, winter, and spring at DWC than at the other study sites. Scarlet creeper was found in prairie dog diets during the summer and fall seasons, with significantly more consumed in summer. Shrub use at the DWC was insignificant. Broom snakeweed comprised just 0.2% of the overall diet.

Grasses contributed $77 \pm 4.06\%$ to the overall prairie dog diets at SCC. Prairie dog diets at SCC contained a higher diversity of grass species than the other

sites. However, alkali sacaton and burrograss comprised the majority of the grass species identified in fecal samples. Sacaton was the most abundant grass found in the fecal samples and made up $50 \pm 3.91\%$ of the overall graminoid composition in the diet, ranged seasonally from 36 to 44% (Table 5). Consumption of alkali sacaton at SCC was significantly less than RLC. Burrograss comprised $42 \pm 5.39\%$ of prairie dog diets. Consumption of burrograss was significantly higher during the fall and winter seasons. Vine mesquite made up $4 \pm 5.76\%$ of the grass component in the diets and was mainly identified in the spring and summer seasons (Table 5). Tobosa contributed $1 \pm 2.10\%$ to the overall diet. Black grama and purple threeawn contributed little to diet composition in each season it occurred and were minor components in overall prairie dog diets contributing 0.3% and 0.2%, respectively.

Consumption of forbs at SCC accounted for $11 \pm 4.33\%$ of the overall diet. More forb species were consumed during the summer and spring seasons. Major forb species identified in diets include: fendler's bladderpod, wooly Indian-wheat, spurge, and wrinkled globemallow. Fendler's bladderpod made up the majority of forb dietary composition during fall and winter (Table 5). Wooly Indian-wheat comprised 63% of the dietary forb composition in spring. Hog potato was found in the diets during the summer season. Broom snakeweed was found in diets throughout the year and contributed 2% to the overall dietary composition and was greatest during the fall.

Relative Preference Indices

Preference indices at RLC reveal that burrograss was significantly preferred over alkali sacaton throughout the year (Table 6). Relative preference indices for

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Table 6. Relative preference indices of bl.

	Fal	pring	Summer	Yr. Avg.
n^j =	10	10	10	
Grasses				
Alkali sacaton	0.52	.56[bf]	1.19[be]	5.96
Black grama	-	-	23.92	7.97
Burrograss	18.0	1.27[g]	0.69[f]	0.94
Purple threeawn	-	1.01	28.06	8.89
Tobosa	-	0.08[b]	5.88[ae]	1.69
Vine mesquite	-	26.00	59.00[f]	21.00
Forbs				
Perennial				
Desert Holly	-	0.00	-	0.00
Fendler's bladderpod	-	0.48	6.05	2.94
Frog-fruit	62.2	-	-	
Hog potato	-	-	184.30	184.30
Scurfy sida	-	7.31	22.73	26.17
Wooly locoweed	-	8.49	-	65.27
Wrinkled globemallow	26.9	4.80[b]	11.80[b]	141.18
Annual				
Abert's dome	-	-	-	
Dakota vervain	-	0.00[b]	10.71	6.82
Faintcrown	-	2.39	-	2.39
Green violet	-	-	-	
Hairy carpetweed	-	-	0.00	0.00
Longleaf ephedra	-	-	-	0.00
Pale globemallow	-	-	-	
Prairie evening primrose	-	0.00	-	0.00
Prostrate pigweed	-	-	-	
Purslane	-	-	-	
Russian thistle	-	0.00	0.00	0.00
Scarlet creeper	-	-	0.00[f]	0.00
Silver-leaf nightshade	-	-	-	
Smooth umbrella-wort	-	96.60[a]	6.90[b]	151.75
Spurge spp.	-	-	2.81[f]	2.81
Strapleaf spine-aster	-	0.00	0.00	0.00
Tansy Mustard	-	0.00	-	0.00
Thicksepal cryptantha	-	-	0.00	160.90
Townsendia	-	0.00	-	0.00
Warty carpetweed	-	-	0.00	0.00
Wooly indian-wheat	-	37.60	-	24.53
Yellowspine thistle	-	-	-	
Shrubs				
Broom snakeweed	117.8	1.30[b]	8.20[b]	238.75
Honey Mesquite	0.0	-	-	

[a,b,c,d] Seasonal RPI means within colony w
[e,f,g] Seasonal RPI means among colonies v
[h] - Denotes plant species was not recorded
[i] 0.00 denotes plant species recorded on s
[j] n = number of study-burrows sampled

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burrograss were higher during the winter and fall than during the spring and summer. Preferences for burrograss, during fall and winter, at RLC were less than RPI's for burrograss during the same time at DWC and higher than SCC. Vine mesquite was heavily preferred during the spring and summer. Alkali sacaton at RLC was preferred more in the winter than at any other time during the year. No preference was revealed for tobosa.

Preference indices for forbs at RLC were variable and higher than any other RPI's reported in the literature (Table 6). Forbs with the highest RPI's include: wrinkled globemallow, Dakota vervain, spurge, and frog fruit. Relative preference indices for these forb species did not significantly differ across seasons. However, they did differ across colonies by season (Table 6). Dakota vervain was more highly preferred at RLC and SCC during the winter than at DWC. Spurge was more preferred during the summer at RLC than at the other colonies. Preferences for broom snakeweed occurred in the fall, winter, and summer seasons (Table 6).

Relative preference indices for graminoids at the DWC showed that burrograss is preferred over the other species (Table 6). However, preferences for burrograss differed significantly across all seasons, with the highest RPI occurring in the fall. Selectivity for burrograss was higher at DWC during fall, winter, and summer than at SCC. Preferences for alkali sacaton were significantly higher during winter and spring (Table 6). Preference indices for vine mesquite and tobosa were highest during spring and summer, respectively, and did not vary across seasons.

Relative preference indices for forbs at DWC indicate a preference for a few species: wrinkled globemallow, scarlet creeper, and smooth umbrella-wort (Table 6).

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Scarlet creeper was highly selected with significantly higher preferences occurring during summer during fall. Summer preferences for scarlet creeper were also significantly higher at DWC than at SCC. Selectivity for wrinkled globemallow did not differ throughout the year. Smooth umbrella-wort was preferred during the winter. Broom snakeweed was preferred throughout the year.

Preference indices for graminoids at SCC reveal that vine mesquite, black grama, and purple threeawn were the most preferred species during summer (Table 6). Tobosa was selected more during the summer than at any other time during the year. Unlike DWC and RLC, alkali sacaton was preferred over burrograss and was consumed significantly more during winter (Table 6).

Selection for various forbs at SCC throughout the study was varied. Important forbs selected for at the SCC colony include wrinkled globemallow, Indian buckwheat, smooth umbrella-wort, hog potato, and wooly locoweed (Table 6). Other forbs selected for during this time period include Indian buckwheat and scurfy sida. Wooly locoweed, wrinkled globemallow, and Dakota vervain were selected for during the winter season.

DISCUSSION

Colony vegetation

Red Lake Colony contained the fewest plant species of all three study colonies. Since the prairie dogs were reintroduced on this site in 1998, a seven-wire electrical fence has surrounded this colony and serves as a mammalian predator deterrent. This fence has also kept large herbivores such as bison, antelope, and oryx out of the interior of the colony. Therefore, the grazing effects of these large herbivores have not contributed to changes in vegetation in the interior of the colony. The relatively short time period the prairie dogs have occupied this site, it has not been sufficiently long enough to substantially alter the vegetation on their own. Due to the initial low-density of reintroduced prairie dogs on the RLC, grazing pressure by prairie dogs over this 3-yr period has not been sufficient enough to change the vegetation composition within the colony.

The DWC and SCC colonies contained a higher diversity of graminoids than RLC prior to the addition of prairie dogs and have been subjected to continued grazing by the large herbivores found in the area. Bison and antelope have been have been observed grazing within the colonies. Although these colonies are newer, herbivory effects of large mammals combined with the grazing effects of prairie dogs has, no doubt changed the vegetative structure and composition at this colony quicker than at the RLC. Different soil type and topography at SCC also explains the occurrence of graminoid species not found on the other sites such as black grama and purple threeawn. The significant decrease in alkali sacaton canopy cover at the SCC during the winter season may be an artifact of sampling four extra burrows. Since

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this colony has significantly higher percentages of bare ground and areas of different topography, significant differences could occur from season to season depending on which extra burrows were sampled within the colony.

Percentages of litter found on the colonies, especially at RLC and DWC appear to be slightly higher than what is described in the range site description for these areas. This can be attributed to the fact that prior to reintroducing the prairie dogs the sites had to be mowed to decrease vegetation height. Therefore the residual vegetation clippings left by the mowing and the clipping of plants by prairie dogs has inflated the amount of litter on the sites to artificial levels.

Diet Analysis

Black-tailed prairie dogs reintroduced into Chihuahuan Desert grasslands prefer graminoids to forbs and shrubs throughout the year. These findings agree with studies conducted in the Great Plains and shortgrass prairie regions, which have established that prairie dogs are primarily gramnivores (Fagerstone et al. 1981; Fagerstone and Williams 1982; Kelso 1939; Lehmer and Van Horne 2001; Stinnett 1981; Summers and Linder 1978; Tiletston and Lechleitner 1966; Uresk 1984). Although prairie dogs preferentially select for graminoids, relative preferences and their composition in the diets vary throughout the year.

Relative preference indices were developed to determine which forage species were preferentially selected for by prairie dogs. Relative preference indices were developed for prairie dogs using vegetation data compiled from all study burrows, because preference indices based on individual study burrows were extremely high and did not accurately measure prairie dog preferences. As RPI values increase so

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does preference for that species. RPI's approaching 1 indicate that a species is being consumed in proportion to its availability on the range. Relative preference indices that are < 1 suggest that prairie dogs are consuming forage species in less quantities than their availability on the colonies. An RPI of 0 denotes no preference for a species.

Relative preference indices developed for species consumed by prairie dogs in Chihuahuan Desert grasslands were at times much higher than indices reported in the literature (Uresk 1984). Two factors could have resulted in high RPI values. First, forage species just may not have been encountered along the vegetation transects. Secondly, prairie dogs may have been consuming plant species found outside the sampling areas. Prairie dog foraging behavior may be spatially influenced by several mechanisms. Forage availability and social behavior may be the principle forces influencing how far prairie dogs will travel to forage. As forage species decrease in abundance around burrows, animals need to travel further to obtain the necessary forage to fulfill their nutritional requirements. Prairie dogs may also simply travel further to obtain highly palatable forages. Social behavior may also dictate how far prairie dogs will go to forage. Prairie dogs rely on the vigilance of many prairie dogs to aid in the detection of predators. Therefore, a lower number of prairie dogs above ground may limit prairie dog foraging to those areas in close proximity to the burrow. As the number of prairie dogs above ground increases, so does the number of "watchful eyes," therefore prairie dogs may venture further away from their burrow to forage on species not found close by.

In order to establish RPI values for a species found in the diets, but not sampled on the study sites a 0.1% frequency was assigned to those species not sampled on the colonies. Consequently, this minimal frequency will exaggerate preference values for that species. However, for species that are major components of prairie dog diets and that are abundant on the range, preference indices become more accurate. Seasonal RPI's were developed from compiled vegetative data from all transects sampled over an entire colony for each season.

Alkali sacaton and burrograss were important forage species throughout the year at all three colonies. Preferences and consumption of alkali sacaton varied from colony to colony throughout the year. However, consumption of alkali sacaton was higher during the spring than during the summer. This may be attributed to the highly nutritious young shoots beginning to grow in the spring. The significantly larger amounts of alkali sacaton consumed at RLC can be attributed to its large abundance within the colony. Consumption of alkali sacaton at the other colonies was significantly less because there was less alkali sacaton and more species to select from.

Relative preference indices and consumption of burrograss were higher than alkali sacaton throughout each season at RLC and DWC. This was unexpected because burrograss is generally not considered to be a valuable forage species due to long wiry awns on the seeds and harsh stiff leaves (Humphrey 1990). Burrograss consumption was lowest in summer and spring and increased in fall and winter. Increased preferences for burrograss during the fall and winter seasons may be based on the phenological attributes of burrograss. Structurally, burrograss is much shorter

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than other graminoid species and therefore contains less silica, lignin, and other structural components used for support in taller plants. As taller species senesce the amount of mature standing material increases and becomes less palatable as a forage species. The smaller amount of structural material in burrograss may provide prairie dogs with a more palatable forage species during the fall and winter seasons. An alternative explanation for selection of burrograss during the fall and winter seasons may be that it retains some nutritional quality that fulfills the nutritional requirements of prairie dog during this time of year. The nutritional qualities of burrograss need to be investigated further to discern its importance as a forage species for prairie dogs.

Relative preference indices and consumption for vine mesquite and tobosa were higher during the spring and summer seasons when these species are most palatable. Stinnett (1981) found that tobosa was a major species consumed by prairie dogs. Although the RPI's for vine mesquite at the RLC were inflated, preference for this species should not be overlooked. Vine mesquite is highly regarded as an excellent forage species for herbivores and it seems that prairie dogs are actively searching out this species. Prairie dog consumption of black grama and purple threeawn was negligible. The high RPI's for these species are an artifact of low occurrence on the range.

Consumption of forbs varied by season for each colony. Typically, prairie dogs consumed more species of forbs during the summer and spring seasons, which corresponds to the time of greatest abundance of forbs on the colonies. However, dietary composition of forbs in prairie dog diets varied throughout the year. The low occurrence of forbs in the diets at RLC is a direct result of the low vegetative

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diversity found at this site. The incidence of wrinkled globemallow in the diets throughout the year at each study site indicates that it may be of benefit to prairie dogs. Other studies have shown globemallow to be an important forage species for prairie dogs (Bonham and Lerwick 1977; Fagerstone et al. 1981; Hansen and Gold 1977; Kelso 1939; Stinnett 1981; Summers and Linder 1978; Uresk 1984). Scarlet creeper was an important diet component at DWC during the summer season. Wooly Indian-wheat was important in prairie dog diets during the spring at SCC. Summers and Linder (1978) and Uresk (1984) found that prairie dogs consumed wooly Indian-wheat in minor amounts. Fendler's bladderpod was an important forb component in the diet during fall, winter, and spring.

As observed in other studies, prairie dogs do consume shrubs, however they are usually minor components in the diets (Stinnett 1981; Uresk 1984). Broom snakeweed seemed to be an important forage species for prairie dogs during the fall season at SCC. Snakeweed was also found in the diets of prairie dogs in southeastern New Mexico (Stinnett 1981). It has been hypothesized that prairie dogs select for shrubs during the winter and fall as their need for water increases (Koford 1958; Stinnett 1981). Since forb production decreases this time of year, snakeweed may become a source of preformed water for prairie dogs. Koford (1958) found that, in general, shrub consumption increased during fall and winter months after other preferred species had matured.

Although it has been documented that prairie dogs will consume insects, there was no evidence of insect fragments found in prairie dog fecal material (Fagerstone et al. 1981; Koford 1958; Stinnett 1981; Uresk 1984; Whitehead 1925). The

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consumption of root material by prairie dogs was not investigated, however it has been shown that prairie dogs will consume root material (Kelso 1939; Koford 1958; Tiletston and Lechleitner 1966).

Forage species that are highly preferred or abundant in the diets may be substantially reduced throughout the colony initiating a grazing induced succession. As graminoids decrease through grazing by prairie dogs, areas within the colony will become favorable for propagation of invasive forb species, litter cover will decrease, and bare ground will increase. The effects that prairie dog have on preferred species in the Chihuahuan Desert will vary. Alkali sacaton will tend to decrease on the range under heavy grazing, while burrograss, is known as an increaser under heavy grazing. Since burrograss is not generally considered to be a preferred forage species, studies are lacking that document the response of burrograss to intense grazing pressure. Presumably as burrograss decreases, areas of bare ground will increase, potentially making conditions favorable for forb and shrub encroachment.

As prairie dog reintroductions continue, thought needs to be given as to how desert grasslands will be affected. The effects of herbivory by prairie dogs and other animals found on the range will substantially alter Chihuahuan Desert grasslands. Therefore, range managers and wildlife biologists must agree on how to best manage the grasslands for optimal wildlife and livestock value.

Management Implications

Among the factors to consider when selecting reintroduction sites for black-tailed prairie dogs, the potential availability of food resources relied upon by prairie dogs is critical. Identifying those forage species that meet or surpass the nutritional requirements of prairie dogs will inevitably improve the success of reintroductions. Results from this study suggest that prairie dogs consume alkali sacaton, burrograss, vine mesquite, and tobosa throughout the year. Therefore, sites containing these species should be considered potential sites for reintroduction of prairie dogs. High relative preference indices for vine mesquite and burrograss during spring and fall, respectively, may suggest that these species might be more important to prairie dogs during times of physiological stress than other forage species. Therefore, potential reintroduction sites containing an abundance of these species should be a priority. Consumption and preferences for burrograss by reintroduced prairie dogs suggests that sites with a large component of burrograss may be more ideally suited as reintroduction sites than previously thought. The short stature of burrograss will also facilitate reintroduction efforts by eliminating vegetation reduction efforts. Further research is needed to discern how reintroduction sites containing different vegetative components affect prairie dog demographics. Understanding how the nutritional properties of important forage species change throughout the year may also provide insight as to which vegetative combination may better meet prairie dog nutritional requirements survival and throughout the year.

Although RPI's for certain species appear to be somewhat artificially inflated, they should not be overlooked as important forage species for prairie dogs. Although,

relative preference indices for vine mesquite were unbelievably high at RLC, it was evident that prairie dogs were actively seeking out this species. Vine mesquite is widely regarded as an excellent forage species. However reintroducing prairie dogs into areas with a high abundance of vine mesquite may not be a practical management initiative. Since vine mesquite is associated with lower, wetter habitat areas the possibility of prairie dog burrows occasionally being flooded does exist.

Understanding which forbs are important to prairie dogs throughout the year may not facilitate the selection of reintroduction sites due to the low abundance of forbs found in mature grassland stands. Presumably forb consumption by prairie dogs is an opportunistic event. As prairie dog grazing and disturbances increase at new reintroduction sites, areas throughout the colony will become susceptible to invasion by forbs. Only once forbs start to become common in the colony will they become large components in prairie dog diets.
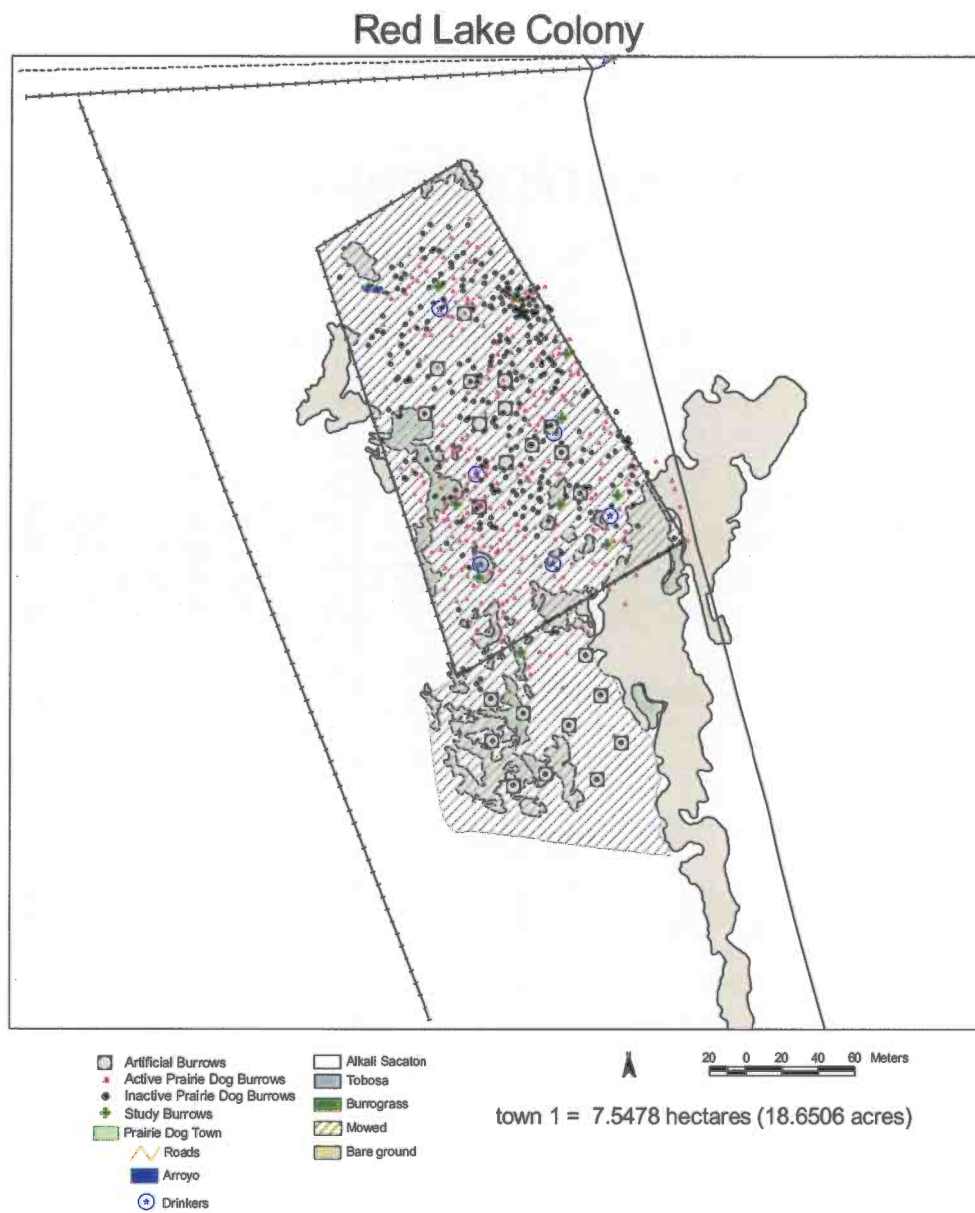
APPENDIX

Red Lake Colony

Artificial Burrows
Active Prairie Dog Burrows
Inactive Prairie Dog Burrows
Study Burrows
Prairie Dog Town
Roads
Arroyo
Drinkers

Alkali Sacaton
Tobosa
Burrograss
Mowed
Bare ground

20 0 20 40 60 Meters

town 1 = 7.5478 hectares (18.6506 acres)

Figure A1. Map of Red Lake South prairie dog colony

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Deep Well Colony

▣ Artificial Burrows	☐ Alkali Sacaton		
▲ Active Prairie Dog Burrows	▨ Tobosa		
● Inactive Prairie Dog Burrows	▨ Burrograss		
✚ Study Burrows	▨ Mowed		
▨ Prairie Dog Town	▨ Bare ground		
∧∧ Roads			
▬ Arroyo			
⊛ Drinkers			

N

20 0 20 40 60 Meters

town 1 = 1.2704 hectares (3.1390 acres)
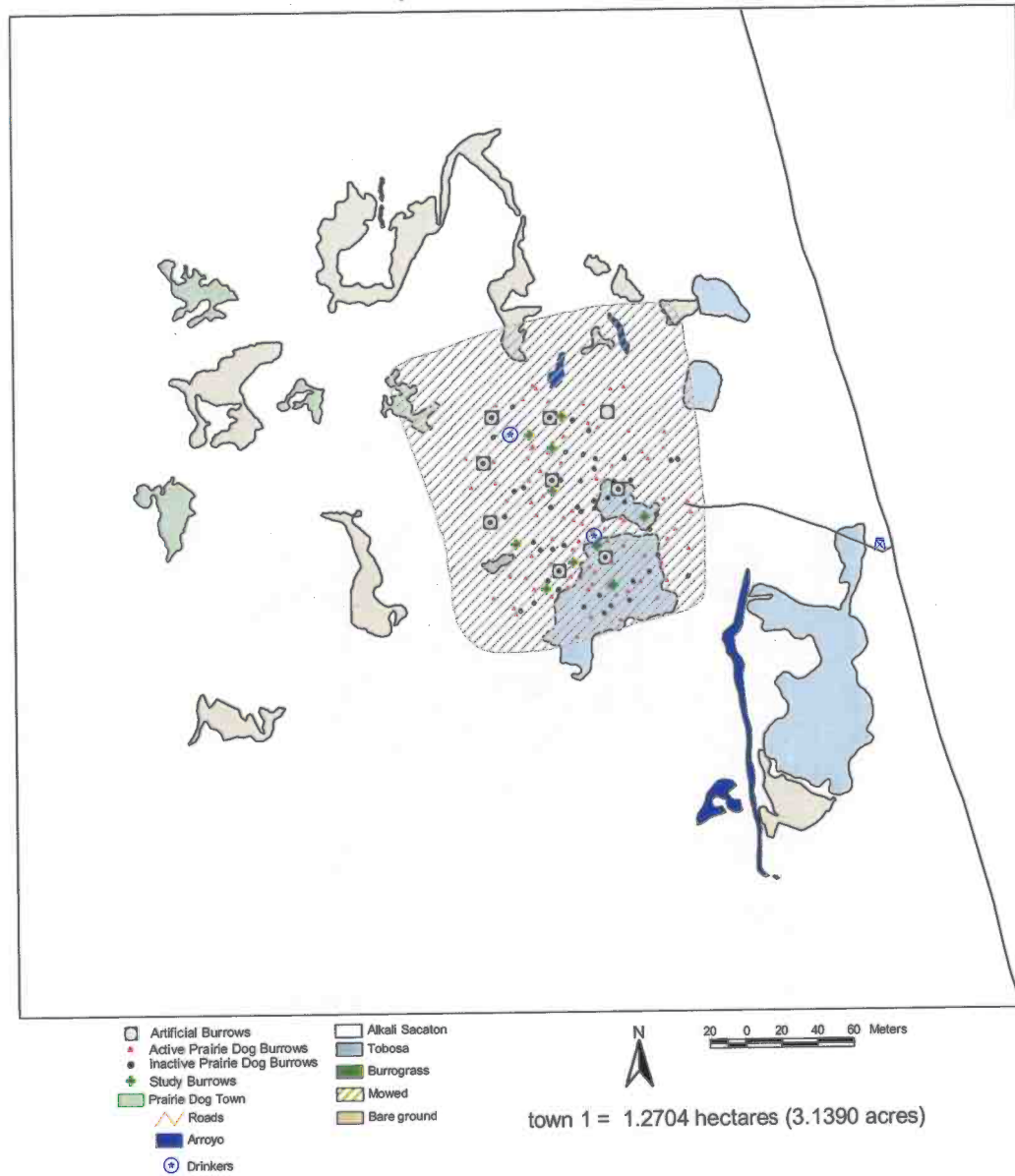
Figure A2. Map of Deep Well prairie dog colony

S-Curve Colony

Legend:
- Artificial Burrows
- Active Prairie Dog Burrows
- Inactive Prairie Dog Burrows
- Study Burrows
- Prairie Dog Town
- Roads
- Arroyo
- Drinkers
- Alkali Sacaton
- Tobosa
- Burrograss
- Mowed
- Bare ground
- Powerline
- Bison Trail
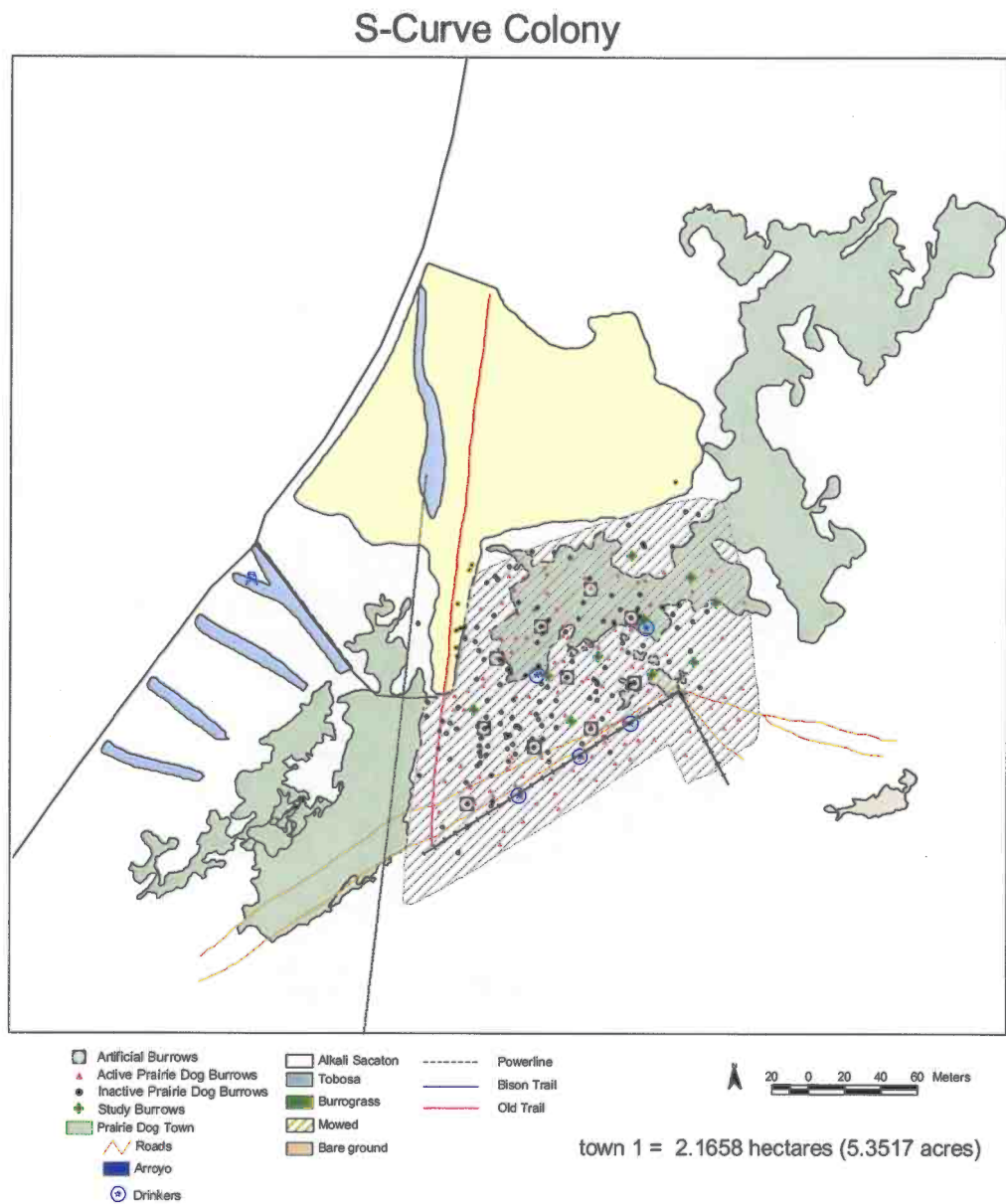- Old Trail

20 0 20 40 60 Meters

town 1 = 2.1658 hectares (5.3517 acres)

Figure A3. Map of S-Curve prairie dog colony

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