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Factors Influencing Relocation Success of Utah Prairie Dog (Cynomys parvidens)

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FACTORS INFLUENCING RELOCATION SUCCESS

OF UTAH PRAIRIE DOG (*CYNOMYS PARVIDENS*)

by

Rachel Curtis

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ABSTRACT

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Rachel Curtis, Master of Science

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Major Professor: Dr. S. Nicole Frey
Department: Wildland Resources

Utah prairie dogs (*Cynomys parvidens*) have been extirpated in 90% of their historical range. Because most of the population occurs on private land, this threatened species is continually in conflict with landowners. The Utah Division of Wildlife Resources has been relocating prairie dogs from private to public land since the 1970s, but relocations have been largely unsuccessful due to high mortality. Prairie dogs are highly social animals, but they are usually relocated without regard to their family group (coterie). I hypothesized that relocating Utah prairie dogs with their social structure intact may positively affect their survival rates and behavior. Utah prairie dogs were relocated from the golf course in Cedar City, Utah to two prepared sites near Bryce Canyon National Park, Utah in 2010 and 2011. Trapped animals were individually marked, and released at the new sites. Prairie dogs were relocated as coteries, or in a control group as randomly trapped individuals. To compare the two sites, vegetation

transects were established at each site to document differences in composition and structure. Two months after relocation, traps were set to recapture released animals. Activity budgets were collected prior to, and following, relocation. Activity data were also collected on wild prairie dog populations for comparison. The best predictor of survival and recapture rate was the animal's weight at initial capture. Larger animals had higher survival, but lower recapture rates. More research is needed to determine if this is due to better body condition, older animals having more experience, or both. Analysis showed no evidence of an advantage to relocating Utah prairie dogs by coteries. There was no benefit to survival, and no difference in behavior between coterie and control relocation strategies. Relocated animals behaved differently from non-relocated prairie dogs. While still significantly different, relocated individuals behaved more like wild prairie dogs than the animals at the urban source population. The vegetation at the two sites was significantly different. One site had significantly less grass cover, more invasive plant cover, and rockier soils. The sites also had different soil structures, which affect burrowing, and long-term retention rates. More research is needed to determine how site selection influences long-term success of a relocation site.

(94 pages)

PUBLIC ABSTRACT

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Utah prairie dogs have been extirpated in 90% of their historic range due to introduced disease, eradication, and habitat destruction. Most of the population lives on private land where animals burrow in lawns and agricultural fields, which keeps this threatened species continually in conflict with landowners. The Utah Division of Wildlife Resources has been relocating prairie dogs from private to public land since the 1970s, but relocations have been largely unsuccessful due to high mortality. Prairie dogs are highly social animals, but they are usually relocated without regard to their family group, or coterie. Coteries typically consist of one reproductive male, several females, and non-reproductive juveniles. Coteries have separate territories and burrow systems within the larger prairie dog colony. If Utah prairie dogs were relocated with their social structure intact, it may affect their survival rates and behavior.

To test this idea, prairie dogs were relocated from the golf course in Cedar City, Utah to two prepared sites near Bryce Canyon National Park, Utah in 2010 and 2011. Release sites had man-made burrow systems, and water was provided while the prairie dogs grew accustomed to their new surroundings. Prairie dogs were trapped, marked with numbered eartags, and released at the new sites. Animals were relocated as coterie groups, or in control groups of individuals trapped with no regard to relatedness. Animals in the different treatments were relocated to separate areas of the relocation sites. Two months after relocation, traps were set to recapture the released prairie dogs, and determine how many animals stayed at their release site. The best predictor of survival and recapture rate was the animal's weight at initial capture. Larger animals had higher survival, but lower recapture rates. Large animals may have higher survival because they have higher fat stores that allow them to survive the stress of relocation. The larger, older animals may also have more experience avoiding predators than young, naïve juveniles. It could also be a combination of body condition and experience. More research is needed to determine the cause of the observed trend, and to determine a minimum weight for future relocation attempts. I observed no survival advantage to relocating Utah prairie dogs with their coterie.

Activity budgets were collected prior to, and following, relocation. Activity data were also collected on wild populations for comparison. Analysis showed no difference in behavior between prairie dogs relocated as coteries, and those relocated with no regard to relatedness. Relocated animals behaved differently from non-relocated prairie dogs.

While still different, relocated individuals behaved more like wild prairie dogs than the animals at the urban source population.

Survival rates were different between study sites. To compare the two sites, vegetation transects were established to document differences in composition and structure. The vegetation at the two sites was significantly different. One site had significantly less grass cover, more invasive plant cover, and rockier soils. The sites also had different soil structures, which affect burrowing, and long-term retention rates. More research is needed to determine how site selection influences the long-term success of a relocation site.

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CONTENTS

Page

ABSTRACT ii

PUBLIC ABSTRACT iv

ACKNOWLEDGMENTS vii

LIST OF TABLES x

LIST OF FIGURES xi

CHAPTER

1. INTRODUCTION 1

OBJECTIVES 4
LITERATURE REVIEW 5

Natural History 5
Behavior 7
Habitat and Food 9
Causes for Population Decline 10
Relocation of Utah Prairie Dogs 13

LITERATURE CITED 16

2. SURVIVAL AND BEHAVIOR OF RELOCATED UTAH PRAIRIE DOGS 20

Study Area 27
Methods 32
Results 39
Discussion 49
Management Implications 57
Literature Cited 57

3. DIFFERENCES IN VEGETATION CHARACTERISTICS OF RELOCATED UTAH PRAIRIE DOG RELEASE SITES 61

Study Area 65
Methods.....69
Results.....71
Discussion.....75
Management Implications.....77
Literature Cited.....77

4. SUMMARY 80

LIST OF TABLES

Table Page

2-1 Utah prairie dog behavior list adapted from Foster-McDonald et al. 2006. 33

2-2 Number of Utah prairie dogs relocated by treatment and site each year, Garfield and Iron Counties, Utah 39

2-3 Recapture frequencies of Utah prairie dogs relocated in 2010 and 2011, Garfield County, Utah 40

2-4 Utah prairie dog relocation survival models created in Program MARK ranked by corrected Akaike's Information Criterion (AICc). Relocations were conducted in 2010 and 2011, Garfield County, Utah 41

2-5 Utah prairie dog cumulative instantaneous behavior observations in 2010 and 2011, Iron and Garfield Counties, Utah. The table includes both the simplified list used in the analysis, and the initial recorded behavior 44

2-6 Univariate results of permutation procedure comparing percent of activity between two groups of Utah prairie dogs. Observations collected in 2010 and 2011, Iron and Garfield Counties, Utah. Reporting standardized test statistic and Pearson Type III probability of a lower delta (approximated p-value) 45

3-1 Plant classes and dominant species composition of Utah prairie dog relocation sites, Garfield County, Utah, August 2011 72

LIST OF FIGURES

Figure Page

2-1 Utah prairie dog study area locations: the source population site at Cedar Ridge Golf Course in Cedar City, Iron County; Lime Kiln and Pat Willis Wash relocation areas, and a wild Utah prairie dog site at Berry Springs, Garfield County, Utah 28

2-2 Locations of Utah prairie dog release sites within the two relocation study areas 29

2-3 Pat Willis control release site, Garfield County, Utah, 2011. The site contains five burrow systems, each with two entrances and an underground chamber. Water is provided by a 3-gal steel poultry waterer. Chicken wire retention cages are placed over the burrow entrances 29

2-4 Utah prairie dog estimated daily survival rate and 95% confidence intervals by initial capture weight (kg) for animals relocated in the summers of 2010 and 2011, Garfield County, Utah 42

2-5 Utah prairie dog estimated recapture rate and 95% confidence intervals by initial capture weight (kg) for animals relocated in the summers of 2010 and 2011, Garfield County, Utah 43

2-6 Average time spent in activity (%) for Utah prairie dog within each group. Observations were collected in 2010 and 2011, Iron and Garfield Counties, Utah 47

2-7 Visual counts comparing the number of Utah prairie dogs observed at the release sites in 2011 compared to the number of animals relocated to that site over time, Garfield County, Utah 48

3-1 Utah prairie dog study area locations: the source population site at Cedar Ridge Golf Course in Cedar City, Iron County; Lime Kiln and Pat Willis Wash relocation areas, Garfield County, Utah 66

3-2 Locations of Utah prairie dog release sites within the two relocation study areas 67

3-3 Pat Willis control release site, Garfield County, Utah, 2011. The site contains five burrow systems, each with two entrances and an underground chamber. Water is provided by a 3-gal steel poultry waterer. Chicken wire retention cages are placed over the burrow entrances.....67

3-4 Average cover (%) of plant classes with standard error bars, Garfield County, Utah, in August 2011. Asterisk indicates $P < 0.05$.....73

3-5 Average cover (%) of soil surface layer between relocation sites with standard error bars. Point intercept surveys conducted in August 2011, Garfield County, Utah. Asterisk indicates $P < 0.05$ 73

3-6 Locations of Utah prairie dog burrows in relation to the release sites within both relocation study areas. Note the larger scale at the Pat Willis site. Locations were mapped in October 2011.....74

CHAPTER 1

INTRODUCTION

Prairie dogs are a diurnal, burrowing member of the squirrel family, Sciuridae, and the genus *Cynomys* (meaning dog-mouse). There are five separate species: black-tailed (*C. ludovicianus*) and Mexican (*C. mexicanus*) prairie dogs in the black tailed subgenus; and Gunnison's (*C. gunnisoni*), white-tailed (*C. leucurus*), and Utah (*C. parvidens*) prairie dogs in the white tailed subgenus. At the beginning of the 20th century it was estimated that there were 1-5 billion prairie dogs in North America (U. S. Fish and Wildlife Service 1991, Slobodchikoff et al. 2009). By 2009 the population had declined to only 1-2% of their historic numbers due to factors including sylvatic plague (*Yersinia pestis*), poisoning, predation, and habitat destruction and degradation. This reduction may have ecosystem effects because prairie dogs play an important role in grasslands, affecting nutrient cycling and plant diversity. For example, the decline of prairie dog populations is associated with the decline of other species including black-footed ferret, swift fox, burrowing owl, golden eagle, and ferruginous hawk (Slobodchikoff et al. 2009).

Utah prairie dogs occur only in southwestern Utah, and have been extirpated in much of their historic range. In the 1920s the population was estimated at 95,000, but by 1972 had declined to 3,300 (U.S. Fish and Wildlife Service 1991). Utah prairie dogs were listed as federally endangered in 1973, but reclassified as threatened in 1984 (U.S. Fish and Wildlife Service 1991). In 2010, Utah prairie dog populations numbered approximately 11,000 (N. Brown, Utah Division of Wildlife Resources, personal

communication). Population recovery is slow due to sylvatic plague outbreaks, and because Utah prairie dogs have slow reproductive and population growth rates (Slobodchikoff et al. 2009).

The U.S. Fish and Wildlife Service only counts populations on federal land toward recovery goals because on these lands the Utah prairie dog will still be protected following delisting. Foraging, burrowing, and their protected status create conflict between landowners and prairie dogs (Elmore and Messmer 2006a). In 2010, 83% of the prairie dogs counted occurred on private land (N. Brown, personal communication), with a high percentage on agricultural land (U.S. Fish and Wildlife Service 1991). To ease the conflict and increase countable populations, the Utah Division of Wildlife Resources has been relocating Utah prairie dogs from private lands to public land since 1972 (U.S. Fish and Wildlife Service 1991), within the bounds of the Endangered Species Act legislation. These relocations have been largely unsuccessful due to high mortality (N. Brown, personal communication), and therefore have done little to improve the population status.

Few relocation studies have been conducted on Utah prairie dogs, but some research has been published on relocating black-tailed prairie dogs. Researchers have found that it is very important to place animals in areas with soils conducive to burrowing, preferably to a site with a pre-existing burrow system (Roe and Roe 2003). If natural burrows are not available, artificial systems can be created with burrows and nest boxes (Truett et al. 2001). Vegetation should be shorter than 30 cm to enhance visibility, often making it necessary to mow vegetation before relocating black-tailed prairie dogs (Roe and Roe 2003). Black tailed prairie dog relocation success is higher when animals

are relocated in larger groups. Reduced emigration from, and increased immigration to, a site may be due to greater sense of security in a larger group and larger habitat patch sizes (Robinette et al. 1995).

Prairie dogs are highly social animals, living in large colonies. Within each dog town, groups of closely related individuals, or coteries, maintain and defend territories containing separate burrow systems and associated food resources (Hoogland 1995). However, in Gunnison's prairie dogs social patterning may be determined by resources rather than kinship (Verdolin and Slobodchikoff 2009). Utah prairie dog coteries typically contain several closely related females, and young non-reproductive males. A single reproductive male is typically associated with each coterie (Manno 2007). Anti-predator vigilance, performed by scanning the immediate vicinity and warning other individuals is an important behavior for prairie dogs. For Utah prairie dogs, individuals are more vigilant when fewer family members are active (Manno 2007).

In a study conducted by Shier (2006), relocating coteries significantly improved relocation success in black-tailed prairie dogs over relocating animals with no regard to relatedness, particularly for adult females. Female black-tail prairie dogs, specifically yearling females, relocated as a coterie showed increased reproductive success. Juveniles relocated later in the season had higher survival than those relocated earlier in the summer. Relocation with a family unit also affected behavior. Individuals in the family treatment group spent more time engaging in social behaviors, foraging, and digging burrows than their unrelated counterparts (Shier 2006). However, another black-tail study found no survival advantage to coterie relocation (Bly-Honness et al. 2004), and

Ackers (1992) suggested that the quality of relocation site has a greater effect on post-release behavior than relatedness of individuals.

OBJECTIVES

The purpose of my study was to determine if trapping and relocating intact coteries improved Utah prairie dog translocation success. I attempted to answer the following questions: (1) did the survival rate of relocated prairie dogs increase when animals were relocated as a coterie compared to animals relocated with no regard to relatedness? (2) was there a difference in behavior between relocated coterie and control treatments? and (3) is survival correlated to vegetation characteristics at the relocation site?

I hypothesized that Utah prairie dogs relocated with family groups would have higher survival rates than those not relocated as a coterie, and that individuals relocated as a coterie would remain with family members instead of dispersing.

A change in behavior post-relocation may be an underlying cause of low survival, and I hypothesized that relocated prairie dogs would display more vigilant behavior, and less foraging behavior, than non-relocated animals. I also expected that individuals relocated with a coterie would spend more time foraging, and less time displaying vigilance than animals relocated with no regard to kinship.

Because I evaluated relocated prairie dogs at two separate sites I supposed that a difference in the grass, forb, and shrub vegetation composition and structure at relocation sites may affect the survival of released animals, such that a large disparity may have been correlated with increased emigration from the study site. Researchers relocating

black-tailed prairie dogs suggest that the quality of the release site may influence the survival of relocated animals more than the social group (Bly-Honness et al. 2004). I hypothesized that lower quality sites with less grass and forb cover would be correlated to a higher level of emigration, and to a lower number of new burrows.

LITERATURE REVIEW

Natural History

Prairie dogs have relatively short life spans; populations can decrease rapidly, but increase slowly and unpredictably (Slobodchikoff et al. 2009). The Utah prairie dog breeding season lasts from mid-March to early April, and reproductive females produce only one litter of pups annually (Slobodchikoff et al. 2009). Utah prairie dog mothers rear their pups in separate nursery burrows that they defend from other prairie dogs. Females will nurse juveniles above ground, which is rarely seen in other prairie dog species. Mothers typically nurse their own young, but will also nurse the young of other coterie members (Hoogland 2009).

Mean litter size, at emergence from the burrow, is 3.88 pups. Utah prairie dog litters are usually sired by multiple males. In one study, litters sampled in 1996 and 1997 showed multiple paternity in 71% and 90% of the litters studied. In comparison, black-tailed prairie dog litters exhibit multiple paternity 5-10% of the time (Haynie et al. 2003). Utah prairie dog survivorship for the first year is less than 60%, and adult survival remains low (Hoogland 2001).

Male Utah prairie dogs, both adults and juveniles, are larger than females, except during late pregnancy. Large male size may be sexually selected for since large males

are more likely to have breeding territories than small males, and are more able to defend young against infanticidal males. Middle aged animals are heavier than young and older individuals (Hoogland 2003). Males are also the primary dispersers, and tend to go further distances when dispersing than females (Slobodchikoff et al. 2009). Female black-tailed prairie dogs usually spend their entire lives in the coterie territory where they were born (Hoogland 1995). Even following habitat manipulation, adult female prairie dogs show high fidelity to their traditional use-areas (Foster-McDonald et al. 2006).

Relatedness within a coterie varies among prairie dog species. Utah prairie dog coteries typically contain several closely related females, and young non-reproductive male offspring. Usually a single reproductive male is associated with the coterie (Manno 2007). In Gunnison's prairie dog populations, one study (Verdolin and Slobodchikoff 2009) found that the relatedness of coterie members did not vary significantly from random. They found that kin selection did not maintain the social group structure, and suggested that social patterning may be determined by resources. In black-tailed and Gunnison's prairie dogs it appears to be very difficult for new members to join a social group in a new colony (Slobodchikoff et al. 2009).

While torpor in black-tailed prairie dogs show short bouts (the number of hours spent in torpor before a rewarming period) following circadian patterns, Utah prairie dog torpor lasts for days, which is similar to other hibernators. Furthermore, Utah prairie dog hibernation varies by elevation. High elevation animals enter hibernation earlier in the autumn, and stay underground later in the spring. In prairie dog populations at higher elevations (3000 m), prairie dogs reached significantly lower minimum body

temperatures than the low elevation animals (1,575 m), and bout length was longer in high elevation sites. Variation in hibernation patterns seems to be due to environment rather than physiological differences, and may be translated to different metabolic requirements based on elevation (Lehmer and Biggins 2005). Male Utah prairie dogs typically begin hibernating in August or September, with females following a few weeks later. Juveniles are aboveground one to two months longer than adults. Occasionally animals are observed aboveground during winter months (U.S. Fish and Wildlife Service 1991).

Behavior

Many studies have been conducted on the social behavior of prairie dogs, particularly black-tailed prairie dogs. While many aspects of behavior are similar, there are differences among the species. For example, social grooming is common in black-tailed prairie dog species, but rarely occurs in Utah prairie dogs. Additionally, female relatives are the perpetrators of infanticide in black-tailed prairie dogs (Slodochikoff et al. 2009), while infanticide in Utah prairie dogs is less common and occurs when males immigrate into a new territory (Hoogland 2007).

Research into the social structure of prairie dogs has shown a complex organization rivaling some primates (Slobodchikoff et al. 2009). Alarm calls are given to warn relatives about potential predators, and studies conducted on Gunnison's prairie dogs have shown these calls to be very specific; there are different calls for predators which elicit different evasive responses. Alarm calls can describe characteristics of predators; for example different colors of domestic dogs, or the size, shape, and clothing

color of human researchers. The level of "dangerousness" is also conveyed. For example, a different call is used for a human carrying a gun versus one who is not. The alarms calls are not the same for all prairie dog species, and even vary slightly by colony. Vocalizations used in a social context, or social chatter, have been recorded, and some linked to specific behaviors (Slobodchikoff et al. 2009).

Anti-predator vigilance by scanning the immediate vicinity and warning other individuals is an important behavior for social animals. For Utah prairie dogs, individuals are more vigilant when fewer family members are active. Utah prairie dogs fall prey to many predator species, including American badgers (*Taxidea taxus*), coyotes (*Canis latrans*), long-tailed weasels (*Mustela frenata*), red foxes (*Vulpes vulpes*), golden eagles (*Aquila chrysaetos*), and northern goshawks (*Accipiter gentilis*; Hoogland et al. 2006). Vigilance varies primarily with the risk of predation, but social monitoring also affects vigilance. Reproductive males are more vigilant than non-reproductive males, particularly when other reproductive males are present. Males are more vigilant than females regardless of the reproductive status of either. Also, females who have lost their litter are more vigilant than lactating females (Manno 2007). Captive, juvenile black-tailed prairie dogs showed no sexual differences in vigilance behavior (Shier and Owings 2007). A study by Elmore and Messmer (2006b) on Utah prairie dog interactions with cattle found that prairie dogs, particularly juveniles, spent more time foraging and less time being vigilant in high grazing treatments compared to control and low grazing treatments. The low grass height associated with grazing increases visibility, but also

reduces available forage. This could negatively affect the prairie dogs by increasing risk of predation, or decreasing energy intake.

Habitat and Food

For all prairie dog species grasses are the major component of the diet, although forbs and shrubs are frequently consumed. Invertebrates are not typically consumed, although remains are occasionally found in fecal samples. As with many herbivores, prairie dog diet varies seasonally based on available species (Slobodchikoff et al. 2009).

By comparing how much of a plant was consumed versus how common it was at the site, researchers have been able to determine if a plant species was preferred or avoided. In a study by Lehmer et al. (2006), Utah prairie dogs preferred scarlet globemallow (*Sphaeralcea coccinea*) and cheatgrass (*Bromus tectorum*) in each season and elevation. Animals in low elevations preferentially foraged on western wheatgrass (*Elymus smithii*), Indian ricegrass (*Stipa hymenoides*), scarlet globemallow, and needle-and-thread grass (*Hesperostipa comata*). Mid elevation animals preferred to forage on cheatgrass and scarlet globemallow, while high elevation animals foraged on wheatgrass species, cheatgrass, and sedges (*Carex* spp.). Utah prairie dogs avoided shrub species such as rubber rabbitbrush (*Chrysothamnus nauseosus*), Douglas rabbitbrush (*Chrysothamnus viscidiflorus*), and black sagebrush (*Artemisia nova*; Lehmer et al. 2006).

Prairie dogs establish complex burrow systems. Burrows are used as refugia, and contain nursery chambers for juveniles. Temperatures in burrows are higher in winter, and lower in summer than the surface temperature. The soil type affects burrow

construction, but in black-tailed prairie dogs does not affect burrow density (Hoogland 1995). Soils must allow deep burrow systems for overwintering animals (U.S. Fish and Wildlife Service 1991). At any time 40-60% of Utah prairie dogs will be visible aboveground (U.S. Fish and Wildlife Service 1991).

Causes for Population Decline

Grazing – Prairie dog towns often occur in areas grazed by cattle; grazing by livestock is a dominant land use activity throughout the Utah prairie dog population range (Elmore and Messmer 2006b). Studies on the effect of grazing on prairie dogs have shown mixed results. In a study conducted by Cheng and Ritchie (2006) simulated grazing, or mowing, to mimic cattle grazing improved the vegetation quality in Utah prairie dog towns, and prairie dogs preferentially foraged in simulated grazing patches. However, animals in heavily "grazed" areas showed significantly lower growth rates than those in an ungrazed control. In this case moderate to heavy livestock grazing may have negative impacts to prairie dogs due to reduced growth rates. However, a study by Elmore and Messmer (2006b) found that grazing level does not affect either Utah prairie dog numbers or burrow densities.

Vegetation has been shown to affect burrow densities. Mow and burn treatments create suitable conditions for colony expansion of black-tailed prairie dogs by increasing available habitat and predator visibility. These treatments increase the rate of colony expansion, and influence its direction (Northcott et al. 2008).

Utah prairie dog habitat has been steadily degraded by heavy cattle grazing and unnatural fire regimes. This has led to a reduction in grasses and forbs, and an increase

in shrubby plant communities (Elmore and Messmer 2006b, Slobodchikoff et al. 2009). Federal, state, and private land managers have tried to improve Utah prairie dog habitat by removing shrubs. While more expensive, mechanical treatments may be a better method for shrub reduction than grazing (Elmore and Messmer 2006b).

Plague – Sylvatic plague (*Yersinia pestis*) is not native to North America, arriving in San Francisco in 1899 or 1900, most likely from Asia. More than 200 mammalian species can be infected, or act as hosts for the disease. A single bite from a flea can transmit enough plague bacteria to kill a prairie dog. Plague was first documented in Utah prairie dogs in 1936. They have scant resistance to plague, and mortality can be 85-99% in a few days to a few weeks (Slobodchikoff et al. 2009). Outbreaks have been reduced using an edible "vaccine," and dusting burrows and animals with deltamethrin insecticidal dust. Interestingly, because prairie dogs are very susceptible to the disease, they usually die before transmitting plague to humans (Slobodchikoff et al. 2009), and thus pose very little health threat to humans.

Human Interaction – There is a high level conflict between Utah prairie dog populations and landowners. A survey of Utah residents conducted by Elmore and Messmer (2006a) in rural, urban, and agricultural settings found that perceptions about prairie dogs vary. Most rural and agricultural respondents felt that Utah prairie dogs should only occur on public land, while most urban respondents believed they should be on both public and private land. Landowners who had prairie dogs on their property were more likely to respond that the animals had no place in southern Utah; however, the majority of landowners felt that prairie dogs had a place in the ecosystem on public land.

Agriculture producers reported that prairie dogs affected their livelihood by loss of forage, equipment damage, horse and livestock injury, loss of economic opportunity, and a loss of public animal unit months (AUMs) due to Utah prairie dog presence (Elmore and Messmer 2006a).

Black-tailed prairie dog colonies show extremely high densities in urban areas compared to rural habitat (Magle et al. 2010). These colonies have value for educational purposes and as source populations for translocation, but the fragmentation associated with an urban landscape has disadvantages. In the Denver, Colorado area urban prairie dog colonies have become genetically different from each other, although the colonies have not been separated long enough to show evidence of inbreeding. The study by Magle et al. (2010) showed extreme isolation due to development, but habitats throughout prairie dog ranges are becoming increasingly modified and fragmented.

Black-tailed prairie dogs in rural colonies retreated into burrows at greater distances when a human researcher approached the colony than prairie dogs in urban settings, suggesting that urban prairie dogs are more accustomed to humans than rural prairie dogs (Magle et al. 2005). Utah prairie dogs show similar increased tolerance in areas with high human activity. However, repeated human disturbance caused black-tailed prairie dogs in both rural and urban settings to retreat into burrows earlier even though the interaction was non-lethal. They did not become acclimated to the researcher's presence, in fact the animals became more sensitive with continued disturbance (Magle et al. 2005).

Relocation of Utah Prairie Dogs

Utah prairie dogs are relocated to increase the prairie dog population in new colonies throughout their historic range. Some removal of prairie dogs is allowed, and relocations are conducted on animals that would otherwise be destroyed. Relocation can also be used as mitigation for development activities under Habitat Conservation Plans (U.S. Fish and Wildlife Service 2009). Surviving animals can then be counted toward species recovery. Relocation sites are prepared with artificial burrows and nest boxes prior to release, and predator control is also conducted following relocation.

Few relocation studies have been conducted on Utah prairie dogs, but some research has been published on relocating black-tailed prairie dogs. Researchers have found that it is very important to place animals in areas with soils conducive to burrowing. Burrows in sandy, rocky, and gravely soils are likely to collapse. Well drained fine sandy loam soils without gravel are favored. Black-tailed prairie dogs are likely to disperse when relocated to areas with poor soil structure (Roe and Roe 2003). Relocated Utah prairie dogs disperse in a random fashion. Dispersing animals construct shallow temporary burrows, which makes them vulnerable to predation until deep burrow systems are established (U.S. Fish and Wildlife Service 1991). It is important that Utah prairie dogs are relocated to a site with a pre-existing burrow system, preferably natural burrows (Roe and Roe 2003). If natural burrows are not available, artificial systems can be created with burrows and nest boxes (Truett et al. 2001).

Black tailed prairie dog relocation success is higher when animals are relocated in larger groups. In a study in Colorado, black-tailed prairie dogs were relocated in groups

of 10, 30, and 60 animals. There was heavy mortality for all groups immediately following relocation. However, the 60 prairie dog group showed greater daily survival rates, and was the only treatment group to show an increase in number the following year. Reduced emigration from, and increased immigration to, the site may be due to greater sense of security in the larger group and larger habitat patch sizes (Robinette et al. 1995). Additionally, for Utah prairie dogs it is important that animals are not released in, or near, established prairie dog colonies (U.S. Fish and Wildlife Service 1991), due to high dispersal following agonistic interactions with resident prairie dogs (Ackers 1992).

Translocation success may also depend on the predator-experience of the relocated population. In a study by Shier and Owings (2007), captive juvenile black-tailed prairie dogs had higher translocation survivorship when reared with predator-experienced adults than captive juveniles without experienced adults. Trained juveniles mimicked the response of an experienced adult when exposed to ferrets, hawks, snakes, and a cottontail control. However, even captive juveniles reared with an adult behaved differently around predators than wild-reared juveniles, suggesting that they do not differentiate predators the same way. Translocated wild juveniles had higher survival after one year than the captive juveniles without an experienced adult, but there was no significant difference between wild and captive-trained juveniles (Shier and Owings 2007). However, relocations of captive and wild juveniles occurred in different years, so other factors may have contributed to survival. Regardless of age, survival of relocated black-tailed prairie dogs decreased significantly with increased predation (Shier 2006).

A translocation study conducted by Ackers (1992) found that relocated Utah prairie dogs spend more time alert and moving than non-translocated resident prairie dogs. In the first 1-3 days following release, animals exhibited considerable alert and running behaviors, and very rarely foraged. Dispersal was also very high during this time period. Relocating animals to quality sites with refuge from predators reduced dispersal and exploratory behavior.

Relocating family groups significantly improved relocation success in black-tailed prairie dogs over relocating animals with no regard to relatedness, particularly for adult females. Female black-tail prairie dogs, specifically yearling females, relocated as a coterie showed increased reproductive success. Relocation with a family unit also affected behavior. For example, individuals translocated as a family spent more time engaging in social behaviors, foraging, and digging burrows than their unrelated counterparts (Shier 2006). However, another study found no survival advantage to coterie relocation (Bly-Honness et al. 2004), and Ackers (1992) suggests that the quality of relocation site has a greater effect on post-release behavior than relatedness of individuals. Ackers found that released Utah prairie dogs behaved independently of social constraints, and social units did not form in the initial months following relocation. Behaviors such as exploring, vigilance, and burrow construction overrode the tendency to divide into social groups. In fact, Ackers determined that the most important factor driving post-release behavior was the presence of natural burrows. There was no behavioral difference between Utah prairie dogs released into an extirpated site and

resident, non-relocated prairie dogs, which suggests that habitat may have a greater affect on behavior than social group (Ackers 1992).

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CHAPTER 2

SURVIVAL AND BEHAVIOR OF RELOCATED UTAH PRAIRIE DOGS

Utah prairie dogs (Cynomys parvidens) have been extirpated in 90% of their historical range. Because most of the population occurs on private land, this threatened species is continually in conflict with landowners. The Utah Division of Wildlife Resources has been relocating Utah prairie dogs from private to public land since the 1970s, but relocations have been largely unsuccessful due to high mortality. Utah prairie dogs are highly social animals, but they are usually relocated without regard to their family group, or coterie. I hypothesized that relocating Utah prairie dogs with their social structure intact may improve their survival rate and result in behavior similar to non-relocated animals. Utah prairie dogs were relocated from the golf course in Cedar City, Utah to two prepared sites near Bryce Canyon National Park, Utah in 2010 and 2011. The animals were trapped, individually marked, and released at the new sites. Prairie dogs were relocated as coteries, or in a control group of individuals trapped with no regard to relatedness. Two months after relocation, traps were set to recapture released animals for a survival estimate. Activity budgets were collected prior to, and following, relocation. Activity data were also collected on wild prairie dog populations for comparison. The best predictor of survival and recapture rate was the animal's weight at initial capture. Larger animals had higher survival, but lower recapture rates. Analysis showed no evidence of a survival or behavioral advantage to relocating Utah prairie dog coteries. While still significantly different, relocated individuals behaved more like wild prairie

dogs than the animals at the urban source population. Larger, older Utah prairie dogs should be relocated to increase relocation success rate.

Prairie dogs are a diurnal, burrowing member of the squirrel family, Sciuridae, and the genus *Cynomys* (meaning dog-mouse). There are five separate species: black-tailed (*C. ludovicianus*) and Mexican (*C. mexicanus*) prairie dogs in the black-tailed subgenus; and Gunnison's (*C. gunnisoni*), white-tailed (*C. leucurus*), and Utah (*C. parvidens*) prairie dogs in the white-tailed subgenus. At the beginning of the 20th century, it is estimated that there were between 1 and 5 billion prairie dogs in North America (U.S. Fish and Wildlife Service 1991, Slobodchikoff et al. 2009). By 2009 populations had declined to only 1-2% of their historic numbers due to factors including sylvatic plague (*Yersinia pestis*), poisoning, predation, and habitat destruction and degradation. This reduction may have ecosystem effects because prairie dogs play an important role in grasslands, affecting nutrient cycling and plant diversity. The decline of prairie dog populations is associated with the decline of other species including black-footed ferret (*Mustela nigripes*), swift fox (*Vulpes velox*), burrowing owl (*Athene cunicularia*), golden eagle *(Aquila chrysaetos)*, and ferruginous hawk (*Buteo regalis*; Slobodchikoff et al. 2009).

Utah prairie dogs occur only in southwestern Utah, and have been extirpated in much of their historic range. In the 1920s, the population was estimated at 95,000, but had declined to 3,300 animals by 1972 (U.S. Fish and Wildlife Service 1991). Utah prairie dogs were listed as federally endangered in 1973, but reclassified as threatened in 1984 (U.S. Fish and Wildlife Service 1991). In 2010, Utah prairie dog populations

numbered approximately 11,000 (N. Brown, Utah Division of Wildlife Resources, personal communication). Population recovery has been slow due to sylvatic plague outbreaks and because Utah prairie dogs have slow reproductive rates (Hoogland 2001, Slobodchikoff et al. 2009).

The U.S. Fish and Wildlife Service only counts populations on federal land toward recovery goals because the Utah prairie dog will still be protected following delisting on these lands. Foraging, burrowing, and their protected status create conflict between landowners and prairie dogs (Elmore and Messmer 2006a). In 2010, 83% of the prairie dogs counted occurred on private land (N. Brown, personal communication), with a high percentage on agricultural land (U.S. Fish and Wildlife Service 1991).

Utah prairie dogs have been relocated from private lands to public land since 1972 (U.S. Fish and Wildlife Service 1991) to increase prairie dog numbers in new colonies throughout their historic range. Some removal of Utah prairie dogs from private land is allowed, and relocations are conducted on animals that would otherwise be destroyed. Relocation can also be used as mitigation for development activities under Habitat Conservation Plans (U.S. Fish and Wildlife Service 2009). Surviving animals can then be counted toward species recovery. Relocation sites are prepared with artificial burrows and nest boxes prior to release, and predator control is also conducted following relocation. These relocations have been largely unsuccessful due to high mortality (N. Brown, personal communication), and therefore have done little to improve the population status.

Few relocation studies have been conducted on Utah prairie dogs, but some research has been published on relocating black-tailed prairie dogs. Researchers have found that it is very important to place animals in areas with soils conducive to burrowing. Burrows in sandy, rocky, and gravely soils are likely to collapse. Well drained fine sandy loam soils without gravel are favored. Black-tailed prairie dogs are likely to disperse when relocated to areas with poor soil structure (Roe and Roe 2003). Relocated Utah prairie dogs disperse in a random fashion. Dispersing animals construct shallow temporary burrows, which makes them vulnerable to predation until deep burrow systems are established (U.S. Fish and Wildlife Service 1991). It is important that Utah prairie dogs are relocated to a site with a pre-existing burrow system, preferably natural burrows (Roe and Roe 2003). If natural burrows are not available, artificial systems can be created with burrows and nest boxes (Truett et al. 2001).

Black-tailed prairie dog relocation success is higher when animals are relocated in larger groups. In a study in Colorado, black-tailed prairie dogs were relocated in groups of 10, 30, and 60 animals. There was heavy mortality for all groups immediately following relocation. However, the 60 prairie dog group showed greater daily survival rates, and was the only treatment group that increased in number the following year. Reduced emigration from, and increased immigration to, the site may be due to a greater sense of security in the larger group and larger habitat patch sizes (Robinette et al. 1995). Additionally, for Utah prairie dogs it is important that animals are not released in, or near, established prairie dog colonies (U.S. Fish and Wildlife Service 1991), due to high dispersal following agonistic interactions with resident prairie dogs (Ackers 1992).

Translocation success may also depend on the predator experience of the relocated animals. In a study by Shier and Owings (2007), captive juvenile black-tailed prairie dogs had higher translocation survivorship when reared with predator-experienced adults than captive juveniles without experienced adults. Trained juveniles mimicked the response of an experienced adult in response to ferrets, hawks, snakes, and a cottontail control. However, even captive juveniles reared with an adult behaved differently around predators than wild-reared juveniles, suggesting that they do not differentiate predators the same way. Translocated wild juveniles had higher survival after one year than the captive juveniles without an experienced adult, but there was no significant difference between wild and captive-trained juveniles (Shier and Owings 2007). However, relocations of captive and wild juveniles occurred in different years, so other factors may have contributed to survival. Regardless of age, survival of relocated black-tailed prairie dogs decreased significantly with increased predation (Shier 2006).

A translocation study conducted by Ackers (1992) found that relocated Utah prairie dogs spend more time alert and moving than non-translocated resident prairie dogs. In the first 1-3 days following release, animals exhibited considerable alert and running behaviors, and rarely foraged. Dispersal was also high during this time period. Relocating animals to quality sites with refuge from predators reduced dispersal and exploratory behavior.

Relocation success may also depend on the social structure of prairie dog colonies. Within each dog town, groups of closely related individuals, or coteries, maintain and defend territories containing separate burrow systems and associated food

resources (Hoogland 1995). Utah prairie dog coteries typically contain several closely related females and young, non-reproductive male offspring. Usually a single reproductive male is associated with the coterie (Manno 2007). Males are also the primary dispersers, and tend to go further distances when dispersing than females (Slobodchikoff et al. 2009). Female black-tailed prairie dogs usually spend their entire lives in the coterie territory where they were born (Hoogland 1995). Even following habitat manipulation, adult female prairie dogs show high fidelity to their traditional use-areas (Foster-McDonald et al. 2006). In black-tailed and Gunnison's prairie dogs, it appears to be difficult for new members to join a social group in a new colony (Slobodchikoff et al. 2009).

Anti-predator vigilance, performed by scanning the immediate vicinity and warning other individuals is an important behavior for prairie dogs. For Utah prairie dogs, individuals are more vigilant when fewer family members are active (Manno 2007).

Relatedness within a coterie varies among prairie dog species. In Gunnison's prairie dog populations, Verdolin and Slobodchikoff (2009) found that the relatedness of coterie members was random. They found that kin selection did not maintain the social group structure, and suggested that social patterning may be determined by resources.

In a study conducted by Shier (2006), relocating coteries significantly improved relocation success in black-tailed prairie dogs over relocating animals with no regard to relatedness, particularly for adult females. Female black-tailed prairie dogs, specifically yearling females, relocated as a coterie showed increased reproductive success. Juveniles relocated later in the season had higher survival than those relocated earlier in the

summer. Relocation with a family unit also affected behavior. Individuals relocated in a family group spent more time engaged in social behaviors, foraging, and digging burrows than their unrelated counterparts (Shier 2006). However, another study found no survival advantage to coterie relocation (Bly-Honness et al. 2004), and Ackers (1992) suggested that the quality of relocation site has a greater affect on post-release behavior than relatedness of individuals.

Ackers (1992) found that released Utah prairie dogs behaved independently of social constraints, and social units did not form in the initial months following relocation. Behaviors such as exploring, vigilance, and burrow construction overrode the tendency to divide into social groups. In fact, Ackers determined that the most important factor driving post-release behavior was the presence of natural burrows. There was no behavioral difference between Utah prairie dogs released into an extirpated site and resident, non-relocated prairie dogs, which suggests that habitat may have a greater affect on behavior than social group (Ackers 1992).

The purpose of my study was to determine if trapping and relocating intact coteries improved Utah prairie dog translocation success. I attempted to answer the following questions: (1) did the survival rate of relocated prairie dogs increase when animals were relocated as a coterie compared to animals relocated with no regard to relatedness? and (2) was there a difference in behavior between relocated coterie and control treatments?

I hypothesized that Utah prairie dogs relocated with family groups would have higher survival rates than those not relocated as a coterie, and that individuals relocated as a coterie would remain with family members instead of dispersing.

A change in behavior post-relocation may be an underlying cause of low survival, and I hypothesized that relocated prairie dogs would display more vigilant behavior, and less foraging behavior, than non-relocated animals. I also expected that individuals relocated with a coterie would spend more time foraging, and less time displaying vigilance than animals relocated with no regard to kinship.

STUDY AREA

This study was comprised of four study areas (Fig. 2-1); the first was the source Utah prairie dog population located on the Cedar Ridge Golf Course in Cedar City, Iron County, Utah. In the first year of the study, some animals were also trapped and relocated from additional urban sites, such as baseball fields and equestrian centers, throughout Cedar City. In the second year of the study, all study animals were trapped and relocated from Cedar Ridge Golf Course. The course was roughly 1780 m in elevation, and received approximately 30 cm of precipitation annually (Western Regional Climate Center 2011a). Sprinkler irrigation provided supplemental water at the golf course. The course utilized a combination of bluegrass (*Poa* sp.) and bentgrass (*Agrostis* sp.), and the dominant soil type was loam (Soil Survey Staff 2012). Average maximum temperatures ranged from 5.7˚C in January to 32.3˚C in July (Western Regional Climate Center 2011b).

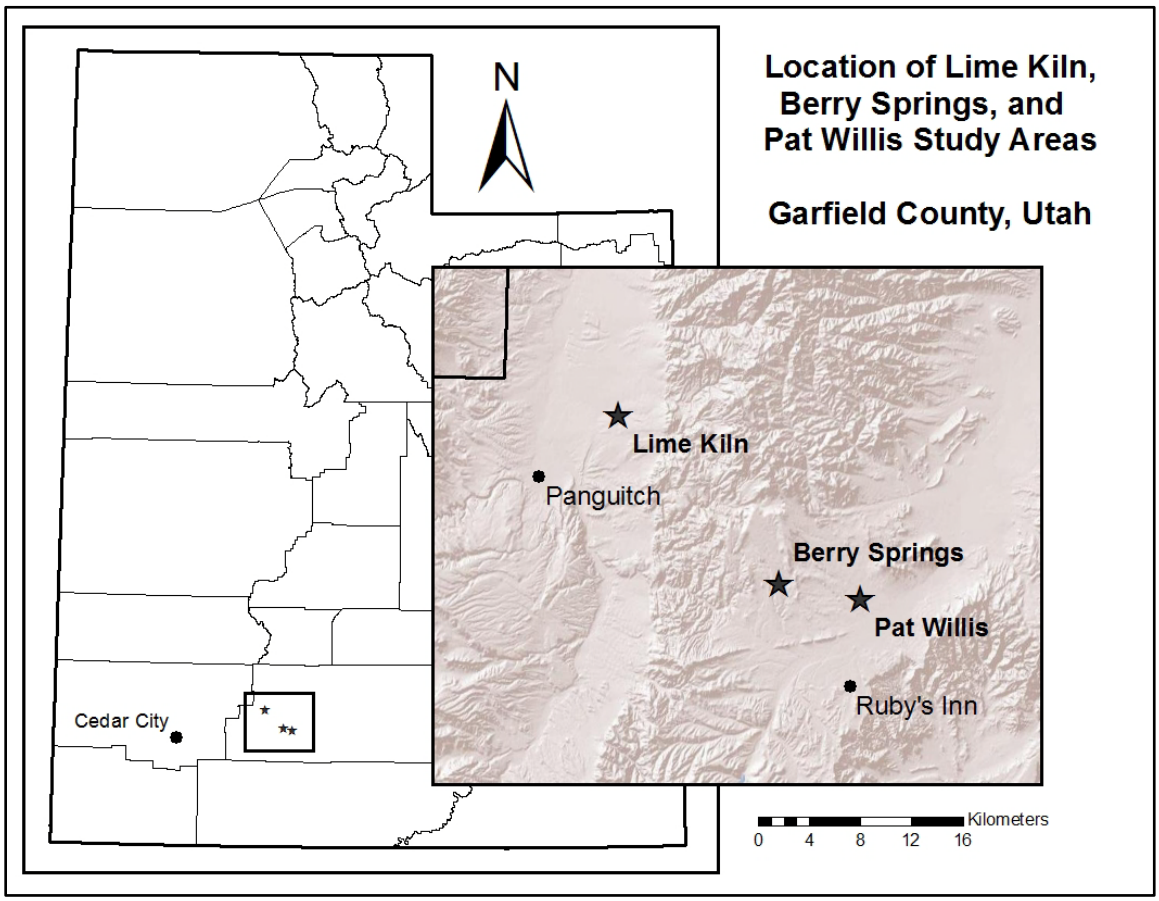


Figure 2-1: Utah prairie dog study area locations: the source population site at Cedar Ridge Golf Course in Cedar City, Iron County; Lime Kiln and Pat Willis Wash relocation areas, and a wild Utah prairie dog site at Berry Springs, Garfield County, Utah.

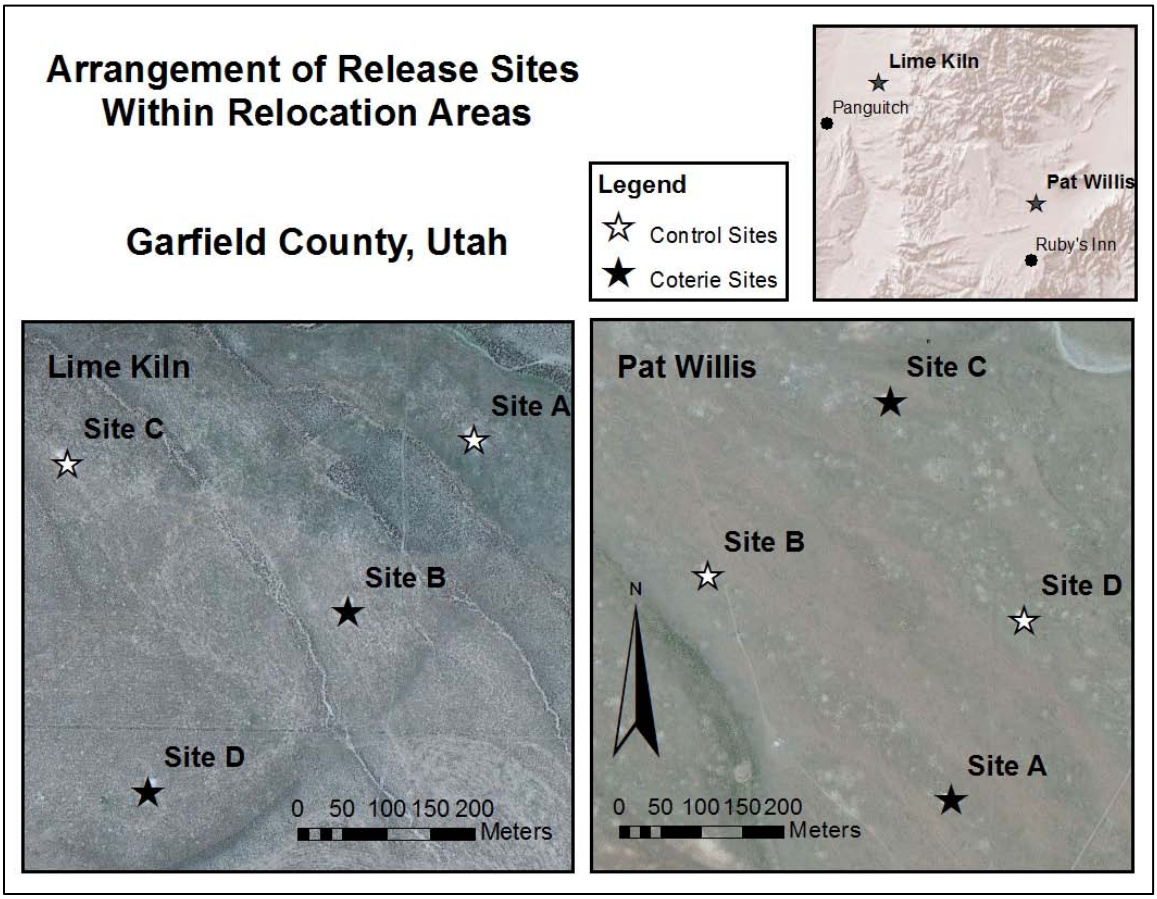


Figure 2-2: Locations of Utah prairie dog release sites within the two relocation study areas.

Figure 2-3: Pat Willis control release site, Garfield County, Utah, 2011. The site contains five burrow systems, each with two entrances and an underground chamber. Water is provided by a 3-gal steel poultry waterer. Chicken wire retention cages are placed over the burrow entrances.

There were 2 relocation study areas. The first study area, Lime Kiln, was located 8 km northeast of Panguitch, Garfield County, Utah, and was managed by the U.S. Bureau of Land Management. In the Lime Kiln study area a 1-km² area of brush was removed, and reseeded using a Great Basin Research Center (Ephraim, Utah) grass and forb seed mix in December of 2008. Dominant recorded plant species included Palmer's penstemon (*Penstemon palmeri*), blue grama (*Bouteloua gracilis*), blue flax (*Linum lewisii*), Indian ricegrass (*Stipa hymenoides*), needle-and-thread (*Hesperostipa comata*), big sagebrush (*Artemisia tridentata*), black sagebrush (*A. nova*), annual mustard, and an assortment of wheatgrass (*Elymus*) species. During the study, average plant height was 36 cm. Soils ranged from gravelly to very cobbly loam (Soil Survey Staff 2012). Panguitch received approximately 25 cm of precipitation annually (Western Regional Climate Center 2011a). Average maximum temperatures ranged from 4.0˚C in January to 29.2˚C in July (Western Regional Climate Center 2011b). Elevation at Lime Kiln was roughly 2080 m.

The Pat Willis study area was in John's Valley north of Bryce Canyon National Park, Garfield County, Utah, and was managed by the U.S. Forest Service. The study area was part of a long drainage of available habitat covering over 10 km². This area had wild prairie dog colonies approximately 500 m to the south and southeast of the release site, and a release site constructed 1 km from the current study area in 2011. The Pat Willis study area was historically reseeded with crested wheatgrass (*Agropyron christatum*). Additional plant species included needle-and-thread, big sagebrush, black sagebrush, rabbitbrush (*Chrysothamnus nauseosus*), broom snakeweed (*Gutierrezia*

sarothrae), and sedges (*Carex* spp.). The average plant height was 27 cm, with silty to cobbly loam soils (Soil Survey Staff 2012). Bryce Canyon National Park, 17 km south of the study site, received approximately 40 cm of annual precipitation (Western Regional Climate Center 2011a); average maximum temperatures ranged from 1.4˚C in January to 26.6˚C in July (Western Regional Climate Center 2011b). The elevation at Pat Willis Wash was approximately 2330 m.

Each relocation study area contained four release sites (Fig. 2-2) greater than 200 m apart, while each site contained 5 burrows 4 m apart. A buried sprinkler box provided a nest chamber, and flexible piping provided 2 entrances for each burrow. Retention cages were placed over each burrow entrance (Fig. 2-3), which also served to protect relocated animals from predators. Water was provided at each site. Two release sites were used for the coterie relocation, and 2 for non-coterie relocation (control) animals. Predator removal of coyotes (*Canis latrans*) and badgers (*Taxidea taxus*) at or near release sites was conducted at both relocation study areas by U.S.D.A. Wildlife Services, but not at Cedar Ridge Golf Course or Berry Springs.

The fourth study area, Berry Springs, also in Garfield County, was used to observe the behavior of a wild Utah prairie dog population. Berry Springs was a previously successful relocation site 6.5 km west of the Pat Willis study area. Elevation, precipitation, temperature and species present in Berry Springs were similar to those at Pat Willis.

METHODS

Activity Budgets

To assess changes in behavior, activity budgets were determined for the Utah prairie dogs prior to, and following, relocation. Additionally, activity budgets were determined for the Berry Springs wild population. To begin, I collected observational data at Cedar Ridge Golf Course based on the methodology of previous studies of black-tailed prairie dogs (Magle et al. 2005, Foster-McDonald et al. 2006). Within the study site, I randomly selected a section of the site to observe. This was especially important at the Golf Course, where only a portion of the population was visible at any given location. After arriving on site, I allowed 15 minutes for the prairie dogs to habituate, and return to normal behavior before observations were collected. To start the observations, I randomly selected a Utah prairie dog and observed it for 5 minutes, recording its activity every 15 seconds from a pre-defined list of behaviors (Table 2-1).

A new individual was selected for each 5 minute observation session, and each animal was observed no more than once per day (Foster-McDonald et al. 2006). Observations of the same animal on separate days were considered to be independent. The time of day that observations were made was randomly selected from eight 2-hour time intervals from 0600 to 2200 hours during the first study season. During the second season, I conducted observations from 0800 to 2000 hours in six 2-hour intervals due to the absence of prairie dog activity in the early morning and late evening (personal observation, Hoogland 2009). After the 2-hour time period was over, the observer moved

to another section of the study area and repeated the process, continuing throughout the day.

Table 2-1: Utah prairie dog behavior list adapted from Foster-McDonald et al. 2006.

Vigilance	
Upright	Animal stands on its hind legs, apparently searching for danger. Animal may forage in upright posture.
Semi-Vigilant	Animal lifts its head for 1-5 sec, apparently examining its surroundings. Animal may forage while semi-vigilant.
Peeking	Animal peeks head out of burrow without entering or exiting.
Aggression	
Chase	Animal pursues another animal or is pursued.
Run Away	Following an approach by another dog, the animal runs away from it, with no pursuit involved.
Tail Spread	Ritualized form of aggression that involves exposure and sniffing of anal glands.
Fight	Animal involved in aggressive direct physical contact with another individual; biting, scratching, etc.
Social	
Grooming	Animal involved in grooming. Designated self or social grooming.
Friendly	Animal involved in friendly display, such as nuzzling or body touching, not classified as grooming.
Other Activities	
Walking	Walking, not in conjunction with another behavior.
Running	Running, not in conjunction with aggressive behaviors.
Foraging	Foraging, but not engaging in any vigilant behavior.
Burrowing	Animal burrowing or digging.
Other	Animal involved in activity not listed above.
Out of View	Animal not visible to observer. Typically inside burrow.

Determining the Coterie

In June 2010, Utah prairie dogs were observed for 2 weeks prior to trapping. I monitored social interactions to determine coterie boundaries, and marked estimated boundary locations on a map. Next, single door Tomahawk wire box-traps (18 x 18 x 50 cm; Tomahawk Live Trap Company, Hazelhurst, WI) were placed near the burrow entrances, and baited with a mixture of peanut butter and sweet oats. Traps were checked each hour to reduce stress to captured animals. Once trapped, animals were marked with commercial hair dye to identify family group. Although prairie dogs are traditionally marked with Nyanzol-D branding dye (Greenville Colorants, Greenville, SC), I chose to use human hair dye because it is less caustic, and I did not need the mark to last for several months. Prairie dogs typically molt in September (Hoogland 1995), and the more gentle hair dye lasted for the few weeks I collected post-relocation dispersal data. The first season I placed the dye on a small patch of fur, the color and location of the mark designated the coterie. Marked animals were then released back into their burrow system. Activity budget observations were continued for another 2 weeks to determine if the estimations of social group were accurate, and if the marking method was effective. All Utah prairie dog trapping and marking was conducted with the Utah Division of Wildlife Resources.

After the 2-week period ensuring that the marking strategy was effective, the Utah Division of Wildlife Resources began trapping Utah prairie dogs and relocating them to the two relocation sites. Following relocation, behavioral observations were conducted using the same methodology as pre-relocation, with the release site also being randomly

selected. In the second season of the study, pre-relocation data were not collected. Behavioral observations on wild Utah prairie dogs at the Berry Springs site were collected using the same methodology. Methods were approved by the Institutional Animal Care and Use Committee at Utah State University (IACUC # 1427).

I calculated activity budgets of common behaviors by determining the percent of time each prairie dog spent engaged in each behavior using SAS (SAS Institute Inc., Cary, NC). Any behavior that accounted for less than 1% of prairie dog activity was either grouped with the 'Other' category, or combined with similar behaviors to simplify analysis. Post-relocation data from 2010 and 2011 were pooled. Data were analyzed using a multi-response permutation procedure with Blossom statistical software (Version W2008.04.02, www.fort.usgs.gov/Products/Software/Blossom, accessed 10 Mar 2012), due to the non-normal distribution of percentage data. Utah prairie dogs are more vigilant during the breeding season for social monitoring (Manno 2007). For this reason, observations were taken only on post-breeding animals, so this behavior would not affect the data.

Relocation

In July of each year of the study, Utah prairie dogs were trapped and relocated to the study areas. The trapping process was similar to that described above. However, this time, if a prairie dog was captured, the trap was labeled by location before being moved to a central processing location, to make certain that animals from different coteries would not be confused with each other.

The animals were sexed, and weighed to 50 g using a spring balance. In 2010, prairie dogs as small as 400 g were relocated. In 2011, all relocated prairie dogs were 550 g or larger. Any animal 750 g or heavier was classified as an adult as per Utah Division of Wildlife Resources protocol, smaller prairie dogs were classified as juveniles. Trapped prairie dogs were individually ear-tagged with a different number in each ear. Double tagging reduced the chance of "losing" an animal if a tag was lost. After all animals had been weighed and tagged, they were transported to their relocation sites the same day. A maximum of 10 individuals comprised each relocated family group. Groups typically contained one breeding male, two or three adult females, and the remaining individuals were juveniles of both sexes. Each coterie was assigned a burrow system within a study site. It typically took multiple days to relocate the 10 family group members. Coteries that were neighbors at the golf course were placed in the same release site to mimic their established colonial structure.

In 2011, I remapped clusters of burrows, and observed interactions to verify coterie boundaries. Some areas of the golf course were trapped the second season, but not the first. In these cases, I mapped burrows and observed interactions as before, but did not have the prior season's observations for verification of coterie boundaries. Trapping methods in the second season were the same as used the prior year except that the prairie dogs were alphanumerically marked with commercial black hair dye to allow the family group and individual to be distinguished using binoculars following release.

Control treatment animals were trapped using traditional methods. Baited wire box-traps were placed near burrow entrances. Trapped individuals were also individually

ear-tagged. In the second season, control animals were alphanumerically marked with black hair dye to designate group and individual. Control prairie dogs were randomly assigned to a group. These individuals were taken to the release site, and released in numbers approximately corresponding in size to coterie groups. I also tried to keep the sex-ratio balanced in the second season of trapping because greater numbers of males were captured, and I wanted to control for any possible sex differences. Excess males were either released when captured, or turned over to Utah Division of Wildlife Resources personnel and relocated to other sites.

Detecting Differences in Survival

In mid-September, the Utah Division of Wildlife Resources recaptured the released animals, using the same methods as previous trapping efforts, to determine survival. At each study area, 100 traps were set. At Lime Kiln, 25 traps were set in each release site. In the Pat Willis study area, most traps were set at the release sites, but some were placed near natural burrows constructed by the relocated animals. There were 8 trap days at each study area, broken into two 4-day sessions, and alternating each week between study areas. When animals were trapped, ear tags were read to identify the trapped animals, and weights were measured to 50 g using a spring balance.

To determine if survival was significantly higher in the coterie treatment compared to the control treatment, the recapture data was analyzed in Program MARK (Version 6.0, warnercnr.colostate.edu/~gwhite/mark/mark, accessed Sep 2010) to compare the corrected Akaike's Information Criterion (AICc) values of different models. Age, sex, field season, relocation study area, and weight at relocation were included as

covariates to analyze their effect on survival. Model significance was calculated using AICc values, and comparing a particular model to the null model. The first time step interval was determined by calculating the average number of days elapsed between relocation and the first trap day at that study area. Daily survival rates were also calculated using Program MARK. My analysis only included survival from the first 2 months following relocation due to small sample size of relocated prairie dogs trapped a year after relocation.

Mortality Surveys and Census

Mortality surveys were conducted at least twice a week in the relocation sites, and surrounding areas. Beginning at the center of each release site I scanned for carcasses while walking concentric circles around the site until I was 100 m away. I planned to identify prairie dog carcasses to separate the individuals missing from mortality from those that dispersed from the release sites.

During the second field season, prairie dog counts were conducted at the release sites each day that activity budget data were collected in the weeks following relocation. Visible prairie dogs were counted a minimum of three times, and the highest count was recorded (U.S. Fish and Wildlife Service 2010). Visual count data were plotted over time to determine how long the released animals remained at the relocation sites before migrating or dying. I defined relocation success by the number of relocated prairie dogs that remained on site instead of dispersing (Robinette et al. 1995).

RESULTS

Survival

The Utah Division of Wildlife Resources and I trapped and marked 779 Utah prairie dogs over the course of the study (Table 2-2). Of that total, 703 animals were trapped from Cedar Ridge Golf Course, and 76 from areas around Cedar City. Over the course of the study 398 females and 381 males were relocated; we relocated 296 adults, and 483 juveniles. Weights ranged from 400 g to 1700 g.

Very few prairie dog carcasses were recovered despite extensive searches. Three individuals were found dead and scavenged near the release sites. One was found recently dead the day after its release, another several weeks after release, and one ear tag was found in coyote scat. Additional prairie dogs were lost to predators. Bones were found around the sites and around raptor perches, but without ear tags it was impossible to identify the individual.

Table 2-2: Number of Utah prairie dogs relocated by treatment and site each year, Garfield and Iron Counties, Utah.

	2010	2011	Total
Treatment			
Coterie	193	200	393
Control	186	200	386
Relocation Site			
Lime Kiln	174	200	374
Pat Willis	205	200	405
Total	379	400	779

Of the 779 relocated Utah prairie dogs in 2010 and 2011, 50 were retrapped at the release sites during the fall trapping periods (Table 2-3). The average number of days between release and retrapping was 56 days (SD: 8.89). Three prairie dogs from the 2010 field season were recaptured in 2011. Two adult females were recaptured in Willis during the September retrapping period, and one male in Lime Kiln was caught and released from a retention cage in August. Two litters of pups were observed at the Willis site in the spring of 2011.

Many models in Program MARK were considered, including combined covariate models. I have only recorded the significance of single covariate models as no combination of covariates had higher model likelihood than one or both of the individual covariates (Table 2-4). The top model by AICc value was survival and recapture dependent only on weight at initial capture (Fig. 2-4 and 2-5).

Additional significant models included recapture by weight, trap day, sex, year of relocation, and survival and recapture by age; however, the likelihood of these models is very low (Table 2-4). Survival and recapture by age generated a daily survival rate

Table 2-3: Recapture frequencies of Utah prairie dogs relocated in 2010 and 2011, Garfield County, Utah.

Category	Frequency	Category	Frequency
2010	29	2011	21
Coterie	26	Control	24
Females	25	Males	25
Adults	24	Juveniles	26

Table 2-4: Utah prairie dog relocation survival models created in Program MARK ranked by corrected Akaike's Information Criterion (AICc). Relocations were conducted in 2010 and 2011, Garfield County, Utah.

Model		AIC				
Survival	Recapture	AICc	Delta AICc	Model Likelihood	Parameters	
Weight	Weight	851.315	0.0000	1.0000	4	*
Null	Weight	851.828	0.5131	0.7737	3	*
Null	Day	859.203	7.8879	0.0194	9	*
Null	Sex	859.566	8.2513	0.0162	3	*
Null	Year	860.536	9.2210	0.0100	3	*
Age	Age	860.599	9.2840	0.0096	4	*
Day	Day	860.849	9.5338	0.0085	12	*
Sex	Sex	861.205	9.8898	0.0071	4	*
Null	Age	861.776	10.4610	0.0054	3	*
Age	Null	862.333	11.0182	0.0040	3	*
Year	Year	862.340	11.0256	0.0040	4	*
Null	Null	862.788	11.4730	0.0032	2	
Day	Null	863.320	12.0048	0.0025	5	
Weight	Null	864.276	12.9609	0.0015	3	
Year	Null	864.308	12.9937	0.0015	3	
Null	Site	864.309	12.9947	0.0015	3	
Sex	Null	864.683	13.3678	0.0013	3	
Group	Null	864.696	13.3811	0.0012	3	
Null	Group	864.754	13.4394	0.0012	3	
Site	Null	864.772	13.4573	0.0012	3	
Site	Site	866.260	14.9456	0.0006	4	
Group	Group	866.648	15.3331	0.0005	4	

* Indicates models with lower AICc values than the null model.

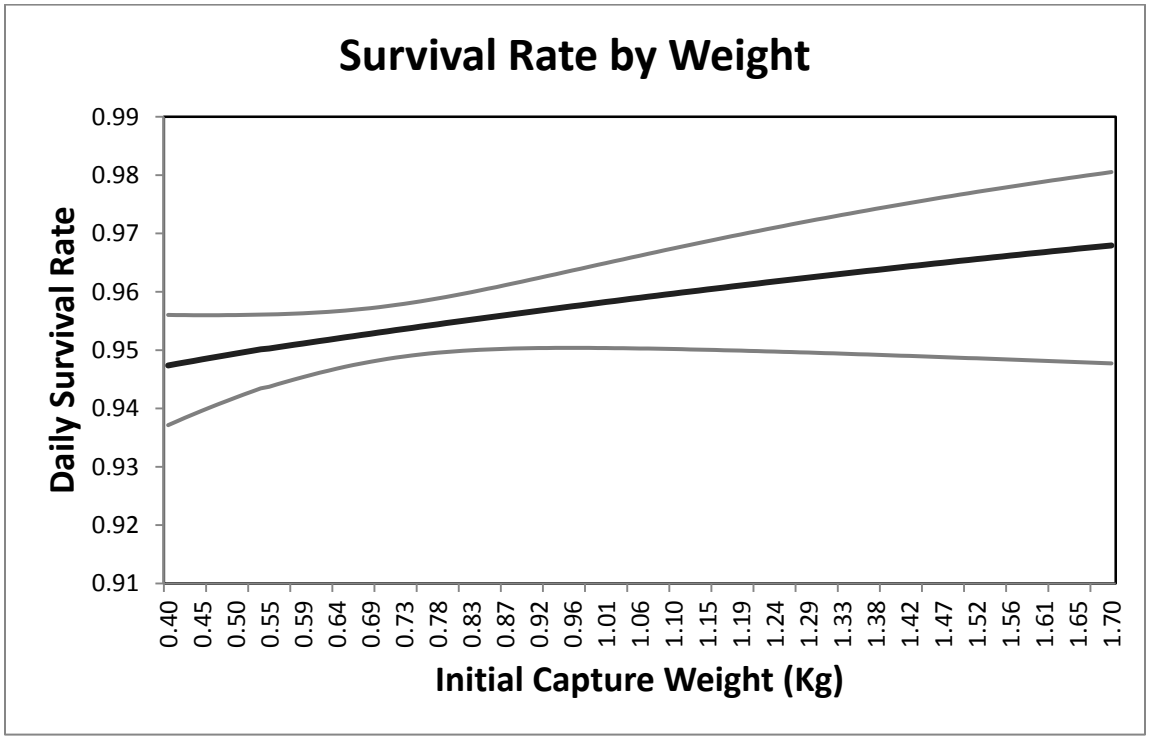


Figure 2-4: Utah prairie dog estimated daily survival rate and 95% confidence intervals by initial capture weight (kg) for animals relocated in the summers of 2010 and 2011, Garfield County, Utah.

of 0.950 for juveniles (under 750 grams) and 0.958 for adults. The recapture rate was 0.533 for juveniles, and 0.406 for adults. Year and sex only affected the recapture rate, keeping the null survival estimate of 0.953. Recapture rate in 2010 was 0.545, and in 2011 the rate was 0.408. Recapture was higher for females at 0.551, and lower for males at 0.402.

Behavior

I obtained 2,377 independent animal observation sessions that generated 47,508 instantaneous behavior samples: 40,608 instantaneous behavior observations in 2010, and 6,900 observations in 2011 (Table 2-5). There was no significant difference in the

post-relocation behavior between 2010 and 2011 (standardized test statistic (sts) = -0.100, P = 0.159), so these data were pooled for additional analyses.

Activity budgets for pre-relocation Utah prairie dogs were significantly different from relocated coterie (sts = -301.288, P ≤ 0.001), relocated control (sts= -272.460, P ≤ 0.001), and wild prairie dogs (sts= -114.242, P ≤ 0.001). Wild prairie dog behavior varied significantly from that of coterie (sts= -13.246, P ≤ 0.001) and control (sts= -11.217, P ≤ 0.001) relocated behavior. There was no significant difference between coterie and control treatment activity budgets (sts= 0.682, P= 0.725). Univariate tests yielded significant differences between groups for many behaviors (Table 2-6, Fig. 2-6)

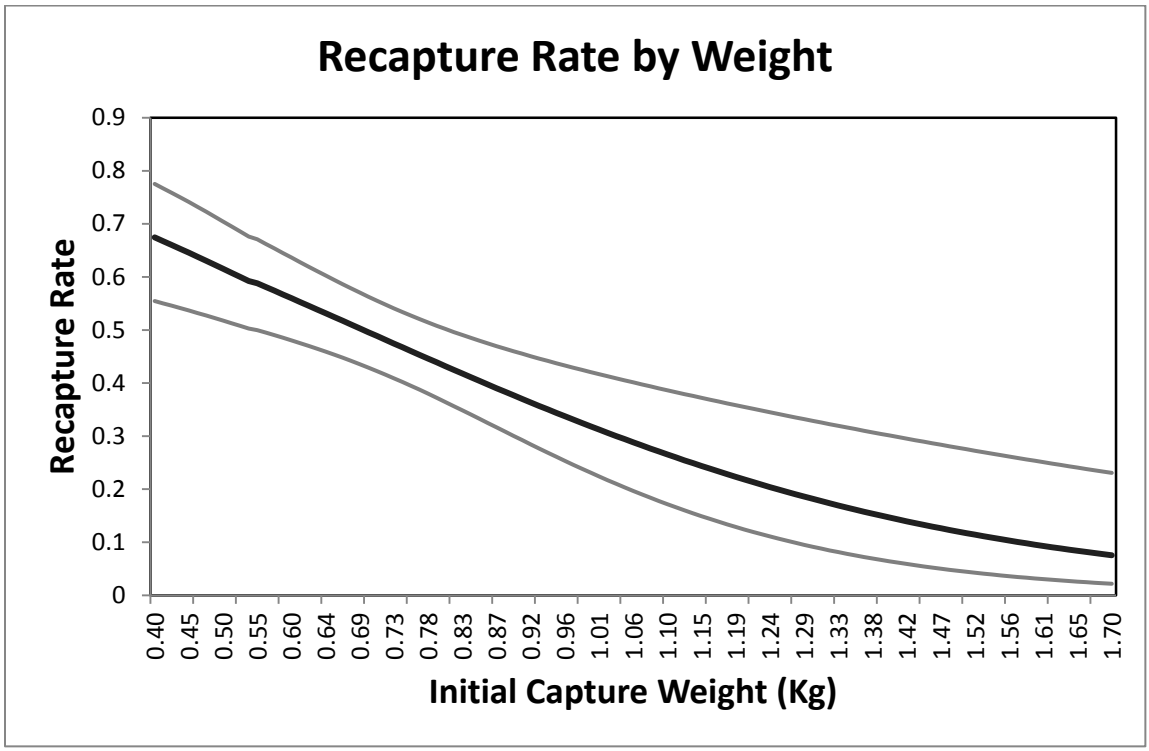


Figure 2-5: Utah prairie dog estimated recapture rate and 95% confidence intervals by initial capture weight (kg) for animals relocated in the summers of 2010 and 2011, Garfield County, Utah

Table 2-5: Utah prairie dog cumulative instantaneous behavior observations in 2010 and 2011, Iron and Garfield Counties, Utah. The table includes both the simplified list used in the analysis, and the initial recorded behavior.

Activity					
Simplified			Recorded		
Activity	Frequency	Percent	Activity	Frequency	Percent
Foraging	2,264	4.77	Foraging	2,264	4.77
Moving	1,807	3.80	Running	337	0.71
			Walking	1,470	3.09
Other	1,290	2.72	Burrowing	218	0.46
			Chasing	82	0.17
			Fighting	70	0.15
			Friendly	299	0.63
			Social Grooming	37	0.08
			Self Grooming	119	0.25
			Other	254	0.53
			Other-Calling	61	0.13
			Other-Laying Down	91	0.19
			Other-Play	18	0.04
			Other-Rolling	1	0.00
			Other-Scratching	20	0.04
			Other-Stretching	4	0.01
			Other-Trapped	16	0.03
Out of View	6,234	13.12	Out of View	6,234	13.12
Peeking from Burrow	1,230	2.59	Peeking from Burrow	1,230	2.59
Semi-Vigilant	18,744	39.45	Semi-Vigilant	18,744	39.45
Vigilant	15,939	33.55	Vigilant	15,895	33.46
			Other-Vigilant Sitting	44	0.09
Total	47,508	100.00	Total	47,508	100.00

Table 2-6: Univariate results of permutation procedure comparing percent of activity between two groups of Utah prairie dogs. Observations collected in 2010 and 2011, Iron and Garfield Counties, Utah. Reporting standardized test statistic and Pearson Type III probability of a lower delta (approximated p-value).

Foraging			
	Coterie	Control	Wild
Pre-Relocation	-19.116	-11.854	-25.701
	≤ 0.001	≤ 0.001	≤ 0.001
Coterie		0.452	-0.760
		0.550	0.155
Control			-1.844
			0.058

Moving			
	Coterie	Control	Wild
Pre-Relocation	-28.422	-21.983	-1.050
	≤ 0.001	≤ 0.001	0.120
Coterie		-0.254	-16.456
		0.258	≤ 0.001
Control			-13.987
			≤ 0.001

Other			
	Coterie	Control	Wild
Pre-Relocation	-12.752	-11.669	-12.146
	≤ 0.001	≤ 0.001	≤ 0.001
Coterie		-0.203	-7.065
		0.273	0.001
Control			-10.460
			≤ 0.001

Out of View

	Coterie	Control	Wild
Pre-Relocation	-33.311	-17.338	-2.687
	≤ 0.001	≤ 0.001	0.028
Coterie		-0.210	-4.468
		0.261	0.007
Control			-1.224
			0.100

Peeking From Burrow

	Coterie	Control	Wild
Pre-Relocation	-69.863	-74.907	-19.035
	≤ 0.001	≤ 0.001	≤ 0.001
Coterie		0.675	-4.617
		0.803	0.006
Control			-4.905
			0.005

Semi-Vigilant

	Coterie	Control	Wild
Pre-Relocation	-390.393	-345.545	-126.801
	≤ 0.001	≤ 0.001	≤ 0.001
Coterie		-1.148	-29.270
		0.110	≤ 0.001
Control			-22.867
			≤ 0.001

Vigilant

	Coterie	Control	Wild
Pre-Relocation	-136.556	-130.016	-86.065
	≤ 0.001	≤ 0.001	≤ 0.001
Coterie		0.958	0.409
		0.999	0.526
Control			0.189
			0.407

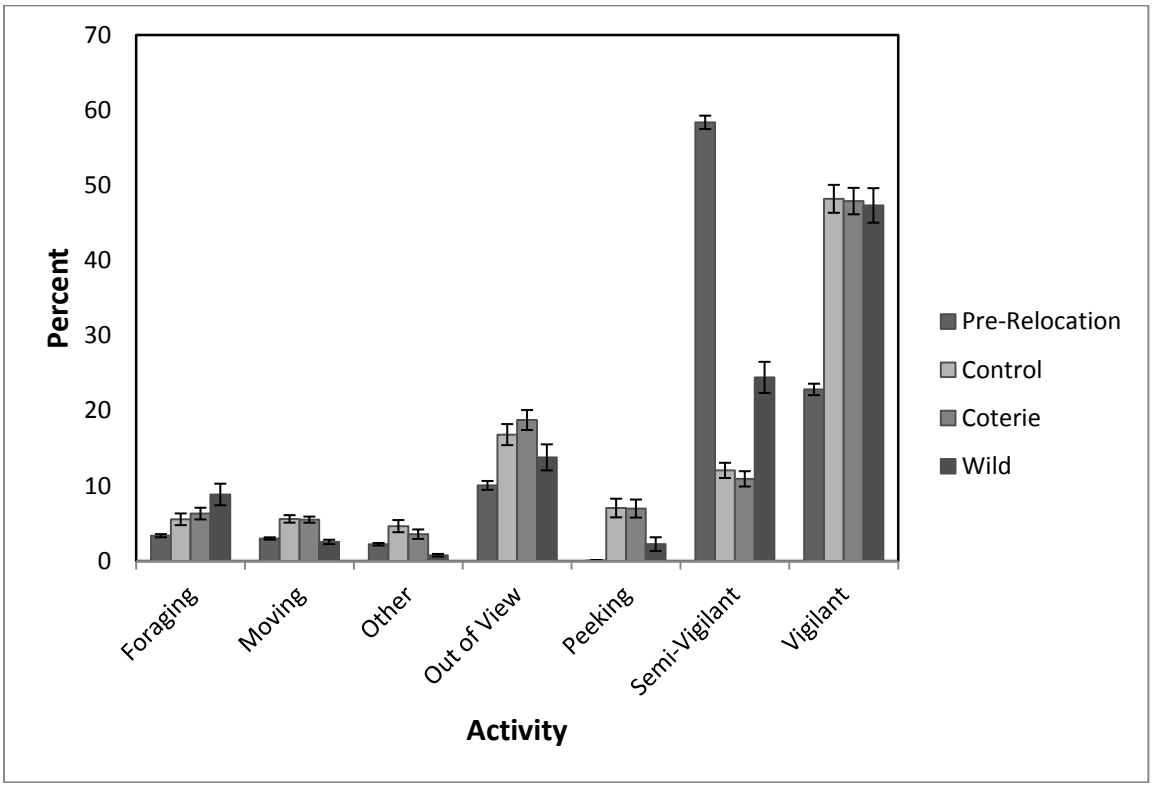
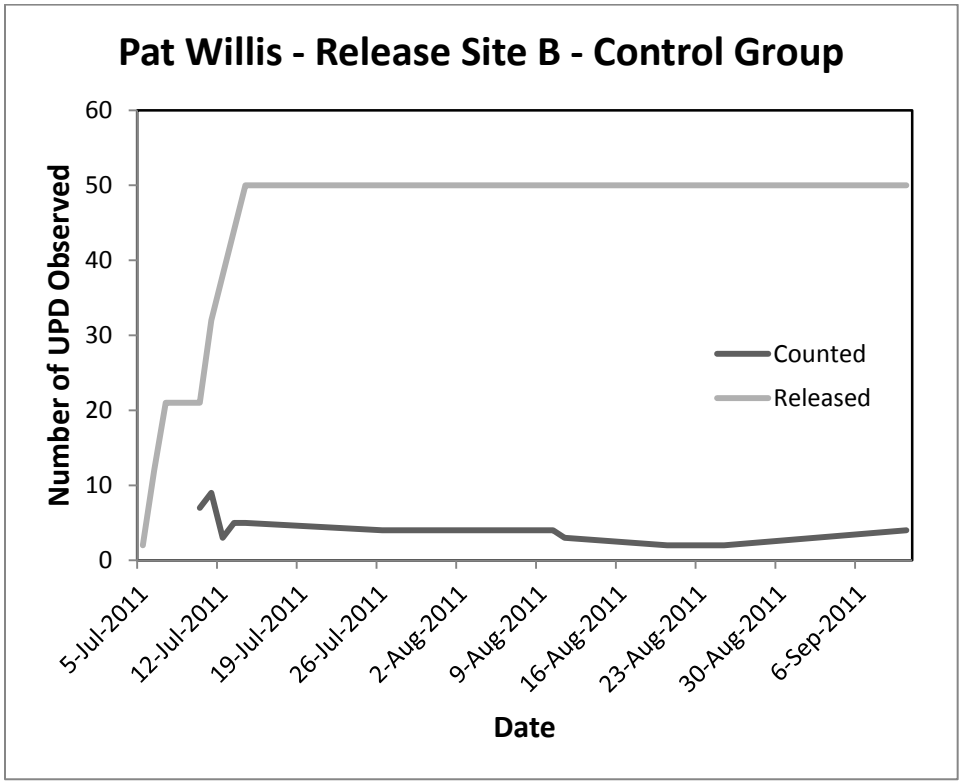


Figure 2-6: Average time spent in activity (%) for Utah prairie dog within each group. Observations were collected in 2010 and 2011, Iron and Garfield Counties, Utah.

Visual counts of prairie dogs at the release sites showed no observable differences between relocation treatments. At each site, numbers were relatively high during the relocation period when new individuals were being added, but counts quickly dropped off and stabilized at a few individuals (Fig. 2-7).



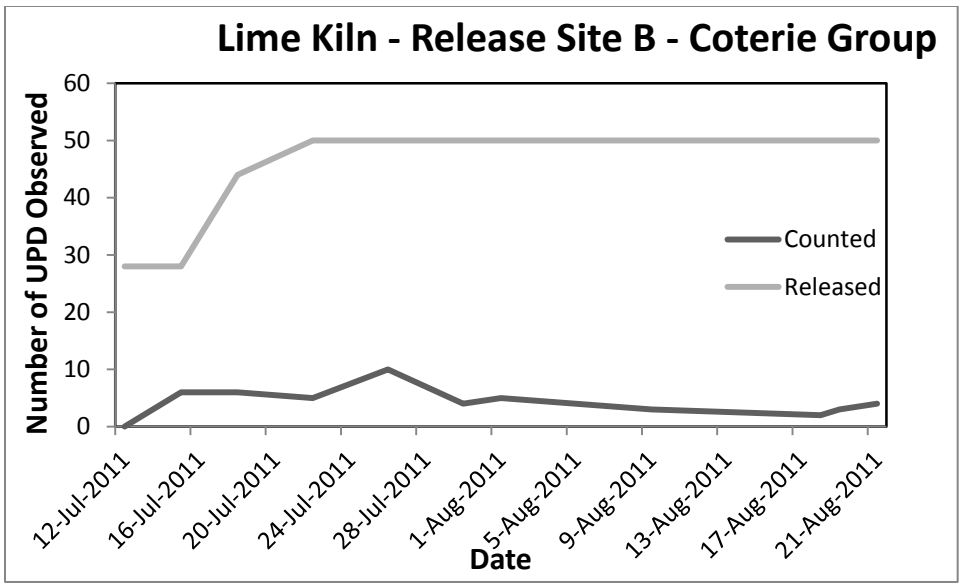


Figure 2-7: Visual counts comparing the number of Utah prairie dogs observed at the release sites in 2011 compared to the number of animals relocated to that site over time, Garfield County, Utah.

DISCUSSION

I found no evidence of a survival benefit to relocating Utah prairie dogs by coteries. The most parsimonious model was both survival and recapture rate dependant on the animal's weight at initial capture. Daily survival rate increased as weight increased. The difference in daily survival rate between the smallest and largest prairie dogs was approximately 2%. Although this number sounds small, when compounded daily a 2% survival difference represents a large loss of small animals. This survival difference may be due to body condition. Most relocated adults lost weight in the 2 months between relocation and recapture. Weight loss may be due to stress from relocation, difficulty finding food, or reduced forage time. It is possible that smaller animals do not have the fat stored to survive heavy weight loss. Previous transplants conducted in August have had higher success; possibly due to juveniles being larger, and allowing reproductive females to regain weight (U.S. Fish and Wildlife Service 1991). I relocated animals primarily in July, which may have caused lower survival than if I had relocated in August. If heavier animals tend to be older, their increased survival rate may also be due to their age and consequently greater experience than small, naïve counterparts. My findings are consistent with previous Utah prairie dog research that found a negative correlation between size and survival (Jacquart et al. 1986). Recapture rate decreased as weight increased. Small juveniles were easy to recapture, and were trapped repeatedly. Large animals had low recapture probability, which suggests that experience may influence survival.

In 2010, Utah prairie dogs as small as 400 g were relocated. In 2011, a minimum threshold was set at 550 g. My study suggests that even this threshold may be too low. I suggest that only adult prairie dogs be relocated, or that a new minimum weight threshold be set. I chose not to determine a new threshold with the data collected for this study because weights were collected in 50 g increments, which is imprecise data for animals weighing 400-1700 g. Weight data should be collected to 1 g, and this data used to set a more accurate minimum weight threshold.

Although data were not consistent enough for analysis due to variation and imprecision, most adults lost weight in the 2 months between initial capture and recapture. In natural populations, weight gain occurs in the summer months to prepare for hibernation (Hoogland 2003). High elevation sites have short growing seasons, and any weight reduction could reduce over-winter survival (Elmore and Messmer 2006b).This may be a concern for the over-winter survival of relocated animals, particularly because female body mass is already reduced due to lactation (Hoogland 2003).

Research on black-tailed prairie dogs has shown increased survival of adults over juveniles, and that juveniles relocated later in the season have higher survival. It is uncertain whether that effect was due to increased physical condition, or allowing juveniles to develop better survival skills prior to relocation (Shier 2006). Most likely the survival effect is due to a combination of both condition and experience. Of course, dispersal is naturally high for Utah prairie dog juveniles (Elmore and Messmer 2006b), so the effect seen here may be due in part to high dispersal of smaller individuals.

Recapture probability was low, but did not necessary mean that mortality was as high as suggested. Many animals that remained in the relocation site were not included in the retrapping figures. For example, one juvenile male relocated in Lime Kiln in July of 2010 was not recaptured during the fall retrapping period that year. However in August of 2011, I found him caught in the wire mesh of a retention cage. He appeared stressed, but uninjured, when I released him. This animal was also not recaptured during the 2011 September retrapping period.

Recapture probability also did not account for emigration from the site. Dispersal was extremely high from both sites. Individuals were observed moving away from release sites within 24 hours of their release. Previous transplants observed a 25-50% decrease within the first 2 days following release (U.S. Fish and Wildlife Service 1991). During follow up visits to the site, it was evident that the relocated animals used the natural burrows over the artificial ones when they were available, and several individuals were seen multiple days using natural burrows progressively further from their release site until I lost sight of them completely. Two individuals were observed nearly 2 km away from their release site within a few weeks of their release. Many ear-tagged individuals in the Pat Willis site were observed intermixed with wild prairie dogs in a neighboring colony. This high dispersal suggests that survival is not as low as the recapture trapping numbers suggest. Instead, released animals may have only abandoned the relocation site. This suggests that “site retention” would be a more accurate term than “survival”.

Movement was evident within the relocation colony as well. Eight of the prairie dogs were not trapped in the release sites where they were originally relocated. Two moved from a treatment site to a control, 3 from a control to a treatment, and 3 moved to different sites within the same treatment. It appeared that dispersing prairie dogs may have used other release sites coincidentally, happening upon them as they moved across the landscape. The only evidence I saw of fidelity to family group was 2 juvenile males dispersing together. On one occasion, I found them occupying the same burrow 200 m from their release site. They continued to disperse, and neither individual was observed again. Also, at the Lime Kiln site, 2 individuals from 1 coterie were recaptured in the same non-original site. Very few of these dispersing animals were visually observed or recaptured. High post-relocation dispersal was also observed in black-tailed prairie dog relocation (Bly-Honness et al. 2004), and previous Utah prairie dog research (U.S. Fish and Wildlife Service 1991, Ackers 1992).

Previous research has shown that prairie dogs should not be released in, or near, existent colonies (U.S. Fish and Wildlife Service 1991). During my research, released animals dispersed into an established wild prairie dog colony without any obvious negative effects. However, adding supplemental animals to release sites containing prairie dogs released the prior year appeared to cause the rapid dispersal of newly released animals.

From my count data, it appeared that most relocated individuals dispersed almost immediately from the release sites, and that a small number of individuals stayed. This agreed with the movement of individuals I observed soon after relocation. I would

expect some decline as other researchers have documented a slow decrease in prairie dog numbers during late summer in natural populations as juveniles disperse (Elmore and Messmer 2006b), but not the level of dispersal seen at my release sites. It is possible that the soft release methods used were not sufficient to encourage released animals to stay. It may be the artificial burrow system that discouraged them as many individuals stayed in the area, but instead utilized natural burrows.

Untagged Utah prairie dogs were captured during the retrapping period. At the Willis site, these animals were primarily juveniles born to the previous year's relocated prairie dogs. At least seven unmarked juveniles were trapped during the recapture period, and one adult male that probably immigrated to the site from a neighboring colony. In 2011, at least one untagged adult male and one adult female were captured at the Lime Kiln site. Although there are no prairie dog colonies in the immediate vicinity of the site it is possible that a dispersing animal found, and remained in, the relocation site. It is also possible that the prairie dogs were illegally captured and released.

I found that the 750 g cutoff for adults versus juveniles was inaccurate, particularly for relocated animals. Utah prairie dogs trapped on the golf course had high initial trap weights. Many individuals classified as adults at relocation were classified as juveniles during recapture because of their low weight. One reproductive female relocated in 2010 weighed 900 g at initial capture. When she was recaptured in 2011 she weighed 700 g. Although her weight classified her as a juvenile, she clearly was not. The idea of selecting a weight threshold is convenient for separating ages, but the current weight of 750 g does not appear to be suitable.

I observed no evidence of a behavior difference between treatments of relocated prairie dogs. No behaviors occurred significantly more or less often for animals relocated with family members than those relocated as part of the control. Regardless of treatment, relocated animals showed significantly different behavior than pre-relocation and wild prairie dogs for many activities. Relocated animals spent more time moving and exploring their new surroundings. The "Other" category was higher in relocated prairie dogs, and included activities such as burrowing that occurred frequently in the relocation colonies. The "Out Of View" behavior typically meant the animal entered a burrow, and remained underground. This activity was common in relocated animals, as was sitting in a burrow entrance with only head exposed, or "Peeking." Relocated animals spent most of their time engaged in "Vigilant" behavior scanning for predators, similar to the wild population animals. With the exception of time spent underground, peeking from burrows, and exploring, there was a trend for relocated prairie dogs to act more like wild prairie dogs than they did prior to relocation.

The pre-relocation, urban prairie dogs at the golf course showed significantly different behavior than both wild and relocated Utah prairie dogs. Pre-relocated animals spent most of their time engaging in semi-vigilant behavior combined with foraging. They spent less time in their burrows and actively scanning for predators.

Utah prairie dogs at the golf course commonly approached members of other coteries beginning with friendly displays that turned into fights. Fighting occurred in the wild prairie dog colonies, but was rarely observed in the relocated animals. This may be

because the released prairie dogs did not have established territories, which eliminated territorial disputes.

My findings were consistent with a previous Utah prairie dog relocation study. Ackers (1992) found that released prairie dogs behaved independently of social constraints, and social units did not form in the initial months following relocation. Behaviors such as exploring, vigilance, and burrow construction overrode the tendency to divide into social groups. In fact, Ackers determined that the most important factor driving post-release behavior was the presence of natural burrows. There was no behavioral difference between animals released into an extirpated site and resident, non-relocated prairie dogs, which suggested that habitat may have had a greater affect on behavior than social group (Ackers 1992). However, Ackers study was conducted prior to the use of artificial nest boxes in relocation sites. I was unable to determine the effect of burrow type on behavior because in my study all animals were released into artificial burrows. I found no evidence that social group had any bearing on post-release behavior.

Antipredator behavior has been shown to be socially transmitted to naïve juveniles by predator-experienced adults (Shier and Owings 2007). Because predator avoidance behavior is not necessarily instinctive, juveniles reared by predator-naïve adults may remain predator-naïve. This could be a concern when relocating prairie dogs from urban areas that experience different predators than their wild counterparts. At Cedar Ridge Golf Course, prairie dogs have little exposure to the coyotes, badgers, and raptors that are the primary predators at the relocation sites. Their experience is with domestic predators, particularly cats, because other potential predators are either wary of

human activity, or removed by golf course personnel. It is possible that prairie dogs relocated from rural environments would have higher relocation success due to their previous exposure to wild predators.

Retention cages are used at soft release relocation sites, but have both positive and negative effects. The cages do not keep the released animals in the burrow system, but do provide protection from avian predators. Prairie dogs also utilized retention cages by climbing on top of them when scanning for predators. This behavior arose at different times in each of the sites. One prairie dog would "discover" it, and the other animals at the site would quickly imitate the behavior. The prairie dogs created tunnels under the cages, but when trying to escape into their burrows they would run into the cages, rather than go under them. The adult male caught in the retention cage mentioned previously had become trapped in the wire mesh when trying to run straight to the burrow entrance instead of around to a tunnel under the cage. In several instances when I would supply water to the sites, prairie dogs would run into a retention cage, not be able to get in, and run to the next one. This common behavior could contribute to high predation rates at the release sites.

My results were different than the Shier (2006) study that found increased survival when prairie dogs were relocated by coterie. This may be due to differences in methodology. Shier meticulously trapped, observed, and recaptured complete family groups to relocate. I captured 10 individuals of each coterie, and may only have had a small portion of the entire coterie (Shier 2006). My results were similar to another black-tailed prairie dog study that utilized similar methods, which also found no survival

advantage to coterie relocation (Bly-Honness et al. 2004). My results may additionally been confounded by relocating randomly trapped individuals from the same source location. It is possible that individuals were grouped with some coterie members by random assignment, as occurred in other relocation studies (Bly-Honness et al. 2004).

MANAGEMENT IMPLICATIONS

My study found no survival or site retention advantage to relocating Utah prairie dogs by coterie, particularly when considering the additional effort required to trap coterie members. Instead, I found that initial trap weight was more important to survival. Large individuals had higher survival than small ones. I suggest that only adult animals be used for relocation, or at least that juveniles are relocated later in the trapping season. Additional research is needed to determine a minimum weight value for Utah prairie dog relocation.

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CHAPTER 3

DIFFERENCES IN VEGETATION CHARACTERISTICS OF RELOCATED UTAH PRAIRIE DOG RELEASE SITES

Utah prairie dogs have been extirpated in 90% of their historical range. Because most of the population occurs on private land, this threatened species is continually in conflict with landowners due to burrowing. The Utah Division of Wildlife Resources has been relocating prairie dogs from private to public land since the 1970s, but relocations have been largely unsuccessful due to high mortality. Utah prairie dogs were relocated in 2010 and 2011 from the golf course in Cedar City, Utah to two prepared sites near Bryce Canyon National Park, Utah. Vegetation transects were established at each site to determine if there was a correlation between site vegetation composition and structure, and Utah prairie dog survival at relocation sites. The vegetation at the two sites was significantly different. One site had significantly less grass cover, more invasive plant cover, and rockier soils. The sites also had different soil structures and long-term Utah prairie dog retention rates. Newly established burrows were clustered rather than randomly distributed. Utah prairie dogs appeared to avoid placing burrows in areas with tall vegetation and rocky soils. More research is needed to determine how site selection determines long-term retention and colonization of a relocation site.

Prairie dogs are a diurnal, burrowing member of the squirrel family, Sciuridae, and the genus *Cynomys* (meaning dog-mouse). There are five separate species: black-tailed (*C. ludovicianus*) and Mexican (*C. mexicanus*) prairie dogs in the black tailed subgenus; and Gunnison's (*C. gunnisoni*), white-tailed (*C. leucurus*), and Utah (*C.*

parvidens) prairie dogs in the white tailed subgenus. At the beginning of the 20th century, it was estimated that there were between 1 and 5 billion prairie dogs in North America (U.S. Fish and Wildlife Service 1991, Slobodchikoff et al. 2009). By 2009 the population had declined to only 1-2% of their historic numbers due to factors including sylvatic plague (*Yersinia pestis*), poisoning, predation, and habitat destruction and degradation. This reduction may have ecosystem effects because prairie dogs play an important role in grasslands, affecting nutrient cycling and plant diversity. The decline of prairie dog populations is associated with the decline of other species including black-footed ferret (*Mustela nigripes*), swift fox (*Vulpes velox*), burrowing owl (*Athene cunicularia*), golden eagle *(Aquila chrysaetos)*, and ferruginous hawk (*Buteo regalis*; Slobodchikoff et al. 2009).

Utah prairie dogs occur only in southwestern Utah, and have been extirpated in much of their historic range. In the 1920s the population was estimated at 95,000, but by 1972 had declined to 3,300 (U.S. Fish and Wildlife Service 1991). Utah prairie dogs were listed as federally endangered in 1973, but reclassified as threatened in 1984 (U.S. Fish and Wildlife Service 1991). In 2010, Utah prairie dog populations numbered approximately 11,000 (N. Brown, Utah Division of Wildlife Resources, personal communication). Population recovery is slow due to sylvatic plague outbreaks, and because Utah prairie dogs have slow reproductive and population growth rates (Slobodchikoff et al. 2009).

Utah prairie dogs have been relocated from private lands to public land since 1972 (U.S. Fish and Wildlife Service 1991) to increase the prairie dog population in new

colonies throughout their historic range. Some removal of prairie dogs is allowed, and relocations are conducted on animals that would otherwise be destroyed. Relocation can also be used as mitigation for development activities under Habitat Conservation Plans (U.S. Fish and Wildlife Service 2009). Surviving animals can then be counted toward species recovery. Relocation sites are prepared with artificial burrows and nest boxes prior to release, and predator control is also conducted following relocation. In spite of these efforts, relocations have been largely unsuccessful due to high mortality (N. Brown, personal communication), and therefore have done little to improve the population status.

Few relocation studies have been conducted on Utah prairie dogs, but some research has been published on relocating black-tailed prairie dogs. Researchers have found that it is very important to place animals in areas with soils conducive to burrowing. Burrows in sandy, rocky, and gravely soils are likely to collapse. Well drained fine sandy loam soils without gravel are favored. Black-tailed prairie dogs are likely to disperse when relocated to areas with poor soil structure (Roe and Roe 2003). Burrows are used as refugia, and contain nursery chambers for juveniles. Temperatures in burrows are higher in winter, and lower in summer than the surface temperatures. The soil type affects burrow construction, but in black-tailed prairie dogs does not affect burrow density (Hoogland 1995). Soils must allow deep burrow systems for overwintering animals (U.S. Fish and Wildlife Service 1991).

Relocated Utah prairie dogs disperse in a random fashion. Dispersing animals construct shallow temporary burrows, which makes them vulnerable to predation until deep burrow systems are established (U.S. Fish and Wildlife Service 1991). It is

important that Utah prairie dogs are relocated to a site with a pre-existing burrow system, preferably natural burrows (Roe and Roe 2003). If natural burrows are not available, artificial systems can be created with burrows and nest boxes (Truett et al. 2001).

Vegetation has been shown to affect burrow densities. Mow and burn treatments create suitable conditions for colony expansion of black-tailed prairie dogs by increasing available habitat and predator visibility. These treatments increase the rate of colony expansion, and influence its direction (Northcott et al. 2008).

For all prairie dog species, grasses are the major component of the diet, although forbs and shrubs are frequently consumed. Invertebrates are not typically consumed, although remains are occasionally found in fecal samples. As with many herbivores, prairie dog diet varies seasonally based on available species (Slobodchikoff et al. 2009).

By comparing how frequently a plant was consumed versus how common it was at the site, researchers have been able to determine if a plant species was preferred or avoided. In a study by Lehmer et al. (2006), Utah prairie dogs preferred scarlet globemallow (*Sphaeralcea coccinea*) and cheatgrass (*Bromus tectorum*) in each season and elevation. Animals in low elevations preferentially foraged on western wheatgrass (*Elymus smithii*), Indian ricegrass (*Stipa hymenoides*), scarlet globemallow, and needle-and-thread grass (*Hesperostipa comata*). Mid-elevation animals preferred to forage on cheatgrass and scarlet globemallow, while high elevation animals foraged on wheatgrass species (*Elymus spp*.), cheatgrass, and sedges (*Carex* spp.). Utah prairie dogs avoided shrub species such as rubber rabbitbrush (*Chrysothamnus nauseosus*), Douglas

rabbitbrush (*Chrysothamnus viscidiflorus*), and black sagebrush (*Artemisia nova*; Lehmer et al. 2006).

Because I evaluated relocated prairie dogs at two separate sites, I hypothesized that a difference in the grass, forb, and shrub vegetation composition at relocation sites may affect the survival of released animals, such that a large disparity may have been correlated with increased emigration from the study site. Researchers relocating black-tailed prairie dogs suggest that the quality of the release site may influence the survival of relocated animals (Bly-Honness et al. 2004). Ackers (1992) also suggested that release site affects Utah prairie dog survival. I hypothesized that lower quality sites with less grass and forb cover would be correlated to a higher level of emigration, and to a lower number of new burrows.

STUDY AREA

This study was comprised of 3 study areas (Fig. 3-1); the first was the source Utah prairie dog population located on the Cedar Ridge Golf Course in Cedar City, Iron County, Utah. In the first year of the study, some animals were also trapped and relocated from additional urban sites, such as baseball fields and equestrian centers, throughout Cedar City. In the second year of the study, all study animals were trapped and relocated from Cedar Ridge Golf Course. The course was roughly 1780 m in elevation, and received approximately 30 cm of precipitation annually (Western Regional Climate Center 2011a). Sprinkler irrigation provided supplemental water at the golf course. The course utilized a combination of bluegrass (*Poa* sp.) and bentgrass (*Agrostis*

sp.), and the dominant soil type at the golf course was loam (Soil Survey Staff 2012). Average maximum temperatures ranged from 5.7˚C in January to 32.3˚C in July (Western Regional Climate Center 2011b).

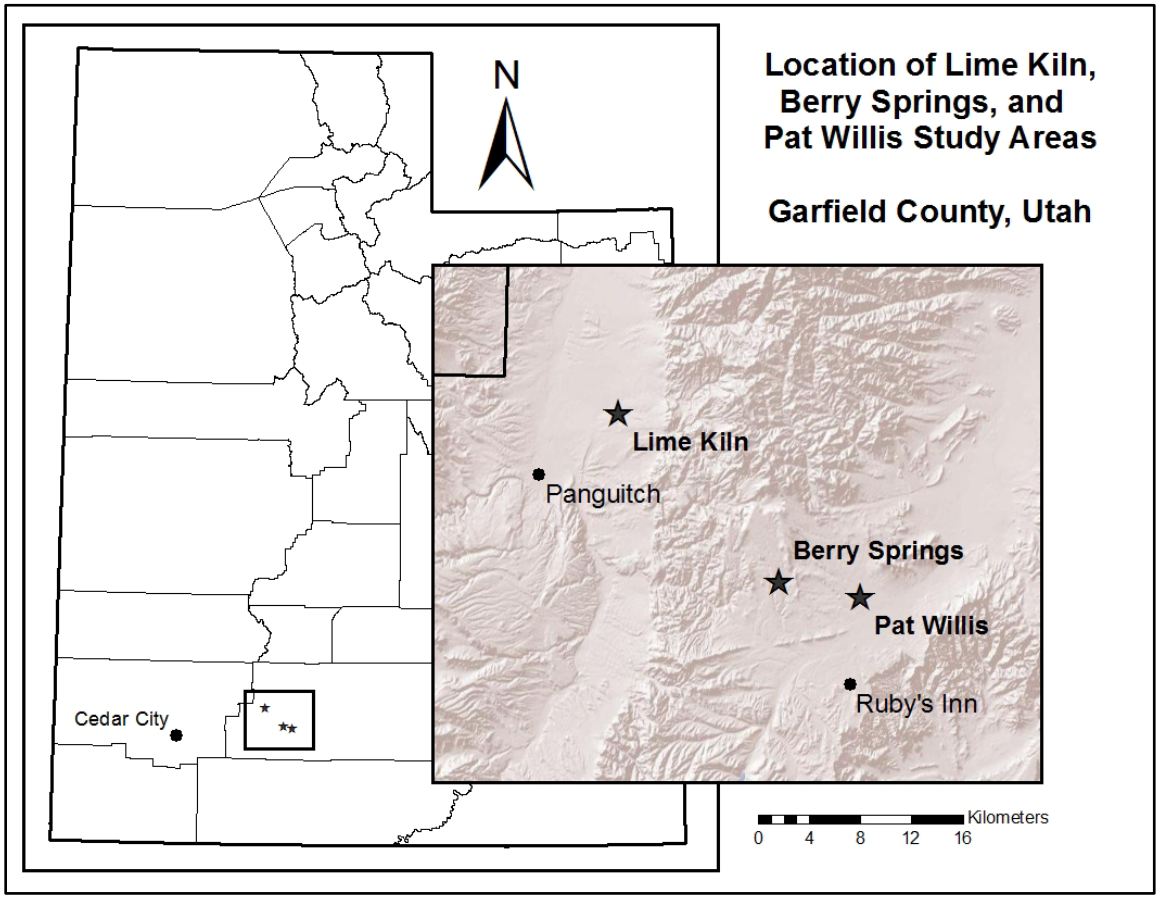

Figure 3-1: Utah prairie dog study area locations: the source population site at Cedar Ridge Golf Course in Cedar City, Iron County; Lime Kiln and Pat Willis Wash relocation areas, Garfield County, Utah.

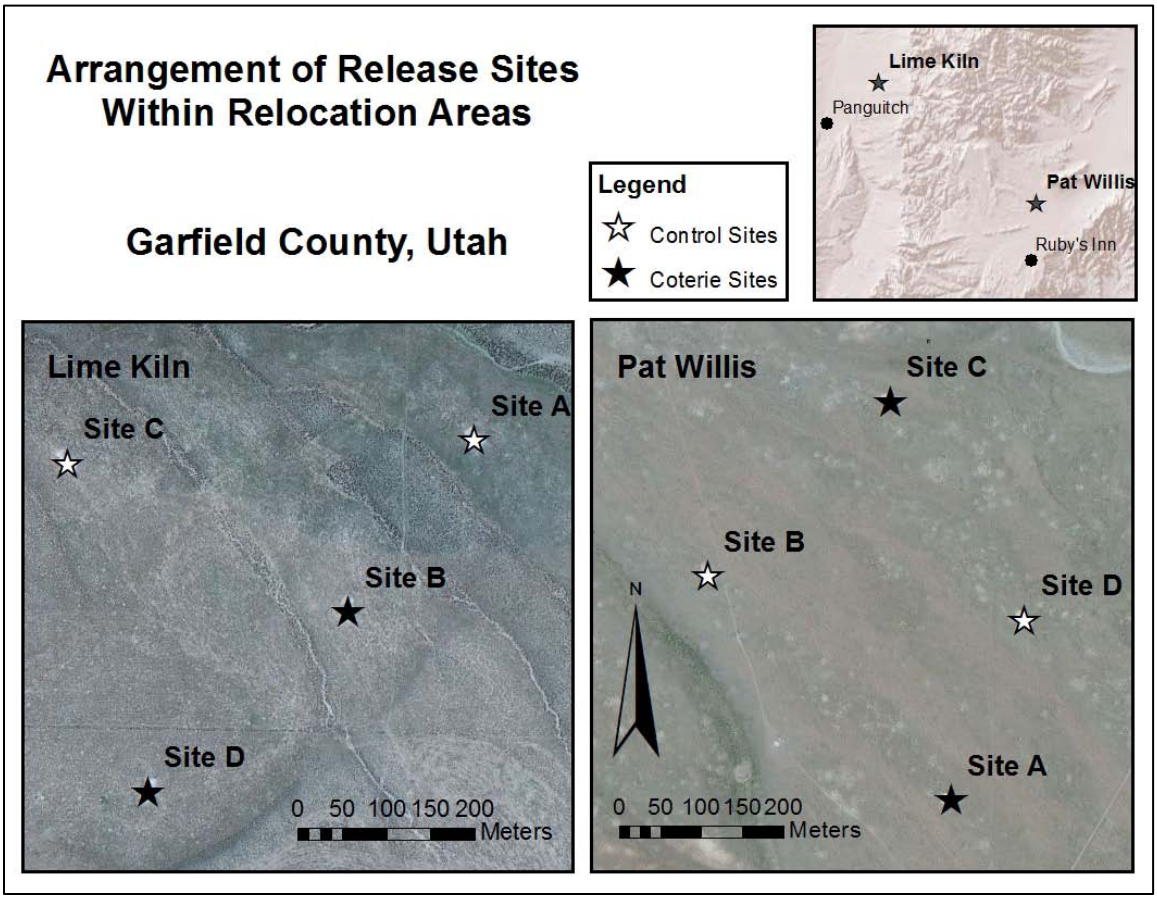

Figure 3-2: Locations of Utah prairie dog release sites within the two relocation study areas.

Figure 3-3: Pat Willis control release site, Garfield County, Utah, 2011. The site contains five burrow systems, each with two entrances and an underground chamber. Water is provided by a 3-gal steel poultry waterer. Chicken wire retention cages are placed over the burrow entrances.

There were 2 relocation study areas. The first study area, Lime Kiln, was located 8 km northeast of Panguitch, Garfield County, Utah, and was managed by the U.S. Bureau of Land Management. In the study area, a 1-km² area of brush was removed, and reseeded using a Great Basin Research Center (Ephraim, Utah) grass and forb seed mix in December of 2008. Dominant recorded plant species included Palmer's penstemon (*Penstemon palmeri*), blue grama (*Bouteloua gracilis*), blue flax (*Linum lewisii*), Indian ricegrass (*Stipa hymenoides*), needle-and-thread (*Hesperostipa comata*), big sagebrush (*Artemisia tridentata*), black sagebrush (*A. nova*), annual mustard, and an assortment of wheatgrass (*Elymus*) species. During the study, average plant height was 36 cm. Soils ranged from gravelly to very cobbly loam (Soil Survey Staff 2012). Panguitch received approximately 25 cm of precipitation annually (Western Regional Climate Center 2011a). Average maximum temperatures ranged from 4.0˚C in January to 29.2˚C in July (Western Regional Climate Center 2011b). Elevation at Lime Kiln was roughly 2080 m.

The Pat Willis study area was in John's Valley north of Bryce Canyon National Park, Garfield County, Utah, and was managed by the U.S. Forest Service. The study area was part of a long drainage of available habitat covering over 10 km². This area had wild prairie dog colonies approximately 500 m to the south and southeast of the release site, and a release site constructed 1 km from the current study area in 2011. The Pat Willis study area was historically reseeded with crested wheatgrass (*Agropyron christatum*). Additional plant species included needle-and-thread, big sagebrush, black sagebrush, rabbitbrush (*Chrysothamnus nauseosus*), broom snakeweed (*Gutierrezia sarothrae*), and sedges (*Carex* spp.). The average plant height was 27 cm, with silty to

cobbly loam soils (Soil Survey Staff 2012). Bryce Canyon National Park, 17 km south of the study site received approximately 40 cm of annual precipitation (Western Regional Climate Center 2011a); average maximum temperatures ranged from 1.4˚C in January to 26.6˚C in July (Western Regional Climate Center 2011b). The elevation at Pat Willis Wash was approximately 2330 m.

Each relocation study area contained four release sites (Fig. 3-2) greater than 200 m apart, while each release site contained 5 burrows 4 m apart. A buried sprinkler box provided a nest chamber, and flexible piping provided 2 entrances for each burrow. Retention cages were placed over each burrow entrance (Fig. 3-3), which also served to protect relocated animals from predators. Water was provided at each site. Two release sites were used for the coterie relocation, and 2 for non-coterie relocation (control) animals. Predator removal of coyotes (*Canis latrans*) and badgers (*Taxidea taxus*) at or near release sites was conducted at both relocation study areas by U.S.D.A Wildlife Services, but not at Cedar Ridge Golf Course.

METHODS

Vegetation Transects

Vegetation surveys were conducted at each relocation site in 2011 to determine the effect of vegetation on prairie dog site retention and dispersal. At each study area, I had 30 transects. Each study area was mapped in a 100-m grid so no two transects overlapped. The necessary number of transects was determined using Dallal's (1997) power analysis equation for 80% power with 0.05 level of significance. The first 15

randomly selected plots were surveyed to provide estimates of means and standard deviation for each site to make the power analysis more accurate.

I established 50-m transects from a central starting point that ran in a random direction. For each transect, a meter tape was anchored at the 0-m and 50-m mark, with the line running as close to the ground as possible. Beginning at the 0-m mark, I used the line-point intercept method (Herrick et al. 2009), recording any plants that intercepted the wire flag every meter at the canopy, lower, and basal/soil surface layers. Dead and live plants were differentiated in the data. I attempted to identify plants to the species level. Some plants, particularly grasses, were too small to be individually identified and were recorded as annual/perennial grasses or forbs. This method provided estimates of species composition, percent cover, basal cover, and bare ground (Herrick et al. 2009). The height of the canopy layer plant was also measured to calculate average vegetation height. Because Utah prairie dogs consume a wide variety of plant species (Lehmer et al. 2006) and species composition varied at each site, I focused my analysis on comparing the percent cover of grasses (this included sedges and rushes), forbs, and shrubs, and comparing vegetation height at each site. I did not compare species composition between sites. I created a weed category in the cover analysis that included annual mustard, tall annual burrs, Russian thistle (*Salsola iberica*), and cheatgrass, because these plants contributed little forage, but made up a large percentage of the plants at the Lime Kiln site. At the soil layer, I combined plant species into classes, and included mustard in the forb category. Vegetation height was compared using a two-sample t-test using SAS (SAS Institute Inc., Cary, NC). Percent cover for each site was calculated using SAS,

but compared using a multi-response permutation procedure in Blossom statistical software (Version W2008.04.02, www.fort.usgs.gov/Products/Software/Blossom, accessed 10 Mar 2012) since percent data has non-normal distribution.

Burrows

At the end of the field season, I mapped new burrows in the relocation sites to assess colonization. There were no prairie dog burrows at either site prior to this study. I defined a burrow as a tunnel where I could not see the end of the tunnel from the surface. This eliminated any partially excavated pits the released animals dug. I used the Average Nearest Neighbor tool in ArcMap 10 (ESRI, Redlands, CA) to assess the distribution of burrows, and a Hot Spot Analysis tool to compare the burrow locations to vegetation cover values of the vegetation plots.

RESULTS

In total 60 point intercept surveys were collected in 2011. Species composition varied by relocation site (Table 3-1).

The two sites had significantly different vegetation cover (standardized test statistic (STS) = -25.174, $P \leq 0.001$). Univariate tests yielded significant results between sites for all plant classes except shrubs (Fig. 3-4). Vegetation height at the Pat Willis site was significantly lower than the Lime Kiln site (t=10.530, $P \leq 0.001$).

Table 3-1: Plant classes and dominant species composition of Utah prairie dog relocation sites, Garfield County, Utah, August 2011.

Lime Kiln				Pat Willis			
Plant Class		Species		Plant Class		Species	
Type	Percent	Species	Percent	Type	Percent	Species	Percent
Forb	7.27	Unidentified Annual Forbs	2.27	Forb	2.47	Combined Minor Forb Species	2.47
		Linum lewisii	1.60				
		Penstemon palmeri	2.27				
		Other Forb Species	1.13				
Grass	25.07	*Bouteloua gracilis*	11.20	Grass	56.80	*Agropyron cristatum*	32.87
		Elymus elymoides	1.27			*Bouteloua gracilis*	1.60
		Hesperostipa comata	5.13			*Carex filifolia*	3.93
		Sporobolus cryptandrus	1.13			*Elymus smithii*	1.20
		Stipa hymenoides	4.53			*Hesperostipa comata*	15.87
		Other Grass Species	1.80			Other Grass Species	1.33
Shrub	14.13	*Artemisia nova*	9.73	Shrub	10.33	*Artemisia nova*	5.47
		Artemisia tridentata	2.47			*Gutierrezia sarothrae*	1.53
		Gutierrezia sarothrae	1.93			Unidentified Shrub	1.47
Weed	15.8	Annual Mustard	14.40			Other Shrub Species	1.87
		Other Weed Species	1.40	Weed	0		0.00
Bare Soil	37.73		37.73	Bare Soil	30.40		30.40

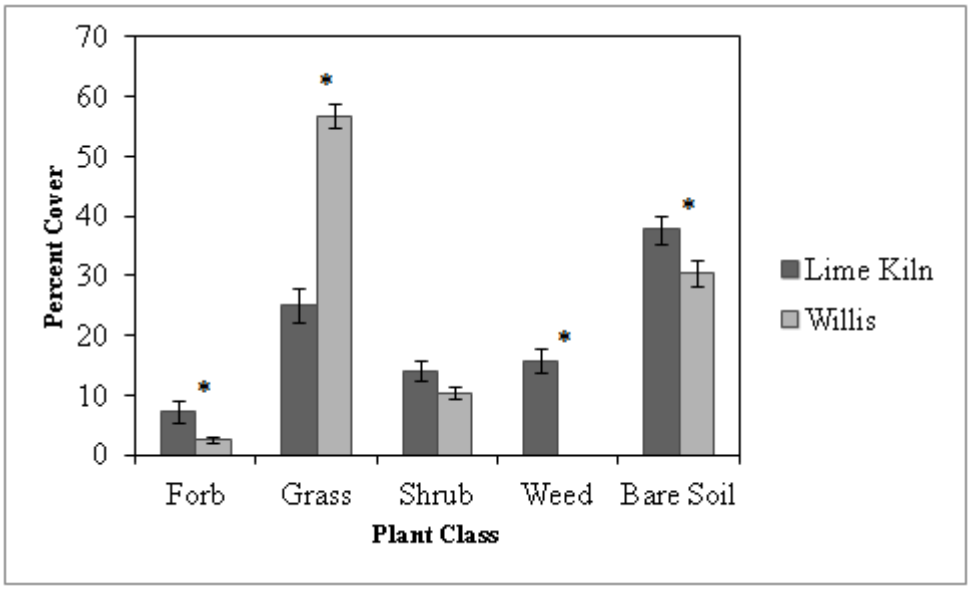

Figure 3-4: Average cover (%) of plant classes with standard error bars, Garfield County, Utah, in August 2011. Asterisk indicates $P < 0.05$.

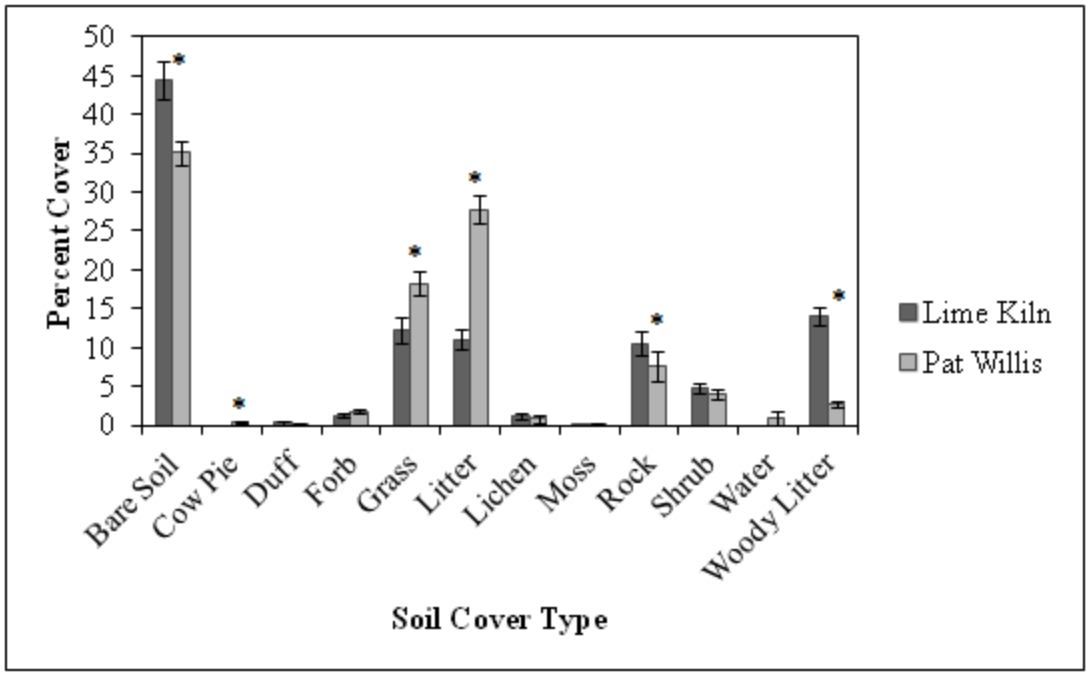

Figure 3-5: Average cover (%) of soil surface layer between relocation sites with standard error bars. Point intercept surveys conducted in August 2011, Garfield County, Utah. Asterisk indicates $P < 0.05$.

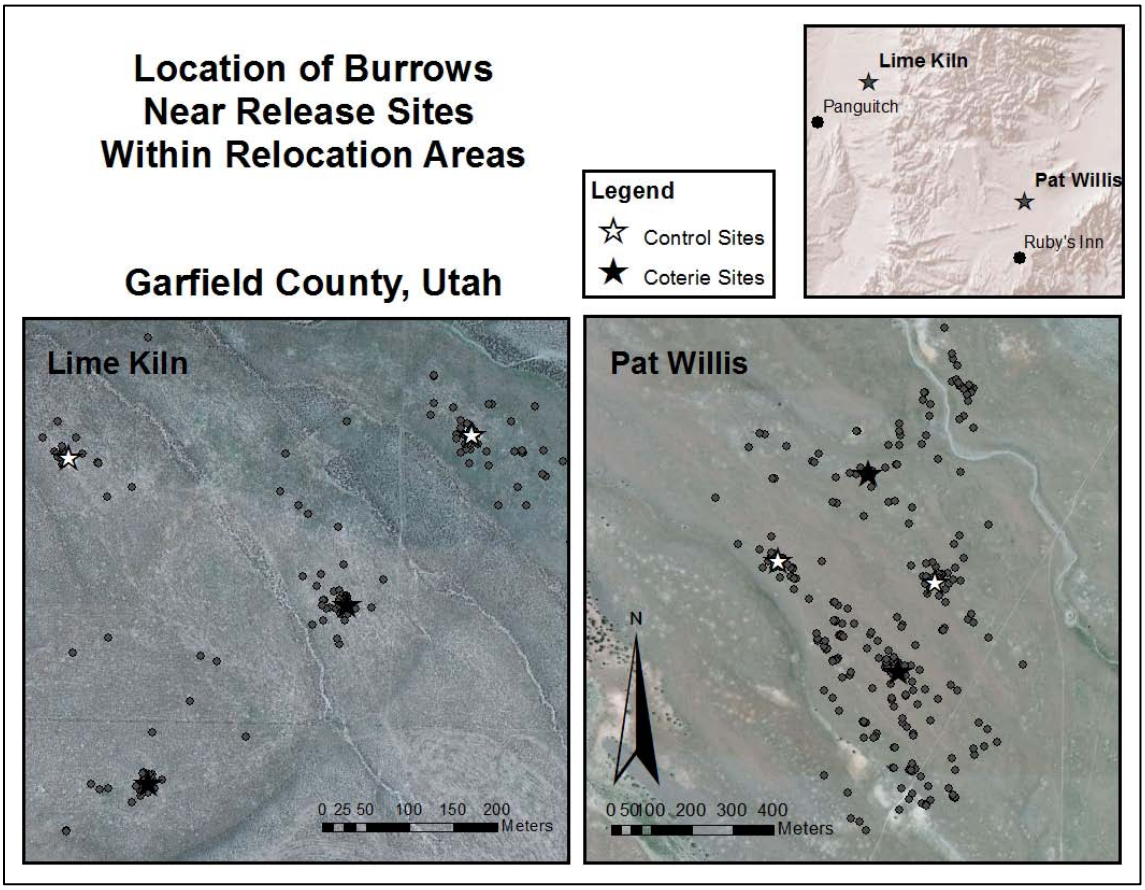

Figure 3-6: Locations of Utah prairie dog burrows in relation to the release sites within both relocation study areas. Note the larger scale at the Pat Willis site. Locations were mapped in October 2011.

Cover at the soil surface layer also significantly varied by site (STS = -20.465, $P \leq 0.001$) (Fig. 3-5). Univariate tests yielded significant results between sites for all basal cover types except shrubs, moss, lichen, forbs, and fine duff. Water cover was indefinable because a livestock watering pond was recorded in one transect.

I found 449 new, natural Utah prairie dog burrows at the relocation areas. Lime Kiln had 143 new burrows, and the Pat Willis site had 306 in the 1-km² area surrounding the relocation sites. The new burrows at both sites were clustered rather than randomly distributed (Fig. 3-6). The nearest neighbor tool takes an average distance from each

burrow to its closest neighbor. The expected mean is the average distance burrows would be separated if the burrows were uniformly distributed. At the Lime Kiln site, the observed mean distance between burrows was 16.2 m, while the expected mean was 32.4 m (Z-score = -12.900, $P \leq 0.001$). At the Pat Willis site, the observed mean distance was 14.5 m, while the expected mean was 32.1 m (Z-score = -19.547, $P \leq 0.001$).

DISCUSSION

The vegetation composition and structure varied significantly between the two relocation sites. In addition to the vegetation differences, the Pat Willis site had more prairie dogs 1 year following relocation, relocated animals reproduced the year following release, and more burrows were created than at the Lime Kiln site. There may be several factors driving these trends.

One factor influencing Utah prairie dog survival at relocation sites may be the difference in vegetation height and composition; vegetation was significantly taller at the Lime Kiln site. This may be due to a combination of taller plant species (e.g.: *Penstemon palmeri*), and cattle grazing at the Willis site. Utah prairie dogs have been shown to prefer foraging in short vegetation (Cheng and Richie 2006) to avoid predators. The Lime Kiln site had significantly higher percentages of bare soil, weeds, and forbs. The Pat Willis site had a higher percentage of grass than the Lime Kiln Site, and grasses are the preferred forage of prairie dogs (U.S. Fish and Wildlife Service 1991, Slobodchikoff et al. 2009). This could have implications for over winter survival, as variation in hibernation patterns are due to environment rather than physiological differences (Lehmer and Biggins 2005), and suitable forage is necessary for adequate weight gain

prior to hibernation (U.S. Fish and Wildlife Service 1991). Relocated animals did appear to preferentially forage on grasses and forbs during the summer months, but were observed heavily consuming broom snakeweed (*Gutierrezia sarothrae*) in the month before hibernation. This was not considered unusual, as prairie dogs are often observed foraging on flowering shrubs during autumn (U.S. Fish and Wildlife Service 1991).

Woody litter was significantly higher at the Lime Kiln site due to the dead sage brush left from the reseeding treatment in 2008. Deep woody litter may have affected visibility and mobility of relocated prairie dogs avoiding predators. Herbaceous litter was significantly higher at the Willis site, because this category included dead grass. This preferred forage was more common at Willis than Lime Kiln.

Soils were significantly rockier at the Lime Kiln site, which is expected given the gravelly to cobbly loam soil classification of the area. Poor soils may have accounted for the lower number of prairie dog burrows observed at Lime Kiln.

Evaluating burrows on this scale was very subjective. I did not correlate the vegetation characteristics and burrow locations because I was unable to set a distance threshold relating vegetation plots to burrows. It was not uncommon for burrows to be 150 - 200 meters from the nearest vegetation plot. Most of the new burrows were clustered around the release sites, particularly at Lime Kiln where there were limited areas with soil conducive to burrowing. Research on black-tailed prairie dogs has shown that dispersal following relocation is significantly higher in areas with poor soil structure (Roe and Roe 2003). The relocated prairie dogs avoided establishing new burrows in drainages, probably to avoid flooding. They also avoided high, rocky benches. It

appeared that the prairie dogs avoided placing burrows in areas with tall vegetation. This preference has been observed in other prairie dog studies (Cheng and Richie 2006, Roe and Roe 2003).

In conclusion, in this study I was able to determine that site differences may affect the long term retention and colonization of a relocation area. However, evaluating which factors are important for successful relocation sites is beyond the scope of this study. Additional research should be conducted on the characteristics of historically successful Utah prairie dog relocation sites.

MANAGEMENT IMPLICATIONS

Relocation site selection is important for the long term retention and colonization of Utah prairie dog release sites. Tall vegetation and rocky soils discourage prairie dogs from establishing burrows, and sites with reduced suitable forage may have lower retention and reproductive rates. Managers should select relocation sites with a percentage of high grass cover, and soils conducive to burrowing.

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CHAPTER 4

SUMMARY

There are many factors that affect the survival and retention of relocated Utah prairie dogs. For my research I specifically studied the effect of coterie relocation, and the vegetation characteristics of my two release sites. In addition to these two factors I evaluated age, sex, year of relocation, and weight at capture to evaluate their effects on survival and site retention.

Ultimately, I found no evidence of a survival, or retention, benefit to relocating Utah prairie dogs by coterie, particularly when considering the additional effort required to trap coterie members. Instead, I found that initial trap weight was very important to survival. Daily survival rate increased as weight increased, possibly due to body condition. Most relocated adults lost weight in the 2 months between relocation and recapture, due to stress from relocation, difficulty finding food, and reduced foraging time. It is possible that smaller animals do not have the fat stored to survive heavy weight loss. The observed increased survival rate may also be due to older, and consequently larger, individuals having greater experience than their small, naïve counterparts. Recapture rate decreased as weight increased. Small juveniles were easy to recapture, and were trapped repeatedly. Large animals had very low recapture probability, which suggests that experience may influence survival. I suggest that only adult animals be used for relocation, or at least that juveniles are relocated later in the trapping season. Additional research is needed to determine a minimum weight value for Utah prairie dog relocation.

I observed no evidence of a behavior difference between treatments of relocated prairie dogs. No behaviors occurred significantly more or less often for animals relocated with family members than those relocated as part of the control. Relocated animals showed significantly different behavior when compared to pre-relocation and wild prairie dogs. However, post-relocation behavior was more similar to wild prairie dogs than pre-relocation. Because of the behavior change following relocation, it may be beneficial to relocate Utah prairie dogs from less urbanized populations.

Although the vegetation characteristics varied significantly between the two relocation sites, this had no apparent effect on site retention 2 months following relocation. However, at the Pat Willis site more prairie dogs were observed 1 year following relocation; relocated animals reproduced the year following release, and more burrows were created than at the Lime Kiln site. Evaluating which site characteristics are necessary for long term retention and colonization of relocation sites is beyond the scope of this study. Additional research should be conducted on the characteristics of historically successful Utah prairie dog relocation sites.

Newly established burrows were clustered rather than randomly distributed at both relocation sites, which suggests that the relocated animals specifically chose the burrow sites. Burrows were primarily concentrated around the release sites, but it also appeared that prairie dogs avoided establishing burrows in areas with tall vegetation, drainages, and rocky soils.

I evaluated the two parts of my research separately, but in reality the relocated Utah prairie dogs and the characteristics of the release sites interplay to affect the

survival, retention, and behavior of the released animals. The vegetation at Lime Kiln was significantly taller than that of Pat Willis, due to different plant species and grazing at the Pat Willis site. It appeared that prairie dogs in Lime Kiln spent more time scanning for predators and less time foraging than their Pat Willis counterparts, possibly due to low visibility in the tall vegetation. There was less suitable forage at Lime Kiln, which also may explain the lack of foraging, fewer burrows, and fewer prairie dogs present the second year of the study. The need for suitable burrows is particularly necessary as refuge from predators, and for overwinter survival. Sites without suitable soils and sufficient forage will be unable to support prairie dog colonies.

Relocation of Utah prairie dogs is an important part of the species recovery, both as mitigation, and to increase the countable population. However, the limited success of previous translocations has done little to accomplish these goals. Hopefully this, and future, research will aid in population recovery, and the delisting of Utah prairie dogs.