SPECIES ASSESSMENT FOR BLACK-TAILED PRAIRIE DOG (*CYNOMYS LUDOVICIANUS*) IN WYOMING

prepared by

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Introduction

Prairie dog colonies once stretched from southern Canada to northern Mexico, east of the Rocky Mountains (Hall 1981). Prairie dogs affect many ecosystem processes (Detling and Whicker 1987) and studies have suggested that prairie dogs are important for the maintenance of biodiversity in grasslands (Miller et al. 1994, Reading and Matchett 1997), increasing species richness or abundance of plants (Bonham and Lerwick 1976, Whicker and Detling 1988), arthropods (Agnew et al. 1987), and vertebrates (Agnew et al. 1986, Barko 1996, Ceballos et al. 1999).

Historically, prairie dogs were the target of widespread eradication programs (Anderson et al. 1986, Miller et al. 1996), which, along with land conversion, led to decline of the species to less than 2% of its original range, by conservative estimates (Miller et al. 1994, Mulhern and Knowles 1995). Competition between livestock and prairie dogs for forage has long been the justification for eradication programs (Collins et al. 1984). However, O'Melia et al. (1982) found no significant difference in weight gain between steers that grazed on or off prairie dog colonies. In fact, facilitation in the form of enhancement of forage quality for, and preferential grazing by, pronghorns (Krueger 1986), bison (Coppock et al. 1983b, Krueger 1986) and domestic cattle (Knowles 1986) have been shown for prairie dog colonies relative to uncolonized mixed grass prairie. Despite the obvious reduction in above-ground biomass available for grazers caused by prairie dogs (Coppock et al. 1983a), ungulates seek out prairie dog colonies to forage (Whicker and Detling 1988). The advantage to grazers comes in the form of enhanced crude protein (nitrogen) content of the newly regrowing shoots of previously clipped vegetation (Detling and Whicker 1987, Sharps and Uresk 1990). Likewise, prairie dogs may maintain an herbaceous cover in grasslands and prevent encroachment of woody species, improving rangelands for other grazers (Weltzin et al. 1997a, Weltzin et al. 1997b).

Natural History

Morphological Description

Black-tailed prairie dogs (*Cynomys ludovicianus*) are robust, stockily built ground squirrels. These animals are usually a buff brown with a grizzled black appearance (Figure 1). The last third of the tail is black tipped and 7-10 cm long. Adult *C. ludovicianus* usually weigh 0.8-1.5kg and reach a length of 31-41cm (including the tail; Clark and Stromberg 1987). The head is broad and rounded with relatively large eyes and small ears. The legs are short and powerful, each foot having 5 digits with well-developed claws for digging. The skull characteristics of black-tailed prairie dogs are described by Hoogland (1996) and Hall (1981), but in general the skull is broad and angular with large processes (Figure 2). Their body pelage molts seasonally (twice yearly; Hoogland 1996) and is different between age and sex groups. The first to undergo the molt are the non-breeding juveniles, second are the non-breeding adults, third are the breeding males, and last are the breeding females (Hoogland 1995). It is thought that this sequence of molting is related to the overall body condition, with the most "fit" individuals molting first (Hoogland 1995). Juveniles undergo a "post-juvenile" molt starting at the rump and extending anteriorly (Smith 1967). Contrastingly, adults will molt posteriorly from the head every October. Males and females will also exhibit a differential molt, with the genitalia and secondary sexual characters molting soon after the head (Smith 1967). The color pattern on individual hairs differs during the respective molt period (Hoogland 1996).

All five species of prairie dogs (see Taxonomy) are similar in morphology and appearance, but since the species' ranges do not overlap, locality is diagnostic (see below; Hoogland 1995).

Taxonomy and Distribution

Taxonomy

The complete taxonomic classification for the black-tailed prairie dog is as follows (Hoogland 1996): Order: *Rodentia,* Suborder: *Sciurognathi,* Family: *Sciuridae,* Subfamily: *Sciurinae,* Tribe: *Cynomyini,* Subtribe: *Spermophilina,* Genus: *Cynomys,* Subgenus: *Cynomys,* Species: *ludovicianus.* Two subspecies of black-tailed prairie dogs are recognized: *C. l. arizonensis* located in the southern portion of the black-tailed prairie dog range and *C. l. ludovicianus* located in the northern part of the black-tailed prairie dog range (Hall 1981; Hoogland 1996). Black-tailed prairie dogs are one of five species in the genus *Cynomys*, in the family *Sciuridae*. Mexican prairie dogs (*C. mexicanus*) are the closest relative to black-tailed prairie dogs but do not overlap in range. White tailed prairie dogs (*C. leucurus*) and Gunnison's prairie dogs (*C. gunnisoni*) are found in intermountain basins of the rocky mountain west (Clark 1987). Utah prairie dogs (*C. parvidens*) are found in short-grass prairies of southwestern Utah and are more closely related to white tailed prairie dogs (Hoogland 1996).

Interestingly, the prairie dog was originally named the "Louisiana marmot" (*Arctomys ludovicianus*) by Ord in 1815 due to its outward resemblance to a marmot, but the name was changed to the current genus *Cynomys* in 1817 by Rafinesque (Smith 1967).

Distribution

Black-tails are the most widely distributed species of prairie dog (Figure 3), thought to once occur from southern Canada to northern Mexico, covering a continuous 400-mile wide band from the foothills of the Rockies to the central lowlands of the Great Plains (Koford 1958, Hall 1981). Currently, this species still occurs over its entire range (except Arizona) in small, fragmented colonies (VanPutten and Miller 1999). Generally, *C. ludovicianus* occur east of the other four prairie dogs in North America, occupying more mesic habitats.

In Wyoming, the distribution of prairie dogs is restricted to the eastern third of the state, where short and mixed grass prairies dominate the landscape (Figure 4). The western extent of this range is not well defined, and there may be a zone of sympatry between *C. ludovicianus* and *C. leucurus*, which occupy the sage-grassland basins in central and western Wyoming. There is only one documented occurrence of a stable black-tailed prairie dog colony west of this area, in the Bighorn Basin. Since this colony is so far from the main range of black-tails and is located along a main highway, it likely represents an artificial, anthropogenic introduction rather than a legitimate range expansion (D. Keinath, personal communication).

Recently the Wyoming Game and Fish Department (WGFD) in cooperation with the Wyoming Bureau of Land Management (BLM) have completed a digital map of *C. ludovicianus* towns in Wyoming using 2002 aerial photographs. The portion of this map that represents active towns is unknown, since no estimate of activity has been assessed for the digitized towns. In addition, the map is incomplete since 1/3 of the photographs were unable to be digitized. In fall 2005, the map should be available on the Wyoming Natural Diversity Database (WYNDD) website (http://uwadmnweb.uwyo.edu/wyndd) after it has been evaluated and the quality of the map can be reported (D. Keinath, personal communication).

Habitat Requirements

General

Black-tailed prairie dogs are thought to have once covered the entirety of the Great Plains grasslands (Hall 1981, Miller et al. 1994) (Figure 5). Short- and mixed-grass prairies are easily colonized by prairie dogs especially when the range is overgrazed or in poor condition (Koford 1958). Tall-grass prairie appears to be difficult for prairie dogs to inhabit (Allan and Osborn 1954), possibly because the high levels of vegetative production interfere with clipping, a behavior used by prairie dogs to lower overall vegetative height, facilitating predator detection. Fine, non-sandy soils seem to be important for burrow construction (Clippinger 1989, Reading and Matchett 1997) and may influence the distribution of prairie dogs. Shrubby areas are less favorable for colony establishment, but may not inhibit expansion of existing colonies (Weltzin et al. 1997a). Gently sloping areas (0-10 degrees) are preferred and slopes over 20 degrees are rarely used in the establishment of new colonies (Clippinger 1989, Reading and Matchett 1997). *Cynomys ludovicianus* is rarely found above 2,377m and usually found below 1,829m (May 2004). Black-tailed prairie dogs do not require open water (Clippinger 1989) because of a specialized kidney physiology (Harlow and Menkens 1986) that allows them to more efficiently use water obtained from plants. There is no seasonal variation in habitat requirements due to the colonial nature of this species; therefore, the breeding, foraging, and over-wintering habitats are similar (Hoogland 1995).

A habitat suitability index (H.S.I.) model was completed in 1989 for black-tailed prairie dogs by the USFWS (Clippinger 1989). Models, such as the one developed by Clippinger (1989), have identified important habitat attributes for the species of interest. The habitat attributes considered by Clippinger (1989) were availability of food, water, cover, and soil type. His conclusions about food was that suitable habitat must contain sufficient grasses for spring and summer consumption, a forb flora which will be utilized in fall, and adequate prickly pear available for water needs during winter. According to Clippinger (1989), the food component of the H.S.I. model needs to be a minimum of 15% herbaceous cover for continuous habitation by prairie dogs. For the cover component, vegetative height levels of 5cm to 20cm are considered optimal with a slope of less than 10 degrees for burrow establishment. The cover values are considered to be the most critical component of the model by Clippinger (1989). Soil type is also considered, and has a broad spectrum of acceptable soil types for burrow establishment. Clippinger's (1989) H.S.I. equation is the following:

$$(V_1 \times V_2 \times V_3 \times V_4)^{1/4} = H.S.I.$$

Where: V_1= % herbaceous cover, V_2= slope, V_3= vegetative height, and V_4= soil type

In Wyoming, short-grass prairies in the southeast along with mixed-grass prairies through the northeast compose the majority of habitat for *C. ludovicianus* (Figure 4). The productive, gently rolling hills of the eastern third of the state provide the necessary habitat for colony establishment. The climate in Wyoming is favorable for year round activity, and provides a plant species composition and productivity comparable to that of the nationwide range.

Area Requirements

Coteries, the smallest family unit of a colony or town, are on average 0.3 ha in size, but can range from 0.05 ha to 1.0 ha in size (Hoogland 1995). In theory, the smallest possible unit of area prairie dogs could colonize would be the area of land needed for one breeding pair or family unit which would be ~ 0.05 ha. In Colorado, studies indicated that *C. ludovicianus* colony sizes ranged from one acre to 4,129 acres, with an average size of 75acres; however, most colonies were 1 – 20 acres in size (see May 2004).

Landscape Pattern

The general landscape pattern needed for continous habitation of black tailed prairie dogs is typified by the gently rolling topography and abundant forage of the Great Plains. Shrub dominanted landscapes can also be colonized, but are less preferred to open habitats of grasses and forbs (Clippinger 1989).

Movement and Activity Patterns

Dispersal

The most common movement of this species is of minimal distance due to its colonial nature. However, long distance dispersal does occur, but is very difficult to track (Hoogland 1995) and seems to be rarely successful due to predation risk away from the colony. A study conducted on intercolonial dispersal by Garrett and Franklin (1988) found that dispersal distances can be as much as 5 km. They also found that prairie dogs rarely disperse to start a new colony, rather they move to another established colony. The most common time for dispersal to occur is about a month or so after the juveniles have emerged for the year (Hoogland 1995).

The ultimate cause of dispersal from the natal breeding sites is to prevent inbreeding (Felhamer et al. 2004). Within *C. ludovicianus* populations, young males leave the family group before breeding, whereas females remain. In addition, adult males usually leave groups before their daughters mature (Hoogland 1982). Immigration and emigration by yearling males can be important for gene flow (outbreeding) in large complexes of black-tailed prairie dogs if dispersal is across mostly colonized area (Hoogland 1995).

Impediments to dispersal are largely centered on predation risk. Black-tailed prairie dogs heavily rely on the alarm calling actions of nearby vigilant conspecifics (Hoogland 1981), and a low degree of visual obstruction to detect danger. When venturing into uncolonized, unclipped territory, the danger of predation increases (Hoogland 1995). As a result, most adult and some juvenile male dispersal is within his home colony, although not near his home coterie. Long distance dispersal, when it occurs, is most commonly associated with juvenile rather than adult males, and is usually solitary rather than group movements. Male dispersal peaks during a postweaning period (June – August; Roach et al. 2001). Dispersal of juvenile females is very uncommon because they usually stay and breed on the home coterie for life. If dispersal does occur with a female prairie dog, it is almost always long distance dispersal to another established colony (Hoogland 1995). Other barriers to movement are few, but include large bodies of water such as wide rivers and large lakes.

Activity Patterns

Prairie dogs are diurnal, usually appearing above ground at dawn during the warmer months and midmorning during the winter months. The heaviest above ground activity occurs between 7am and 11am and 5pm and 8 pm (Tileston and Lechleitner 1966, Biggins et al. 1993). *Cynomys ludovicianus* may spend as much as 95% of their time above ground during the daylight hours, and retreat into burrow for only 15-20 minutes to momentarily escape the heat (Hoogland 1995).

Black-tailed prairie dogs are not "obligate hibernators"; instead, they exhibit a state of facultative torpor due to food shortage (in captivity) during the winter months (Harlow and Menkens 1986) and/or weather (i.e., ambient temperature for free-ranging *C. ludovicianus*; Lehmer et al. 2001, 2003). Free-ranging females demonstrated facultative aestivation in summer months during periods of precipitation (Lehmer et al. 2003). Although *C. ludovicianus* demonstrate facultative torpor, they can be active throughout the year (Hoogland 1995). Facultative torpor is one area of prairie dog physiology and ecology that needs further study.

Reproduction and Survivorship

Breeding Behavior

Black-tailed prairie dogs exhibit a harem-polygynous mating system (Hoogland et al. 1987). Usually, one breeding male, two to three adult females, and one or two yearlings of each sex make up a territorial family group, or coterie, although as many as 26 prairie dogs may occupy the largest of coteries (Hoogland 1995). Fierce protection of coteries by males can lead to combat between males, but rarely leads to serious injury or death. Coterie size may vary from 0.05 to 1.1

ha and will contain a variable number of burrows depending on the number of animals, especially breeding females, on that coterie. Since prairie dog females usually stay on the natal coterie, this species avoids inbreeding by four mechanisms: 1) male biased natal dispersal, 2) older males disperse from coteries when daughters become sexually mature, 3) yearling females are unlikely to come into estrus when their father is on the colony, and 4) behavioral avoidance of mating with kin. These mechanisms are further explained in Hoogland (1995).

Breeding Phenology

The breeding season of black-tailed prairie dogs occurs between late January and early April (Clark and Stromberg 1987) and lasts for 2-3 weeks (Smith 1967). Timing of copulation is probably dependant on food availability and the severity of the preceding winter (Koford 1958, Smith 1967). Black-tailed prairie dogs are generally synchronized breeders (Hoogland 1981), breeding the same day in a coterie, and perhaps over 5 days throughout the colony (Hoogland 1995). Gestation is between 28 to 32 days (Smith 1967, Clark and Stromberg 1987). Altricial young are usually born in the early spring and emerge from burrows at about 6 weeks of age. Pups are fully grown in about 90 days (Clark and Stromberg 1987). Latitudinal differences in time of breeding are also evident; for example, *C. ludovicianus* in Texas and Oklahoma breed in January, in Colorado during February, and in Montana during March (Hoogland 1995, 1996).

Fecundity and Survivorship

Sexual maturity does not occur until 2 years of age (Smith 1967) differing from white tail prairie dogs which mature and breed at 1 year of age. Garrett et al. (1982) found that the age of first reproduction and pregnancy rate were both affected by the availability of food, and Knowles (1987) found that litter size is directly connected to precipitation level of the preceding year. Additionally, (Koford 1958) stated that breeding success is not necessarily depressed in small groups as it is in other social organisms like colonial nesting birds. An average litter size is 4 (Anthony and Foreman 1951) to 5 pups (Clark and Stromberg 1987) with the range occurring between 2 and 8 (Hoogland et al. 1987).

Survivorship of male prairie dogs can be 3 or 4 years old and females usually live to be 5 or 6 years old (see Figure 6; Hoogland et al. 1987). Natal survivorship is unknown, but infanticide has been documented and is considered the major cause of juvenile mortality within colonies (Hoogland 1995, 1996). Juvenile survivorship does not appear to be as sex-biased as adult survivorship with about 50% of each sex surviving their first year (Hoogland 1995).

Population Demographics

Metapopulation Dynamics

Although immigration and emigration to and from neighboring colonies is not important in maintaining genetic diversity (see below), maintaining corridors between distinct colonies is important for the long-term persistence of a metapopulation. A metapopulation can persist as long as rate of recolonization (i.e., after events such as plague eliminates a colony) exceeds rate of extinction. Increased isolation and disconnectivity of colonies will decrease successful dispersal between colonies, increase genetic diversity between colonies, and may decrease genetic diversity within isolated colonies through possible inbreeding and overall loss of alleles. Movement between existing or unoccupied colonies is affected by physical aspects of the surrounding landscape, such as tall grasses or urban and agricultural development. Maintaining corridors such as drainages, roads, or trails could facilitate recolonization of unoccupied colonies and continual dispersal among colonies (Roach et al. 2001).

Genetic Concerns

Dobson et al. (2004) demonstrated that the polygynous mating system (coteries within colonies) and female philopatry (see Dispersal below) of *C. ludovicianus* results in a strong genetic differentiation of coteries within a colony. This genetic substructure within a colony has a conserving influence on genetic diversity because different alleles predominate in different coteries, and decrease the loss of genetic diversity of the entire colony. In fact, the genetic diversity within a colony was influenced more from coteries within the colony than immigrants (males) from neighboring colonies. Translocation of females (essentially increasing the female dispersal rate) could actually increase the rate of inbreeding and loss of genetic variation by bringing related males and females into spatial proximity (Sugg et al. 1996, Dobson et al. 2004). This information should be considered when reintroducing or relocating *C. ludovicianus* to different colonies.

Food Habits

Cynomys ludovicianus is herbivorous, consuming the stems, leaves, seeds, and roots of various grasses, forbs, shrubs, and cacti. However, despite this breadth of food sources, black-tailed prairie dogs are not considered opportunists (Uresk 1984), apparently selecting for specific species of these growth forms. In fact, prairie dogs have been shown by Wydeven and Dahlgren (1982) and Fagerstone et al. (1981) to choose plants that are not abundant on the range colonized. Unlike other ground squirrels, and even other species of *Cynomys*, the black-tailed prairie dog does not store food in its burrow (Koford 1958) or hibernate during the winter.

The first known food habit study (Kelso 1939) found that western wheat grass (*Agropyron smithii*) and six-weeks fescue (*Festuca octoflora*) were most important followed by Russian thistle (*Salsola australus*), prickly pear cactus (*Opuntia* spp.) and saltbush (*Atriplex* spp.). Uresk (1984) found that only four plant species composed 65% of the diet of black-tails in South Dakota, of which grasses accounted for 87% of the diet and forbs composed 12%. Summers and Linder (1978), as well as Fagerstone et al. (1981) and Wydeven and Dahlgren (1982) also found that grasses are the most important component of prairie dog spring and summer diets, sometimes composing up to 90% of the food eaten.

Much controversy has arisen on the food habits of prairie dogs due to the potential for competition with domestic cattle (Uresk and Bjugstad 1983). However, steer weight gain on pastures with and without prairie dog grazing were not statistically significant (O'Melia et al. 1982, Uresk and Bjugstad 1983). Further, preferred plant species overlap between cattle and prairie dogs is not significant (Knowles 1986). Studies of the grazing relationship between bison (*Bison bison*) (Coppock et al. 1983b, Krueger 1986), pronghorn (Krueger 1986), and cattle (Knowles 1986) suggest that prairie dogs increase nutritional value of forage and change grazing habits by increasing shoot nitrogen and reducing standing dead biomass (Detling and Whicker 1987).

Seasonal change in diet is very common and is thought to occur in response to the decreased crude protein and increased fiber of mature plants (Fagerstone et al. 1981). Koford (1958) and Fagerstone et al. (1981) found that during winter, basal parts of buffalograss (*Buchloe dactyloides*), prickly pear cactus, fourwing saltbush (*A.canescens*), and rabbitbrush (*Chrysothamnus* spp.) were important. Shallow digging for roots may also be an important source of protein during winter (Tileston and Lechleitner 1966). During spring, the newly greening vegetation is preferred and the dominant species consumed are Russian thistle, scarlet globemallow (*S. coccinea*) and summercypress (*K. scoparia*). Shifts from C_3 to C_4 plants throughout the summer may occur in response to the subsequent greening of these species. During fall, the green bases of grasses such as buffalograss and blue grama (*Bouteloua gracilis*) are sought (Koford 1958, Fagerstone et al. 1981). Winter food items include mostly roots and prickly pear cactus (Summers and Linder 1978, Wydeven and Dahlgren 1982). Interestingly, prairie dogs have apparently developed the necessary physiology to cope with the oxalic acid occurring in prickly pear, in order to gain its moisture rich benefit in the winter diet (Fagerstone et al. 1981). It has been suggested that prairie dogs choose the most succulent form of vegetation available on a seasonal basis due to water stress (Fagerstone et al. 1981). Grass may compose as much as 85% of its wet weight as water (Hansson 1971), thus providing prairie dogs with the water needed for efficient assimilation (Becksted 1977).

Community Ecology

The potentially disproportionate influence of black-tailed prairie dogs in prairie ecosystems has led their being called keystone species, but this designation has been contentious (Stapp 1998; Miller et al. 2000). Prairie dogs (*Cynomys* spp.) are important members of grassland communities. They affect rangeland habitats by influencing plant species diversity and composition, creating habitat preferred by other wildlife species (May 2004). An estimated 170 vertebrate species have been alleged to rely on prairie dogs for some life needs (Clark et al. 1982; Reading and Matchett 1997; Lomolino and Smith 2003b). Well known obligates of prairie dog colonies include black-footed ferrets (*Mustela nigripes*) (Biggins et al. 1985, Reading 1993) and burrowing owls (*Athene cunicularia*) (Tyler 1968, Sharps and Uresk 1990), both of which depend on prairie dogs for burrow structures and/or food.

Prairie dogs are thought to affect many ecosystem processes (Detling and Whicker 1987) and habitat characteristics (Weltzin et al. 1997b), thereby having direct and indirect influences on the flora and fauna around them. For example, the black-tail's practice of "clipping" tall vegetation from burrow entrances to increase predator detection is similar to grazing and burning rangeland practices that encourage new plant growth, which is more nutritional and palatable to other wildlife species and domestic livestock (Knight 1994; May 2004). Removal of this species from prairie ecosystems could have effects on plant and animal species diversity and abundance over time. Lomolino and Smith (2003b) determined that *C. ludovicianus* towns harbored more rare and imperiled species (i.e., swift fox, black-footed ferrets, and burrowing owls), and therefore a decrease in prairie dogs could be detrimental to these species.

Conservation

Conservation Status

Federal Endangered Species Act

In 1998, two petitions were received by the U.S. Fish and Wildlife Service (USFWS) to list *C. ludovicianus* as threatened under the Endangered Species Act of 1973 (ESA). One petition was filed on July 30, 1998 by the National Wildlife Federation (NWF), and the second petition was received on August 26, 1998 from the Biodiversity Legal Foundation, the Predator Project, and Jon C. Sharps (see USFWS 2004b). These petitions listed several factors that could be major threats to the viability and conservation of *C. ludovicianus*, including habitat loss, habitat fragmentation, disease, unregulated shooting and poisoning, and the synergistic effects of these threats and others. The 90-day finding for the petitions was published in the Federal Register (FR) on March 25, 1999 (USFWS 1999) which stated that the petition action may be warranted. The 12-month finding by the USFWS on February 4, 2000 announced that listing *C. ludovicianus* was warranted but precluded (USFWS 2000), and therefore considered a candidate for listing.

Four of the five necessary conditions for listing were demonstrated (all were met except #2) (VanPutten and Miller 1999). These conditions were:

1. Present of threatened destruction, modification, or curtailment of habitat.
   This condition for listing was met by demonstrating the limiting of habitat, and reduction of populations, that has occurred largely due to agricultural interests.
2. Over-utilization for commercial, recreational, scientific, or educational purposes.
   This condition was not met. However, recreational shooting of prairie dogs may be reinvestigated in the future, depending on regulation of this activity by agencies.
3. Disease or predation
   This condition was met due to the high mortality (99.9%+) of prairie dogs faced with sylvatic plague. Unfortunate epizootics could easily eliminate the population.
4. Inadequacy of existing regulatory mechanisms
   This condition was met due to the classification of prairie dogs as pests in the states in which they occur. Adequate management actions to curtail recreational shooting and poisoning do not exist for many states.
5. Other natural or man-made factors affecting its continued existence.
   This condition was met due to reasons in #4.

Candidate listing required reassessments and resubmitted petitions to be listed annually in the FR (see USFWS 2001, USFWS 2002, USFWS 2004a). From these assessments and available scientific and commercial information it was determined that the petitioned action to list *C. ludovicianus* under the provisions of the Endangered Species Act (ESA) was not warranted on August 18, 2004. As a result, *C. ludovicianus* is no longer considered a candidate for listing (USFWS 2004b). The action to remove *C. ludovicianus* from the ESA candidate list was based on the following determinations: 1) destruction of habitat from agricultural conversion and other factors was no longer a threat, 2) modification of habitat due to the presence of plague was a moderate, imminent threat, 3) the present limitation of habitat due to chemical control was no longer a threat, 4) effects due to scientific or education purposes and commercial use of the species via the pet trade were not threats, 5) recreational shooting could be a low, imminent threat in some circumstances, 6) predation was not a threat, 7) disease was a moderate imminent threat, 8) the inadequacy of existing regulatory mechanisms was a moderate, imminent threat, and 9) chemical control and synergistic effects were moderate imminent threats (USFWS 2004b).

Bureau of Land Management

The State Offices of the Bureau of Land Management (BLM) in Montana, New Mexico, North Dakota, South Dakota, and Wyoming list *C. ludovicianus* on their sensitive species lists. According to the BLM Manual 6840, this designation is meant to provide protection of *C. ludovicianus* and the habitat on which they depend. Therefore the BLM is responsible for reviewing programs and activities on BLM land to determine their potential effect on *C. ludovicianus* (USDOI BLM Wyoming 2001; Keinath et al. 2003).

Forest Service

The range of *C. ludovicianus* encompasses portions of four forest service regions: the central part of the Northern Region (R1), the eastern half of the Rocky Mountain Region (R2), the eastern portion of the Southwestern Region (R3), and the western portion of the Southern Region (R8). Currently *C. ludovicianus* is listed as a sensitive species in Region 2 (http://www.fs.fed.us/r2/projects/scp/) and the subspecies, *C. l. arizonensis* is listed in Region 3 (New Mexico and Arizona; BISON 2004a).

State Wildlife Agencies

The Wyoming Game and Fish Department (WGFD) has developed a matrix of habitat and population variables to determine the conservation priority of all species in the state. Seven classes of Native Species Status (NSS) are recognized, with NSS1 representing critically imperiled species and NSS7 representing stable or increasing species. Classes 1, 2, 3, and 4 are considered to be high priorities for conservation attention. The WGFD assigns *C. ludovicianus* a special concern rank of NSS3. The NSS3 rank is based on WGFD estimates that *C. ludovicianus* populations in Wyoming are declining or restricted in numbers and/or distribution and habitat is restricted and/or vulnerable to human disturbance (Oakleaf et al. 2002; Keinath et al. 2003). Oklahoma also recognizes *C. ludovicianus* as a special management concern. See Table 2 for a complete list of state designations for *C. ludovicianus* across its range.

<u>Heritage Ranks and WYNDD's Wyoming Significance Rank</u>

The Natural Heritage Network assigns range-wide and state-level ranks to species based on established evaluation criteria (e.g., Keinath and Beauvais 2003, Keinath et al. 2003). *Cynomys ludovicianus* merits a global rank of G3 (averaged), which means that when the range-wide population is considered, it is deemed by Heritage scientists as rare or local throughout its range or found locally in a restricted range. This is based on evidence that the extent of occupied habitat and abundance has been reduced from its historic range (NatureServe 2004).

Twelve western states and provinces have assigned a State Rank to *C. ludovicianus*, none of which rank it as demonstrably secure (Figure 7). In general, state ranks are assigned based on the assessed risk of extinction within a state, where S1 species are deemed critically imperiled and S5 species are deemed demonstrably secure. These assessments are based on the biological information on population status, natural history, and threats at the state level. *Cynomys ludovicianus* is ranked as imperiled (S2) in New Mexico, Wyoming, and Saskatchewan; vulnerable (S3) in Kansas, Montana, Oklahoma and Texas; and apparently secure (S4) in Colorado, Nebraska and South Dakota. They are presumed extirpated (SX) in Arizona and their status is under review in North Dakota (SU) (NatureServe Explorer 2004; Keinath et al. 2003, Keinath and Beauvais 2003). The black tailed prairie dog was ranked as imperiled in Wyoming due to the following factors pertaining mainly to large towns (Keinath et al. 2003):

- Their range encompasses a moderate proportion (between 10% and 50%) of the state. Their historic range in Wyoming likely covered about 40% of Wyoming (Clark and Stromberg 1987). However, given fragmentation of habitat suggesting 0.01% of this historic range being occupied (Table 1), prairie dogs may actually cover less than 240,000 acres, or 0.004% of the state (e.g., Luce 2001). Wyoming likely contains about 17% of the historic black-tailed prairie dog range.
- They exhibit low range occupation (<20% of delineated range) and a patchy range-wide distribution. Historic distribution touches several states, including Montana, Wyoming, North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, Texas, New Mexico, Arizona, and Colorado, but is quite patchy within this range.
- Their abundance within Wyoming is uncertain but probably declining (due to the intrinsic vulnerabilities and external threats noted below). At the turn of the century, black-tailed prairie dogs occupied more than 40 million acres, but estimates suggest less than 1% of that area is currently occupied (Merriam 1902 as cited in Van Putten 1999; Van Putten and Miller 1999). The area of occurrence is now very patchy (Mulhern and Knowles 1995). In Wyoming about 0.01% of historically occupied land contains currently active colonies (Luce 2001), which correlates to about 600,000 acres. However, estimates of active towns are al low as 130,000 acres (Mulhern and Knowles 1995).
- They have high intrinsic vulnerability due to habitat specificity and susceptibility to disease. Black-tailed prairie dogs are habitat specialists that occur mainly in flat, short and mixed-grass prairies with fine, non-sandy soils (e.g., Hall 1981;Miller et al. 1994; Clippinger 1989). Further, they are very susceptible to plague (*Yersinia pestis*), and Wyoming seems to be experiencing a statewide epizootic as of summer 2001 (personal communications with state land managers).
- They face high extrinsic threats, including active eradication programs, land conversion, and habitat fragmentation. Poisoning, shooting, land conversion can each be a substantial threat to black-tailed prairie dogs, but when combined they can devastate entire populations beyond the point of recovery (e.g. Luce 2001; Gilpin 1999).

The black-tailed prairie dog's Wyoming Contribution Rank is "high," because it is a native resident with a moderate proportion of its otherwise restricted continental range in Wyoming. Further, it has a restricted and patchy continental distribution and is arguably more secure in Wyoming relative to other states (Keinath et al. 2003, Keinath and Beauvais 2003).

Biological Conservation Issues

Abundance and Abundance Trends

No good estimate of *C. ludovicianus* abundance across its range is available, although it is estimated to be in the millions. Abundance of *C. ludovicianus* is generally expressed in terms of surface area (hectares/acres) occupied by their colonies (Miller and Cully 2001), as it is more cost-effective than surveying populations and calculating density. The USFWS believe that estimates of occupied habitat provide the best available and most reasonable means of gauging populations and status of the species across its range (USFWS 2004b). Ground-truthing exercises are currently being carried out in New Mexico, Oklahoma, Texas, and Wyoming; therefore, a better understanding of the accuracy obtained from using surface area occupied (obtained from aerial surveys) to estimate abundance will be gained (Luce 2003; USFWS 2004b). Using recent estimates of active *C. ludovicianus* acreage obtained from aerial and remote sensing surveys, estimates of *C. ludovicianus* abundance was calculated by multiplying each acre by the typical density of individuals per acre in colonies across its range (2 to 18 individuals per acre). From these calculations the most current estimated abundance of *C. ludovicianus* is between 3,684,000 and 33,156,000 (average 18,420,000; USFWS 2004b). At the beginning of the 19th century, *C. ludovicianus* numbered near five billion (see BISON 2004b). Thus the abundance of black-tailed prairie dogs has drastically decreased in the past century. It is estimated that *C. ludovicianus* has been reduced across its western range by about 98 – 99% of its former abundance (Wuerthner 1997).

In Wyoming, Mulhern and Knowles (1995) estimated that between 53,000 and 82,590 hectares were occupied by black-tailed prairie dogs. Estimates from 2003 indicate that *C. ludovicianus* occupy approximately 51,000 hectares, which conforms to the projected decline suggested by Wyoming Game and Fish Department as a result of plague-infested colonies (USFWS 2004b). In Wyoming, habitat loss or modification does not seem to be a large threat to *C. ludovicianus* populations, since very little habitat has been lost within the past 30 years (i.e., only 25,000 acres of rangeland converted to crops) and possible future land conversion is rather unlikely, since Wyoming's climate is not conducive to productive and economic crop growth (WBPDWG 2001). Please refer to Table 1 for a state-by-state account of occupied acreage and Table 2 for population trends throughout *C. ludovicianus* range.

Prior to 2003, most rangeland estimates of *C. ludovicianus* abundance were inconsistent and based on imprecise and cursory information, such as limited aerial surveys, review of available aerial photographs, and estimates from weed and pest control staff (Sidle et al. 2001; USFWS 2004b). These various methods provided incomplete and ad hoc data in order to determine abundance trends. For more valid estimates, methodologies across *C. ludovicianus* range need to be standardized. In addition, colonies need to be surveyed more regularly. Taking these actions will not only provide a more accurate estimate of abundance, but will also help document changes in populations as a result of plague, drought, and habitat alterations (see Inventory and Monitoring below).

<u>Distribution and Connectivity Trends</u>

At the turn of the 1900's black-tailed prairie dogs occupied more than 40 million nearly continuous hectares (Merriam 1902 as cited in Van Pelt 1999), and their range included portions of eleven States, Canada, and Mexico. Less than 1% of that area (< 324,000 ha) was occupied as of 1998 (VanPutten and Miller 1999). Despite the loss of habitat, *C. ludovicianus* are still widely distributed over their original range; although, they now occur in small, fragmented, isolated patches (Miller et al. 2000; USFWS 2004b). Arizona is the only state that the black-tailed prairie dog has been totally extirpated from its former range (Mulhern and Knowles 1995). Reduction in connectivity between colonies has probably had minor impacts on genetic diversity (see Roach et al. 2001, Dobson et al. 2004), but major impacts on recolonization success after serious population reductions (i.e., after plague or eradication efforts; see below).

Range contractions have been most evident in Arizona (now extirpated), western New Mexico, and western Texas through conversion of grasslands to desert shrub lands and in the eastern portion of *C. ludovicianus* range in Kansas, Nebraska, Okalahoma, South Dakota, and Texas through cropland development (USFWS 2004b). Most of the range reduction from agricultural development occurred in the early- to mid-1900s, and is a minimal threat today (see Extrinsic Threats).

The Interstate Black-tailed Prairie Dog Management Team plan states that Wyoming has a fraction (~ 0.01%) of the historical range currently occupied by active colonies (Luce 2003). In Wyoming, there is very little land under cultivation (< 5%), so the levels of land conversion observed in other parts of this species range have not impacted the species as severely. Competition with livestock ranching, and the control efforts that result (see Below), remains the main threat to further loss of species range. Landowner incentive programs may promote the use of some lands, currently used intensively for grazing, for prairie dog habitat.

Extrinsic Threats

The cause of *C. ludovicianus* population declines in the past century can be attributed to 1) intensive eradication programs, 2) agricultural conversion of rangelands, 3) sylvatic plague, 4) urbanization, and 5) recreational shooting. (Wuerthner 1997; Van Pelt 1999). The synergy of these threats may reduce populations drastically. The following section will address these issues. oisoning and shooting of prairie dogs by ranchers, and agricultural conversion of habitat are responsible for the majority of *C. ludovicianus* population decline (Miller et al. 1990, 1994)

Control Programs

Poisoning programs were initiated in the early 1900's when prairie dogs were first deemed an agricultural threat by Merriam (1902 as cited in Van Pelt 1999), with accusations that prairie dogs compete with domestic livestock for forage (Hoogland 1996). Both small-scale (i.e., trapping and drowning) and large-scale (i.e., poisoning and fumigation) eradication programs were used (Barko 1997). Since federal eradication programs were initiated in 1915, many federal land and wildlife management agencies, as well as state agencies, have been responsible for the extirpation of prairie dogs from millions of hectares (Anderson et al. 1986, Mulhern and Knowles 1995). In fact, it is thought that such poison eradication programs were responsible for the extirpation of *C. ludovicianus* in Arizona (see AGFD 1988). Despite modern evidence about grazing relationships (Coppock et al. 1983b, Uresk and Bjugstad 1983, Uresk 1984), and demonstration of the economic inefficacy of poisoning (Miller et al. 1996), this practice has continued into the 1990's with state and federal mandates. Though federal and state agencies have slowed poisoning in 1999 (WYGF 2001), private land owners are still permitted to exterminate prairie dogs from their lands. However, many states, including Wyoming, are developing incentive programs for private landowners to keep prairie dogs on their lands (WYGF 2001). Shooting also occurs for population control across the range of all 5 species in the U.S. (Mulhern and Knowles 1995). The USFWS (2004b) no longer consider control programs a threat to the persistence of *C. ludovicianus* populations across its range; chemical control programs and synergistic effects were considered a moderate imminent threat.

Recreational Shooting

Little is known about recreational shooting affects on *C. ludovicianus* populations; however, it is suggested that recreational shooting would only limit, not extirpate populations (Vosburgh and Irby 1998). Fox and Knowles (1995 in Mulhern and Knowles 1995) state that it would require one recreational day of shooting for every 6ha of prairie dogs to adversely affect populations. In addition, the USFWS (2004b) have found recreational shooting only a low, imminent threat, since it has been recognized that populations are capable of recovering from such adverse impacts. However, in some states, interest in recreational shooting has increased. Some States with large amounts of public land are experiencing increased shooting pressures on prairie dogs (USFWS 2004b). For example, in Wyoming, an increase in requests from the public as to where to shoot prairie dogs has been noted by Wyoming Game and Fish Department, Wyoming Department of Agriculture, and local Chambers of Commerce. This increased interest in prairie dog shooting, both locally and out-of-state has raised some concern that recreational shooting may become a significant contributor to *C. ludovicianus* population declines in Wyoming (WBTPDWG 2001). States concerned with increased recreational shooting are beginning to implement regulations to better monitor and control this activity (USFWS 2004b). Recently, Thunder Basin National Grassland has implemented a no shooting policy on 45,000 acres of prairie dog habitat in northeastern Wyoming (USDA 2004). This ban is one of the first of its kind on public lands. Other States, such as Arizona, Colorado, Montana, and South Dakota have also begun to restrict hunting on *C. ludovicianus* by limiting seasons and/or closing public lands. Still other States have begun to require hunting permits for public lands (Luce 2003). Shooting restrictions extended by some states on black-tails are a positive step; however, some researchers are concerned that it will cause a shift of shooting to the other species of *Cynomys* (VanPutten and Miller 1999).

Habitat Alterations

Reductions in *C. ludovicianus* habitat have occurred across its historical range, as a result of urban development and conversion of rangelands for agricultural purposes. Historically, it was conversion of short- and mixed-grass prairie for agriculture that was the major cause of populations decline, specifically in the eastern range of *C. ludovicianus* (Graul 1980, Dinsmore 1983). However, conversion of habitat from agricultural development is no longer deemed a threat to the persistence of *C. ludovicianus* (USFWS 2004b), since most of the arable land has already been converted (Mulhern and Knowles 1995). This reduced threat is in part a result of research by Sidle et al. (2001) that noted that vast areas of suitable habitat for colonization and expansion of this species still remain, as well as reports that estimate hundreds of millions of acres of potential habitat still remain intact (see USFWS 2004b and Table 1). Along the Front Range in Colorado, urbanization is considered one of the greatest threats to habitat loss (CBOS 1996; CDOW 2003). The USFWS (2004b) recognize that this may be a factor in habitat loss along the Front Range, but does not feel urbanization would present a substantial threat to *C. ludovicianus* across its entire range. In Wyoming, the population of Crook, Cambell, Johnson, Sheridan, and Laramie Counties has increased >10%, Weston, Converse, Platte, and Goshen Counties has increased by <10%, and the only county within *C. ludovicianus* range that has decreased, is Niobrara County (Miller 2001). The associated urban development with the population growth may become more of a threat to *C. ludovicianus* populations than has been present in the past.

Losses in extent and connectivity of native short- and mixed-grassland ecosystems of the Great Plains of North America have been drastic. Historically, *C. ludovicianus* range was continuous and covered >40 million hectares; however, over the past century, this habitat has been fragmented and reduced to less than 600,000ha (Miller and Cully 2001). Fragmentation of grasslands has occurred from such activities as agriculture, urban development (and its associated roads), and oil and gas development (Van Pelt 1999). As a result of this fragmented landscape, colonies have been isolated from one another, disrupting gene flow and successful distribution of dispersing males from their natal colony (Roach et al. 2001). Although habitat has been fragmented and some colonies isolated, it does not appear that this creates a great loss in genetic diversity (see Dobson et al. 2004). On the other hand, if populations are isolated from potential emigrating individuals, and the population within that colony is eliminated, it could become locally extinct. The USFWS (2004a) suggest that isolation of colonies may present a defense against the spread of plague, leaving some remnant populations unaffected and therefore do not deem habitat fragmentation an imminent threat to *C. ludovicianus* populations. In Wyoming, oil and gas development and population increase may become an issue, since suitable *C. ludovicianus* habitat is being developed (see Figure 8).

Although habitat loss appears to be a large threat to *C. ludovicianus* populations, it does appear that this species can adapt to various changes in their habitat. For example, Sidle et al. (2001) documented active *C. ludovicianus* colonies on small patches of grassland surrounded by agricultural development and near housing developments in Nebraska, and in the vicinity of roads and other developments in Wyoming.

Disease

Sylvatic plague (*Yersinia pestis*; known as Bubonic plague in humans) is an exotic bacterial disease that first entered the United States just before the turn of the century (Culley 1989). It was first discovered in the 1940's in Texas (Cully et al. 1997). This disease has profound impacts on populations of prairie dogs (mortality $\geq$ 99%), which have little to no immunity. The plague can be especially devastating for isolated populations (see Wuerthner 1997). However, isolation of populations as a result of habitat fragmentation may be beneficial in preventing the spread of plague throughout entire metapopulations (see Habitat Alteration above). Plague not only has serious immediate effects, but long term population and demographic effects as well when coupled with shooting and poisoning. In fact the demographic changes imposed by such activities may place the species in an "extinction vortex" that the species may not recover from (Gilpin 1999). Populations west of the Dakotas commonly experience epizootics every 5-7 years (Culley, pers. comm.) and these outbreaks may hold the population level at about 40% of what it was before the epizootic (Knowles 1987).

Plague continues to be a threat to *C. ludovicianus* populations in Wyoming. Nearly all Wyoming populations of white and black-tailed prairie dogs have witnessed declines due to plague outbreaks since the 1930's (WBTPDWG 2001). It is suspected that the plague is responsible for population declines in Wyoming (see Abundance Trends). Important locations of extensive black-tailed colonies, such as Thunder Basin National Grassland, have experienced losses of up to 70% of the total active acreage due to plague epizootics (T. Byer, personal communication).

The movement and maintenance of plague is not well understood (Anderson and Williams 1997) and needs further research. However, it has not yet expanded to cover the species national range. The occurrence of *Y. pestis* is generally west of the Dakotas; however, new reports indicate steady eastward movement in the southern part of the range, into Kansas (Cully et al. 2000). It is thought that the disjunctive and patchy distribution of *C. ludovicianus* populations throughout its range has prevented the devastating affects of plague on populations (WBTPDWG 2001).

Although the USFWS (2004b) considers plague the most important factor influencing black-tailed prairie dogs, they still only view plague as a moderate, imminent threat. They base their findings on the following information: 1) high exposure doses of plague bacilli may be necessary for disease contraction in some individuals, 2) limited immune response has been observed in some individuals, 3) a population dynamic may have developed in low-density isolated populations that contributes to the persistence of these populations, 4) the apparent ability of some sites to recover pre-plague levels after a plague epizootic, and 5) approximately one-third of the species' historic range has not been affected by plague.

Other

Predation of prairie dogs by coyotes (*Canis latrans*), badgers (*Taxidea taxus*), black footed ferrets (*Mustela nigripes*), bobcats (*Lynx rufus*), rattlesnakes (*Crotalis* spp), bullsnakes (*Piuophis melanoleucus*), golden eagles (*Aquila chrysaetos*), prairie falcons (*Falco mexicanus*), and accipiter and buteo hawks (*Accipiter* sp. and *Buteo* sp.) has occurred for as long as these species have inhabited the Great Plains. It is unlikely that these predators present a significant population threat to the species on their own (Hoogland 1981, 1996; WBTPDWG 2001). In addition, coloniality and antipredator calls offer a great predator detection system to minimize predation loss (Linner 2001). However, human predation in the form of recreational shooting may be an important adverse factor (see Recreational Shooting above), since recreational hunting can remove many individuals each day and change the demographic structure of metapopulations (Knowles 1987).

Invasive plant and animal species (other than plague, discussed below) do not appear to be a problem affecting prairie dog abundance or distribution.

Intrinsic Vulnerability

Habitat Specificity and Fidelity

Black-tailed prairie dogs occupy short- and mixed-grass prairie ecosystems, which can vary with respect to plant species composition, soil type, and topography (see Habitat). However, due to the colonial nature of *C. ludovicianus*, high fidelity for their habitat, once selected, is demonstrated. A loss of utilized habitat may cause populations to decrease.

Territoriality and Area Requirements

Within colonies, family groups (coteries) are extremely territorial defending their territory from other coteries (Hoogland 1995). Coterie's territories usually occupy about one-third of a hectare (Hoogland 1996); however, coteries occupying areas as large 1.01 hectares have been documented (Hoogland 1995). Since individuals of a coterie obtain 99% of their food and other resources within their territory, size and habitat quality is important (Hoogland 1995). Hof et al. (2004) estimated that one hectare could successfully maintain 18.4 individual prairie dogs. However, this number may be high for Wyoming. For example, when compared with other states within *C. ludovicianus* range, it appears that populations within Wyoming require larger tracts of land per colony, averaging 13 – 764 hectares per colony (see Clark et al. 1982). Fragmentation that reduces habitat availability may be detrimental to the populations.

Susceptibility to Disease

Although coloniality is thought to benefit communities of *C. ludovicianus* (i.e., predator detection), coloniality also promotes the spread of disease, which could significantly suppress local populations (Linner 2001). For example, sylvatic plague (*Yersinia pestis*), an exotic bacterial disease that first entered the United States just before the turn of the century (Culley 1989), has profound impacts on populations of *C. ludovicianus* (mortality $\geq$ 99%), which have no immunity. Plague can spread across whole *C. ludovicianus* complexes in just a few years (e.g., Anderson and Williams 1997, Cully and Williams 2001). Plague not only has serious immediate effects (mortality), but long term population and demographic effects, such as local extirpation of colonies, reduced colony size, increased variance in local population sizes, and increased distances between colonies. The latter can reduce the effectiveness of dispersal among colonies to recolonize after local extinction and increase the probability of extinction for entire complexes (Culley and Williams 2001). The effects of plague on populations are even more devastating when coupled with shooting and poisoning. In fact the demographic changes imposed by such activities may place the species in an "extinction vortex" that *C. ludovicianus* may not recover from (Gilpin 1999). Populations west of the Dakotas commonly experience epizootics every 5-7 years (Culley, pers. comm.) and these outbreaks may hold the population level at about 40% of what it was before the epizootic (Knowles 1987).

In Wyoming plague continues to be a threat to black-tail populations. The disease has not yet expanded to cover the species national range, but nearly all Wyoming populations of white and black-tailed prairie dogs have witnessed declines due to plague outbreaks. Important locations of extensive black tailed colonies, such as Thunder Basin National Grassland, have experienced losses of up to 70% of the total active acreage due to plague epizootics (T. Byer, personal communication). The movement and maintenance of plague is not well understood (Anderson and Williams 1997) and needs further research. The occurrence of *Y. pestis* is generally west of the Dakotas. However, new reports indicate steady eastward movement in the southern part of the range, into Kansas (Cully et al. 2000).

Dispersal Capability

Cynomys ludovicianus are capable of dispersing from natal colonies as far as 5km; however, *C. ludovicianus* will rarely disperse beyond the natal colony due to predatory risk without the warning "predator" calls of conspecifics (see Dispersal). In fact, it is estimated that survival rate decreases by 40% for each 5km dispersal distance (Hof et al. 2002). Roach et al. (2001) showed that prairie dogs within a 264km^2 area of the Central Plains Experimental Range and Pawnee National Grasslands in northern Colorado had a dispersal rate among established colonies of about 39%. It is largely unknown how often *C. ludovicianus* disperse to previously unoccupied sites, but is thought to be rare. Garret and Franklin (1988) demonstrated that dispersal rates increased as available food resources decreased. In highly fragmented colonies (i.e., urban and agricultural development), dispersal capability may be limited. The inability to disperse may create areas of high population density, increased competition for resources, and result in decreased habitat quality, which may lead to population decline and increased inbreeding (see Johnson and Collinge 2004). Other factors that could affect the dispersal of *C. ludovicianus* is the availability of high-visibility corridors or attractants such as chirping of other prairie dogs (Hof et al. 2002).

Reproductive Capacity

Hoogland (2001) demonstrated that *C. ludovicianus* have lower intrinsic rates of increase and are consequently more vulnerable to colony extinction than most other rodents. Five factors are responsible for this slow reproduction: 1) survivorship is <60% in the first year, 2) only one litter/year is produced, even under optimal conditions, 3) only 6% of males copulate as yearlings, 4) the probability of weaning a litter each year is only 43%, and 5) mean litter size at first juvenile emergence is usually 3.08. In addition, females may breed in their first year, but generally do not breed until their second year. On top of that, free-ranging species may only live three – to four years (Hoogland 1995). As a result, *C. ludovicianus* are slow to recover from population crashes such as a plague epizootic and must rely on recolonization from other colonies to recover or reestablish (see Metapopulation Dyamics). Cincotta et al. (1987) suggest that dispersing prairie dogs do not reproduce during their first year in a new colony. This may also play a factor in reproductive capacity. In spite of these facts, some researchers have suggested that *C. ludovicianus* are capable of rapid population increases subsequent to substantial reductions (see USFWS 2004b).

Protected Areas

In some areas of the species range, prairie dogs are protected from anthropogenically induced effects on national monuments, wildlife refuges and specially protected areas of federally managed lands. One such area is a shooting restricted zone in Thunder Basin National Grassland, Wyoming which provides approximately 20,000 acres. However, in contrast to the species range as a whole, the amount of protected area present is a very small percentage. The lack of large tracts of protected prairie dog range has caused some concern among managers due to the inter-colony dispersal that must occur to ensure long term survival of colony complexes that necessarily span large areas of land. As conservation plans are formulated and adopted by various management agencies, the amount of protected area is expected to increase. However, the extent of protections afforded and the extent of land thus impacted is currently uncertain.

Population Viability Analyses (PVAs)

For purposes of intensive management a suitable PVA has not been developed (Luce 2001). However, an interactive, web-based PVA model has been completed by Michael Gilpin at San Diego State University (SDSU) and contracted with the USFWS is available to view and use at http://gemini.msu.montana.edu/ ~mgilpin.prairie_dog.html. This PVA gives an excellent overview of many aspects of prairie dog management including an introduction to the metapopulation structure of black-tails. The interactive "applets" allow the user to manipulate varying conditions that effect population size and persistence such as plague and shooting.

Conservation Action

Existing Conservation Plans

The eleven states within the range of *C. ludovicianus* began a multi-state conservation effort in 1998 to promote conservation and avoid the federal listing of *C. ludovicianus*. The Black-Tailed Conservation Assessment and Strategy (CA&S) was developed in 1999. The purpose of the CA&S is to manage, maintain, and enhance habitat and populations of *C. ludovicianus* across its historic range and reduce the number of threats impacting their viability through the cooperation of private, tribal, federal, and state landowners. It provides actions, opportunities, and incentives for interested parties to become involved with conservation efforts of *C. ludovicianus*, as well as management suggestions such as eliminating mandatory control, regulating seasons or possession limits, maintaining and conserving required habitat and ecosystems, and establishing core populations on public lands to provide animals for dispersal to uninhabited areas or individuals for recolonization (Van Pelt 1999). In 2003 a Multi-State Conservation Plan (MSCP) was completed as an addendum to the CA&S to provide guidelines under which adaptive management plans will be developed by individual states and their respective working groups representing all stakeholders viewpoints (see Luce 2003). Currently ten of the eleven states in the range of *C. ludovicianus* have developed or drafted state prairie dog management plans: Interagency Management Plan for Black-Tailed Prairie Dogs in Arizona (Van Pelt et al. 2001), Conservation Plan for Grassland Species in Colorado (CDOW 2003), Kansas Black-Tailed Prairie Dog Management Plan (Kansas Department of Wildlife and Parks 2002), A Species Conservation Plan for the Black- and White-Tailed Prairie Dogs in Montana (Knowles 1999), New Mexico, North Dakota, Oklahoma (see Luce 2003), South Dakota Black-tailed Prairie Dog Management Plan (Cooper and Gabriel 2005), Texas Black-Tailed Prairie Dog Conservation and Management Plan (TBTPDWG 2004), Draft Wyoming Black-Tailed Prairie Dog Management Plan (Kruckenberg et al. 2001; WBPDWG 2001). Together, the CA&S, the MSCP, and the eleven state management plans hope to remove enough threats to *C. ludovicianus* in order to curtail needs for listing under the ESA while allowing for more flexible management practices. The following target objectives were created in the MSCP to help achieve this goal:

1. Maintain at least the currently occupied acreage of black-tailed prairie dogs in the U.S. (see Table 1).
2. Increase to at least 1,693,695 acres of occupied black-tailed prairie dog acreage in the U.S. by 2011.

3. Maintain at least the current black-tailed prairie dog occupied acreage in the two complexes greater than 5,000 acres that now occur on the adjacent to Conata Basin-Buffalo Gap National Grassland, South Dakota, and Thunder Basin National Grassland, Wyoming.
4. Develop and maintain a minimum of 9 additional complexes greater than 5,000 acres (with each state managing or contributing to at least one complex greater than 5,000 acres) by 2011.
5. Maintain at least 10% of total occupied acreage in colonies or complexes greater than 1000 acres by 2011.
6. Maintain distribution over at least 75% of the counties in the historic range or at least 75% of the historic geographic distribution.

The issue of recreational shooting is slowly being addressed over much of the range of black-tailed prairie dogs. Licenses that were previously un-necessary to shoot *C. ludovicianus* are now required in all states except Montana and Wyoming. However new management ideas have been presented by the Wyoming citizen's working group. These ideas include: temporary closing of shooting if population numbers decline to 15% above objective (200,000 acres) from current levels, develop management units/licensing protocols, and work with the public to develop management strategies (WYGF 2001). In Wyoming, shooting restrictions were enacted on focal populations in Thunder Basin National Grassland during the spring of 2001 to allow populations to expand in anticipation of black-footed ferret reintroduction. Future yearlong closures are proposed by the Wyoming Game and Fish Department (WYGF) for areas considered as important focal regions for conservation of the species (WYGF 2001). Wyoming G&F has begun to develop a memorandum of understanding (MOU) between agricultural, weed and pest, and wildlife commissions to limit poison distribution and to develop land owner incentives for keeping prairie dogs on their lands (WYGF 2001).

The National Forest Service (NFS) has also adopted management strategies to conserve *C. ludovicianus* on NFS lands (i.e., Thunder Basin National Grassland, Dakota Prairie Grasslands, and Nebraska National Forest Land) which are occupied (>70%) by *C. ludovicianus* populations (USDA 2004). These strategies include guidance and directions for the use of rodenticides, landownership adjustment, vegetation management, livestock grazing, prairie dog shooting/hunting, and other management options to either expand or limit growth of prairie dog populations and colonies on NFS lands (see USFWS 2004c).

Conservation Elements

Although *C. ludovicianus* has not been listed as threatened or endangered by the Endangered Species Act, the long-term decline in abundance and distribution across its historic range suggests that there is a need to undertake conservation actions to mitigate such a decline while viable populations still exist. This need is compounded by the fact that the *C. ludovicianus* provides habitat and a food source for a variety of wildlife species, including the endangered black-footed ferret (see Community Ecology). In Wyoming, conservation efforts should be attentive, since far less habitat has been lost in Wyoming than in most other states within the species' distribution (WBTPDWG 2001) and only 79% of suitable habitat is currently occupied by *C. ludovicianus* in Wyoming (see Table 1). Five main conservation elements should be addressed for *C. ludovicianus* conservation management in Wyoming. For more rangewide suggestions, please review Van Pelt (1999). Specific approaches that have been proposed to address these conservation elements are provided in the following section.

1. **Habitat Conservation**: Reduce conversion of land to uses not compatible with local persistence of *C. ludovicianus* and minimize impacts of semi-compatible uses, including livestock grazing and resource extraction.
2. **Disease Control**: The spread of disease (specifically sylvatic plague) among *C. ludovicianus* should be investigated and management should seek to minimize its impacts on prairie dog complexes.

3. **Shooting and Extermination Control**: Unless strictly controlled, recreational shooting and pest control efforts aimed at killing *C. ludovicianus* are not compatible with healthy populations.
4. **Inventory and Monitor Populations**: Current monitoring efforts are insufficient to generate reliable and comparable trend information and are therefore inadequate to track the future of *C. ludovicianus* populations. A thorough and consistent methodology must be applied in Wyoming and across its range, as discussed in the Inventory and Monitoring section below.
5. **Public Education**: In order to apply the above mentioned conservation elements to successful management programs in Wyoming, public attitudes toward prairie dogs need to change. Literature citing the importance of *C. ludovicianus* to rangeland habitat and its associated species need to be easily acquired and come in a variety of materials (i.e., brochures, videos, information boards, etc.).

<u>Acting on Conservation Elements</u>

There are many state citizens' working groups that have developed or are currently drafting conservation plans for *C. ludovicianus* and provide suggestions for management practices for *C. ludovicianus*. In addition, research published that focused specifically on *C. ludovicianus* has also provided management suggestions that may provide the best opportunity to conserve preferred habitat and viable populations of *C. ludovicianus*.

1. **Habitat Conservation**: It appears that conservation efforts to protect lands currently occupied (and adjacent) by *C. ludovicianus* is beneficial for maintaining or increasing abundance (see Table 2). Identifying tracts of lands occupied by *C. ludovicianus* (especially those >5,000 acres; see Van Pelt 1999) should be conducted through coordinated efforts of all federal agencies to maximize the conservation potential and preserve, if not increase, occupied habitat. In Wyoming, this objective is no less than 200,000 acres (WBTPDWG 2001). Maintaining large tracts of land will provide enough acreage and *C. ludovicianus* population to support reintroduced and recovering black-footed ferret populations, as well as other associated species (Luce 2003). Lomolino et al. (2003) suggest a mixed strategy for preserving habitat: maintain or develop widely

distributed large and small complexes (connected for dispersal purposes; Roach et al. 2001), and retain small and large isolated colonies throughout the range to help create barriers to prevent spread of the plague and potential eradication of metapopulations. Create buffers (~75 feet) around protected areas to provide area for expansion. In cases where adjacent land is not compatible with prairie dog colonies (i.e., hay or crop fields), create barriers beyond the buffers (i.e., tall grasses) to prevent establishment and/or foraging in these sites (CBOS 1996). Provide incentives for private landowners to voluntarily maintain prairie dog colonies on portions of their lands, since conserving *C. ludovicianus* habitat is not fully possible without the assistance of private landowners. In Wyoming, this is important, since private land constitutes a large percentage of total prairie dog habitat (WBTPDWG 2001). The multi-state conservation plan outlines a possible incentive program that could be pursued by individual states under such authorities as the Conservation Title of the Farm bill, Conservation Reserve Program, or Grasslands Reserve Program in Appendix E (Luce 2003). In addition, impacts that could adversely affect established or potential *C. ludovicianus* through urban, oil, and/or gas development should be minimized or eliminated. The following are suggestions to mitigate habitat alteration:

- Identify suitable habitat and current colonies before proposed oil and gas exploration and urban development sites are initiated.
- Determine local population densities, quality of habitat, spatial distribution of colonies and habitats (for connectivity and dispersal purposes), and how activities (i.e., drilling) may impact these factors.
- Locate roads outside areas of current, recent, or potential prairie dog habitats identified.
- Place restrictions on vehicle traffic (for mining operations) during the breeding season and dispersal (March through August) to help minimize stress and possible increased infanticide.

2. **Disease Control**: Currently there are no known vaccines to immunize *C. ludovicianus* against threat of the plague. However, steps can be taken to mitigate plague impacts. The multi-state conservation plan (Appendix D; Luce 2003) provides a plague protocol for all eleven states to initiate. It includes a plague monitoring protocol, procedures for visual evaluation of prairie dog colonies for plague, field procedures for collecting and handling

carcasses as diagnostic specimens, and procedures for swabbing rodent burrows. It is important to identify colonies in which the plague affected populations, and try to isolate these colonies from other complexes to stop the spread of the disease. In this case, colonies should be greater than 3km from their nearest neighbor colonies (Cully and Williams 2001). In addition, implementing the suggested mixed-strategy complex design (connected complexes with isolated colonies) will help reduce disease transmission, while maintaining some vital corridors to facilitate repopulation of eradicated populations (see Lomolino et al. 2003).

3. **Shooting and Extermination Control**: Unless strictly controlled, recreational shooting may not be compatible with healthy populations of prairie dogs, altering behavior and reproductive success, especially if this activity increases (Reeve, personal communication; Vosburgh and Irby 1998; USFWS 2004b). Further, unlike some threats (e.g., disease) it is well under the control of land managers. Optimally, shooting should be eliminated, particularly on otherwise impacted towns (i.e., large plague epidemics). During the past few years, several states have established better regulations (i.e., closures and season restrictions) that allow for management of recreation shooting; as well, they have changed the status of species from pest to a designation that recognizes the need for management. However, inn Kansas, North Dakota, and Wyoming, *C. ludovicianus* is still considered a pest and controlled as such (Luce 2003). The following are some restrictions that could help regulate recreational shooting of *C. ludovicianus* to assist in the conservation and protection of the species (Luce 2003):

    - Seasonal closures to all shooting during whelping and dependent young period (March 1 to June 30).
    - Require permits specific to designated areas and limit take.
    - Collect data on harvest (i.e., age and sex of animals harvested), hunter days per county, and hunter days/harvested animal through annual field checks and mail surveys, allowing State Wildlife Agencies to accurately quantify annual harvest.

    In Wyoming, *C. ludovicianus* is considered a pest and management is overseen by the Wyoming Weed and Pest Council, Board of Agriculture, and Wyoming Game and Fish Commission. Currently a memorandum of understanding is being drafted in which these agencies agree to limit the distribution of poisons and their participation in poisoning efforts when survey results indicate conservation plan objectives (i.e., acreage) is in jeopardy. Temporary restrictions on agency poisoning or cooperation with landowners using poison or other control methods should be implemented at local levels when necessary (i.e., poisoning compounding impacts by other threats to populations; WBTPDWG 2001).

4. **Inventory and Monitor Populations**: Conducting a baseline, state wide inventory of the number of acres contained within is crucial for long term population monitoring of this species. This information will allow management agencies to develop population targets, identify important population centers throughout the state, and give a measurable level of increase or decrease in population size under new management regimes. Sidle et al. (2001) present new estimates of prairie dog abundance in four states that are critically important to conservation of *C. ludovicianus*, and present a new aerial survey technique for abundance estimation that is replicable, includes estimates of precision, and does not require trespass permission from private landowners (Miller and Culley 2001; Sidle et al. 2001). It is important that methods range-wide are compatible with each other for comparison. The following strategies were outlined in the Wyoming conservation plan (WBTPDWG 2001):
   - Develop a cooperative effort to fund and conduct research and regularly scheduled inventories.
   - Continue to develop remote census techniques (i.e., Sidle et al. 2001).
   - Evaluate aerial transect techniques to identify the approach and sampling design best suited for Wyoming (see Appendix IX).
   - Conduct selected techniques in areas where ground surveys are being conducted (e.g., Thunder Basin National Grasslands) and evaluate accuracy and precision of techniques.
   - Coordinate with adjacent states to assure that results will be comparable.
     - Select a reliable method, and initiate inventories to document occupied habitat (initiated July 2002).
     - Conduct monitoring survey at three-year intervals from 2002.
5. **Public Education**: Lamb et al. (2001) conducted an eleven state survey within short-grass prairie systems regarding the public's attitude and knowledge of black-tailed prairie dogs.

Overall, the public did not highly regard *C. ludovicianus* and did not consider conservation of *C. ludovicianus* of great importance when compared with larger environmental issues, such as global warming. People will only value grasslands and prairie dogs to the degree that they understand them. Therefore, education of prairie dog may increase the desire to manage prairie dogs, especially since the anti-prairie dog attitude is still pervasive in federal, state, and public views (Knowles 1999; Lamb et al. 2001). Education and outreach materials should cover many topics including but not limited to prairie dog management, prairie dog ecology, plague, and effects of prairie dogs on rangelands and agricultural land. It is important that outreach materials and education programs are factual and represent interests of all stakeholder groups (TBTPDWG 2004). Examples of educational techniques could be: in-school presentation, nature hikes, slide presentations, brochures, and interpretative displays (CBOS 1996).

Habitat Preservation and Restoration

Habitat fragmentation and transformation of the Great Plains grasslands biome has been the most extensive of any in North America. This habitat alteration has impacted the continuity of large, historic habitat needed to establish extensive networks of prairie dog colonies and maintain inter-colony genetic diversity. Clearly, this is an important component of future conservation efforts. Programs that create, protect, and restore suitable habitat and connectivity offer some promise to provide habitat for successful prairie dog colonies/populations.

Roe and Roe (2003) offer guidelines to be used when selecting habitat for *C. ludovicianus* relocation efforts, which could be used for habitat restoration/preservation efforts (see Table 3). The guidelines present environmental parameters specific to soils, vegetation height, cover, and palatable species, slope, and optimal proximity to other established prairie dog colonies. In addition, Lomolino and Smith (2003b) and Lomolino et al. (2003) recommend conserving a network of native prairie reserves strategically located across the historic range of *C. ludovicianus*. They suggest that the network be comprised of "clusters" of large (presumably >10 ha, but size is not directly specified by the authors) towns, as well as large, isolated towns. The latter will be less likely to be infected or serve as a source for spread of the plague. Large towns will also be more likely support populations of *C. ludovicianus* and other associated vertebrates into the future (Lomolino and Smith 2001), buffering adverse effects from various extrinsic extinction forces (i.e., land conversion, expansion of roads, habitat reduction and fragmentation, and plague).

When restoring habitat for reintroduction of *C. ludovicianus*, whether to provide a food-base for black-footed ferrets, or to reestablish *C. ludovicianus* in their historic range, long-term planning is needed, as well as sufficient 1) area of land and habitat, 2) pre-introduction ecological studies and site preparation, 3) breeding individuals to make a reproducing population, 4) protection, and 5) monitoring and follow up studies (AGFD 2004).

Information Needs

Identifying specific information needs will help management agencies to formulate appropriate conservation strategies by targeting key areas needed for effective conservation of the species. The following list briefly notes some of the key information needed to develop sound *C. ludovicianus* conservation strategies.

1. **Inventory/Monitoring**: The development of long term monitoring and inventory of black-tailed prairie dog populations is needed. Without a way to reliably and quantitatively determine trends in abundance and distribution, managers have no way to assess the status of *C. ludovicianus* populations or the effect of management actions on these populations. Inventories should determine locations and sizes of colonies, land ownership, and presence of plague. Monitoring of known *C. ludovicianus* populations will help managers assess the affects of impacts, such as oil and gas projects, on population trends. Remote sensing and aerial and ground techniques need to be developed and standardized among agencies to ensure validity, smooth information flow, and communication (see Sidle et al. 2001).

2. **Disease**: Plague continues as one of the most detrimental threats to this species longevity and healthy population growth. Although some research has investigated the dynamics of plague in prairie dog colonies, there are still huge questions regarding its prevalence, cycle of occurrence, and distribution in the natural environment. Managers need to know how plague spreads between colonies and how it is maintained within colonies. Strategies allowing managers to predict and mitigate epizootics is very important given the catastrophic impact this disease has had on prairie dogs; for instance, field trials of vaccinations or parasite management strategies and/or real-time, large-scale, high-resolution mapping of epidemics. It is unknown if prairie dogs may one day develop immunity to the disease or if virulence will stay high.
3. **Shooting and Poisoning**: Recreational shooting effects have been studied preliminarily (Knowles 1987, K. Gordon, pers. comm.), but further research is needed to fully understand the impact of this activity on demographic structure and population dynamics. Depending on the outcome of ongoing studies, shooting may continue in some areas, but regulation and monitoring of this activity are keys to controlling its effects as evidenced by many years of hunting regulation for game species.
4. **Ecological Ramifications**: More research is needed on the long-term effects of *C. ludovicianus* on floral, faunal, and soil communities to determine if they are indeed a keystone species, and important for the persistence of a variety of species (see Community Ecology above).

Tables and Figures

Table 1: Baily Eco-Region habitat model distributions for each state (Native American tribes in Montana, South Dakota, and North Dakota set acreage objectives independent of states.)

State	Historic Habitat*	Current Habitat	Gross Habitat**	Suitable Habitat***	Minimum 10-Yr Objective
AZ	7,047,137	0	7,047	4,594	4,594
CO	27,352,880	631,102	273,529	255,773	255,773
KS	35,835,079	130,521	150,714	148,596	148,596
MT	60,442,757	90,000	297,286	240,367[1]	240,367[1]
NE	36,035,433	80,000	146,741	137,254	137,254
ND	11,045,269	20,500	110,453	100,551[2]	100,551[2]
NM	39,021,449	60,000	96,661	87,132[3]	87,132[3]
OK	21,606,120	22,000	70,868	68,657	68,657
SD	29,262,553	160,000	218,121	199,472[4]	199,472[4]
TX	78,592,452	167,625	310,945	293,129	293,129
WY	22,067,599	125,000	179,072	158,170[5]	158,170[5]
Total:	368,308,727	1,486,748	1,861,436	1,693,695	1,693,695

* Refers to total potential habitat encompassed within the range (Hall 1981), not occupied habitat

** Gross habitat = total acreage of primary range x 1% + total acres of peripheral range x .1% (Table 2 and Figure 3)

*** Suitable habitat = gross habitat minus habitat with >10% slope, or other unsuitability factors (Agricultural lands were included in suitable habitat if they fit the slope and suitability factors)

1 The acreage objective in the State of Montana's 2001 Management Plan is 90,000-104,000 acres for non-tribal lands. The state's acreage objective will be subject to modification in response to a financial incentives program for landowners if an incentives program is funded. Separate objectives will be set by individual Native American tribes.

2 The current acreage objective listed in the North Dakota Management Plan is 33,000 acres, including non-tribal and tribal lands. The state of North Dakota and the Standing Rock Indian Reservation will determine the target acreage for each jurisdiction. The state is willing to consider an objective of 100,551 acres on non-tribal lands if a financial incentives program for private landowners is funded. Tribal lands will have separate acreage objectives.

3 The New Mexico acreage objective is based on a percent increase per year, which would take approximately 10 years to achieve the current acreage objective. If future statewide survey efforts indicate a different acreage than the estimated minimum current acreage listed, the rate for achievement of the 10-year objective will be adjusted accordingly.

4 The acreage objective for South Dakota includes 169,551 acres of non-tribal lands and 29,921 acres of tribal lands (pending final approval of management plan).

5 Wyoming's draft management plan contains an objective to maintain the current acreage, or 200,000 acres, which ever is greater.

Table 2: Overview of *C. ludovicianus* status throughout its range.

Country	State/Province	State Status (May 2004)	Heritage Rank	BLM Species of Concern	Population Trend (USFWS 2004b)
United States					
	Montana	Nongame Wildlife; Pest	S3	yes	Decreasing[3] Increasing/Stable[4,5]
	North Dakota	Nongame Wildlife	SU	yes	Stable?/Decreasing?
	South Dakota	Game Wildlife; Varmint	S4	yes	Increasing/Stable[4]
	Wyoming	Species of Special Concern	S2	yes	Decreasing[3] Stable[4]
	Nebraska	Nongame Wildlife	S4	nr	Absent[6] Increasing[4]
	Kansas	Wildlife	S3	nr	Absent[6] Increasing[4]
	Colorado	Small Game Species	S4	nr	Decreasing[1,3] Increasing[4,5]
	New Mexico	No Legal Listing	S2	no	Absent[6] Stable?
	Arizona	Extirpated; Nongame mammals	SX	no	Extirpated[1,2]
	Oklahoma	Species of Special Concern	S3	nr	Absent[6] Stable?
	Texas	Nongame Wildlife	S3	nr	?
Canada					
	Saskatchewan	Special Concern	S2	n/a	Stable[4]
Mexico					
	Amenazada	Threatened	n/a	n/a	Absent[1,2,6] Stable[4]

Heritage Rank: SU = unknown, SX = extirpated, S2 = imperiled, S3 = vulnerable, S4 = apparently secure

BLM Species of Concern:

yes = the State's BLM office recognizes *C. ludovicianus* as a Species of Concern
no = the State's BLM office does not recognize *C. ludovicianus* as a Species of Concern
nr = not reported

Population Trend: 1 = habitat conversion, 2 = control efforts, 3 = plague, 4 = habitat preservation, 5 = recovered, 6 = absent from historic range, ? = not enough information

Table 3: Guidelines for *C. ludovicianus* habitat restoration and preservation. Adapted from Roe and Roe (2003).

Parameters		**Description**
Vegetation	species	western wheatgrass (*Pascopyrum smithii*), blue grama (*Bouteloua gracilis*), buffalograss (*Buchloe dactyloides*), sand dropseed (*Sporobolus cryptandrus*), cheatgrass (*Broums tectorum*), sixweeks fescue (*Vulpia octoflora*), ring myhly (*Muhlenbergia torreyi*), sedges (*Carex* spp.), scarlet globemallow (*Sphaeralcea coccinea*), and plains prickly pear (*Opuntia polyacantha*).
	cover	<40% bare ground; shortgrass prairie grasslands 58-70%; …
	height	<30cm
Soil	depth	≥2.0m
	type	loamy with little to no gravel; low in clay (<30%); meduim in sand (~50%); medium to high in silt (>70%) with good drainage.
Slope		< 20%; preferably ≤10%
Proximity to established colonies		≥46m and up to 185-277m

Figure 1: Photograph of adult and juvenile black-tailed prairie dog, Devils Tower National Monument, WY, © Steven W. Buskirk

Figure 2: Drawing of skull morphology of *C. ludovicianus*, adapted from Hoogland (1981).

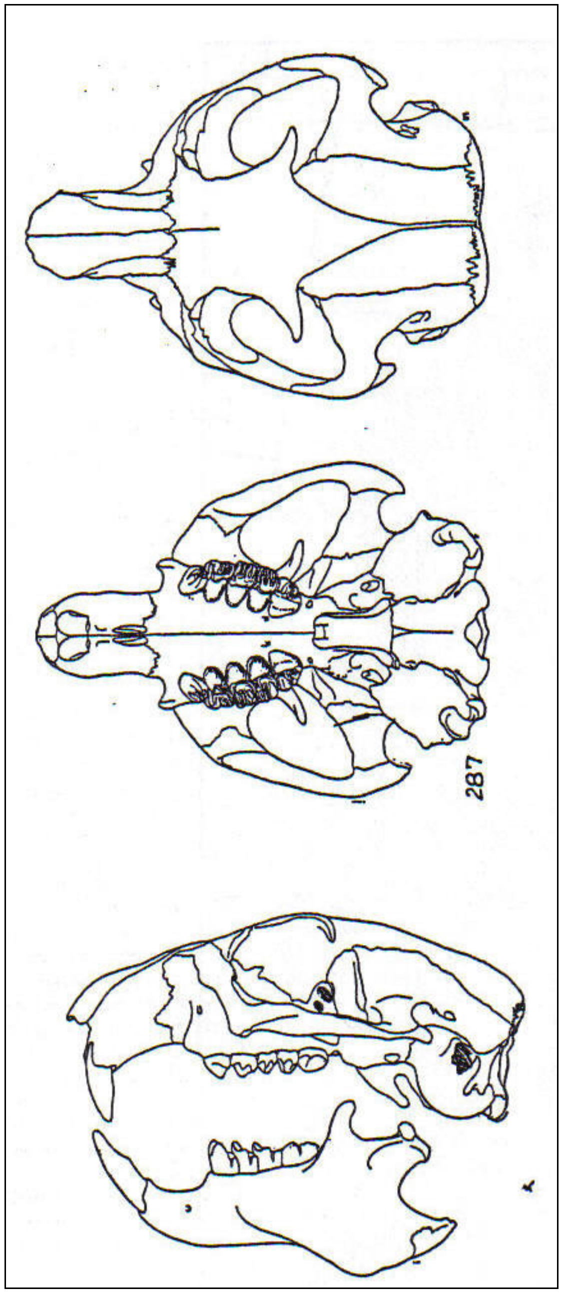
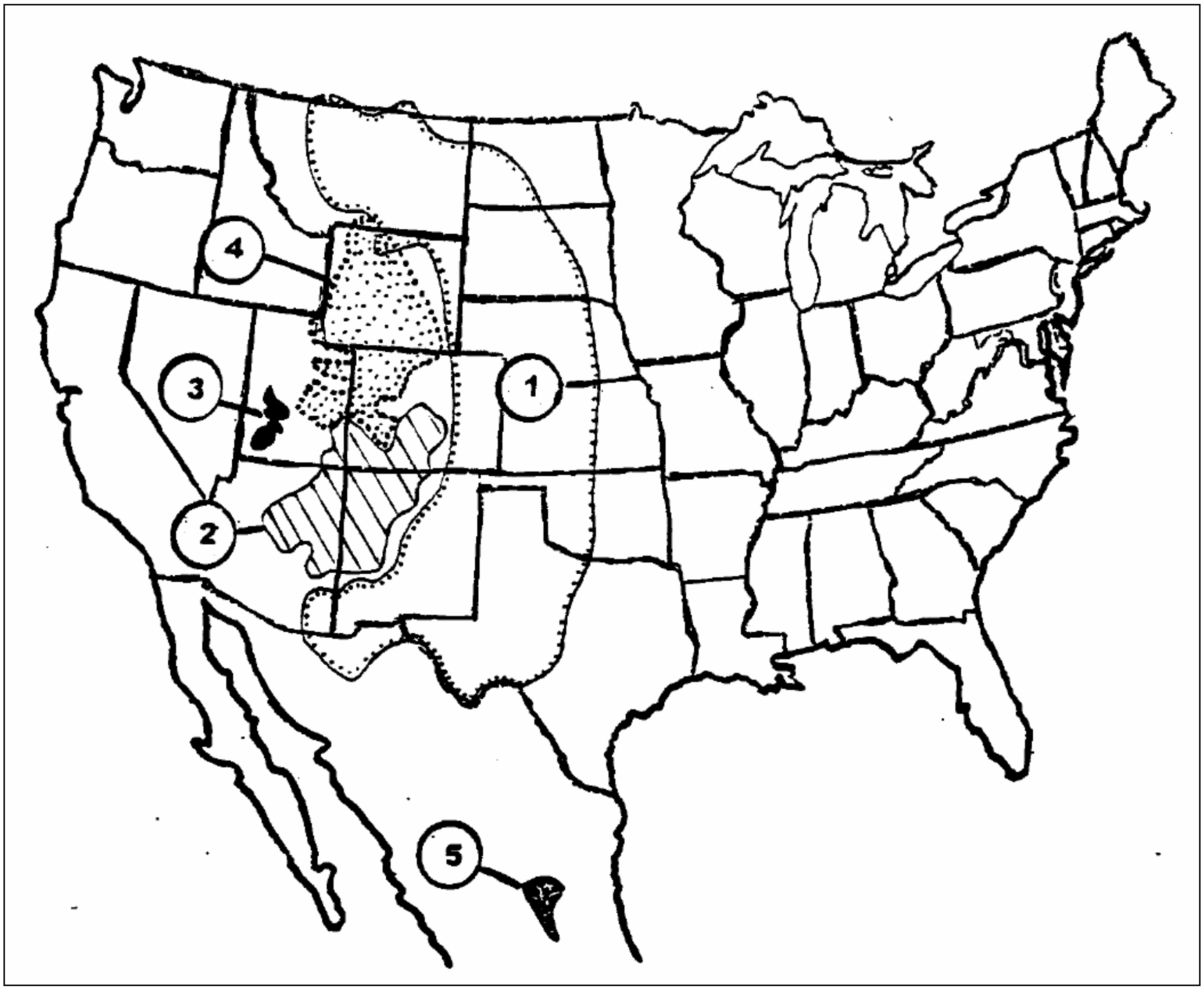


Figure 3: North American range of all prairie dog species from Hall (1981).



1. Black-tailed prairie dog
2. Gunnison's prairie dog
3. Utah prairie dog
4. White-tailed prairie dog
5. Mexican prairie dog

Figure 4: Possible distribution of *C. ludovicianus* based on mixed-grass and short-grass prairie distribution in eastern Wyoming (map acquired from WYGISC website: www.wygisc.uwyo.edu).

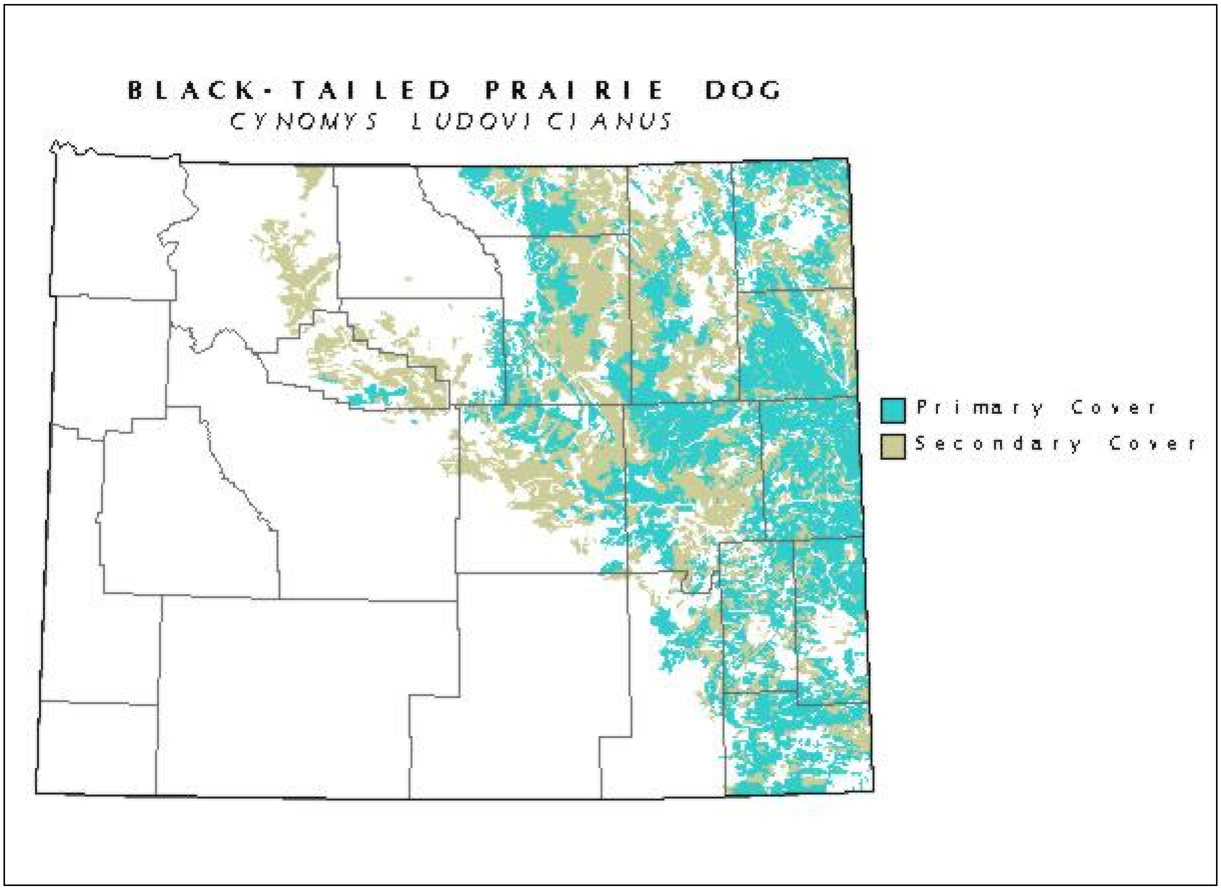


Figure 5: Rangewide distribution of the black-tailed prairie dog. Outline is the historic distribution from Hall (1981) and the shaded portion of the range map is from State surveys. This map does not include current distribution of populations in Canada and Mexico (acquired from Luce 2003).

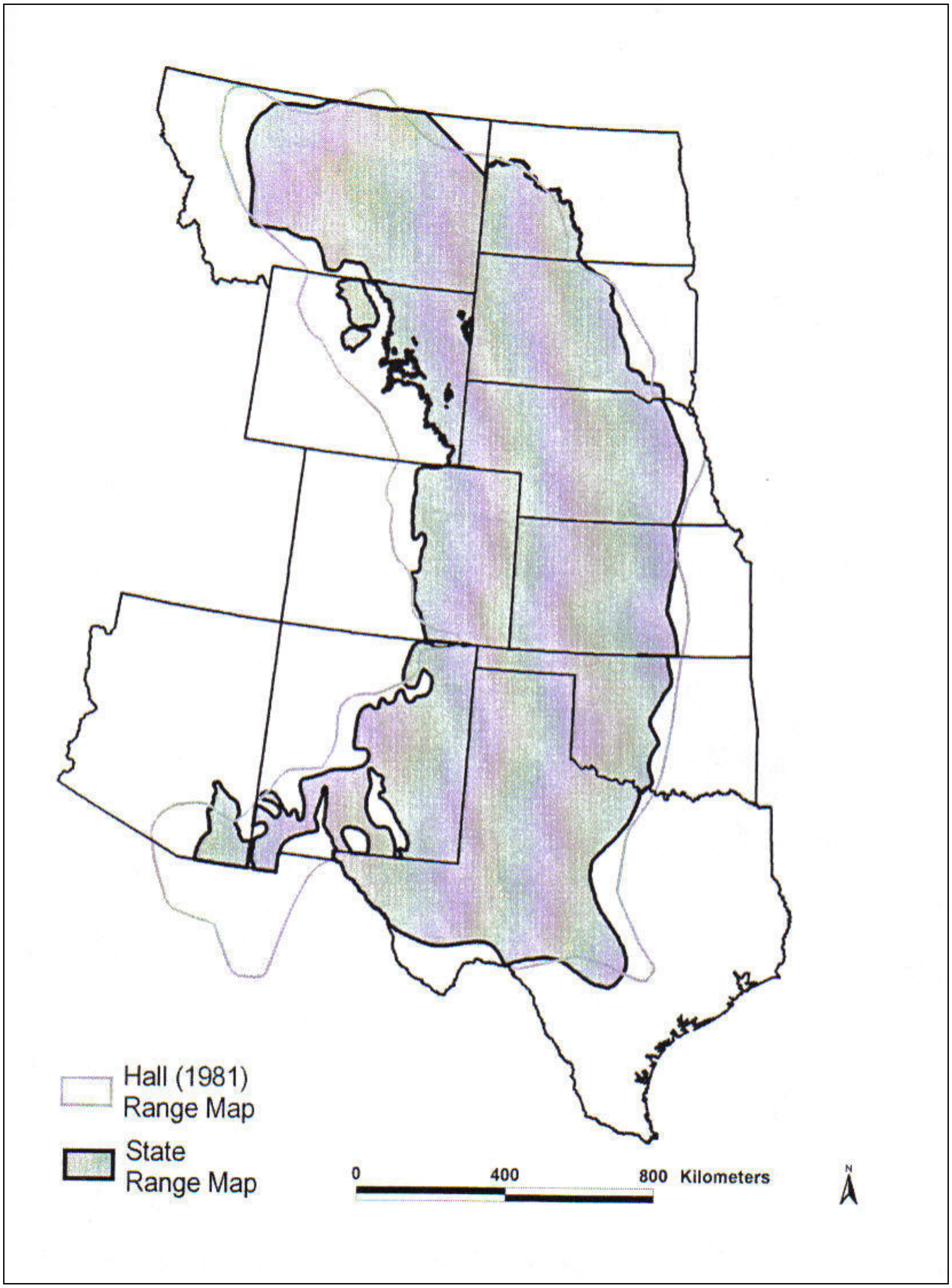
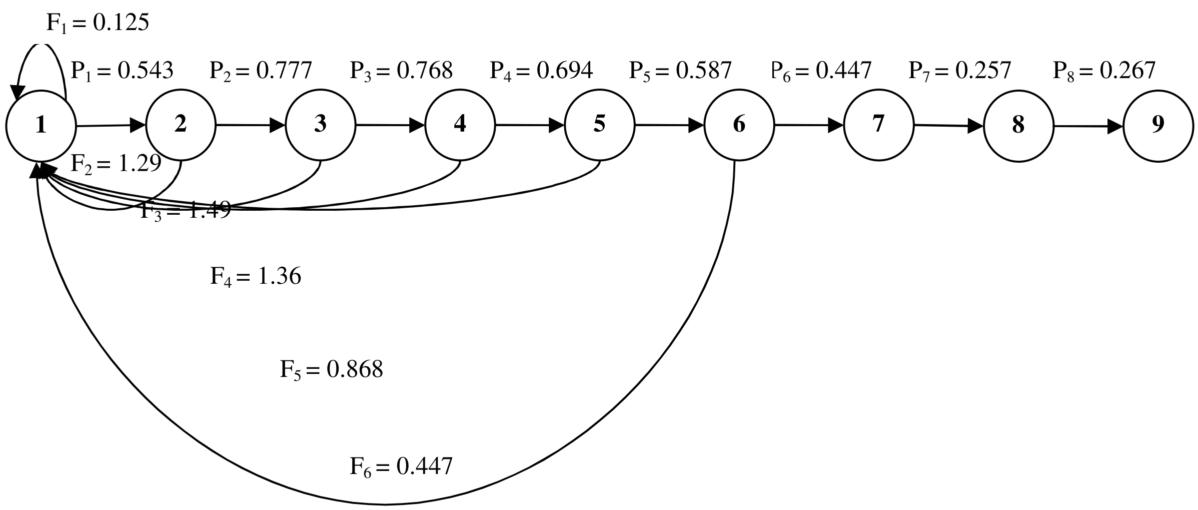


Figure 6. Loop diagram depicting a) life cycle and b) related matrix model elasticities for female black-tailed prairie dogs (*Cynomys ludovicianus*) (courtesy J. Pauli, University of Wyoming). Pi denotes the probability of surviving to the next age class and Fi denotes the fertility of that age class. eij denotes the elasticity from age class j to age class i. Although female black-tailed prairie dogs can reach an age of 9, age classes >6 were excluded in elasticity analyses because older age classes fail to reproduce. The basic loop diagram was constructed from J. Hoogland's 14 year study (1975-1988) of black-tailed prairie dogs in Wind Cave National Park (Hoogland 1995).



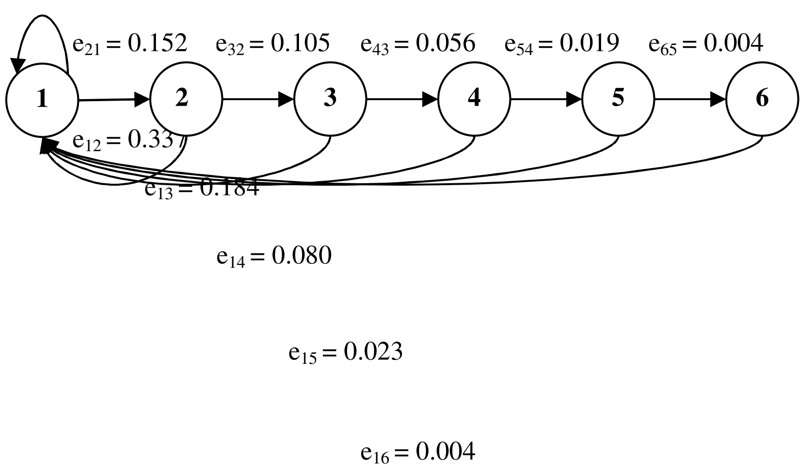


Figure 7: Map of Natural Heritage Ranks for the black-tailed prairie dog (NatureServe 2004).

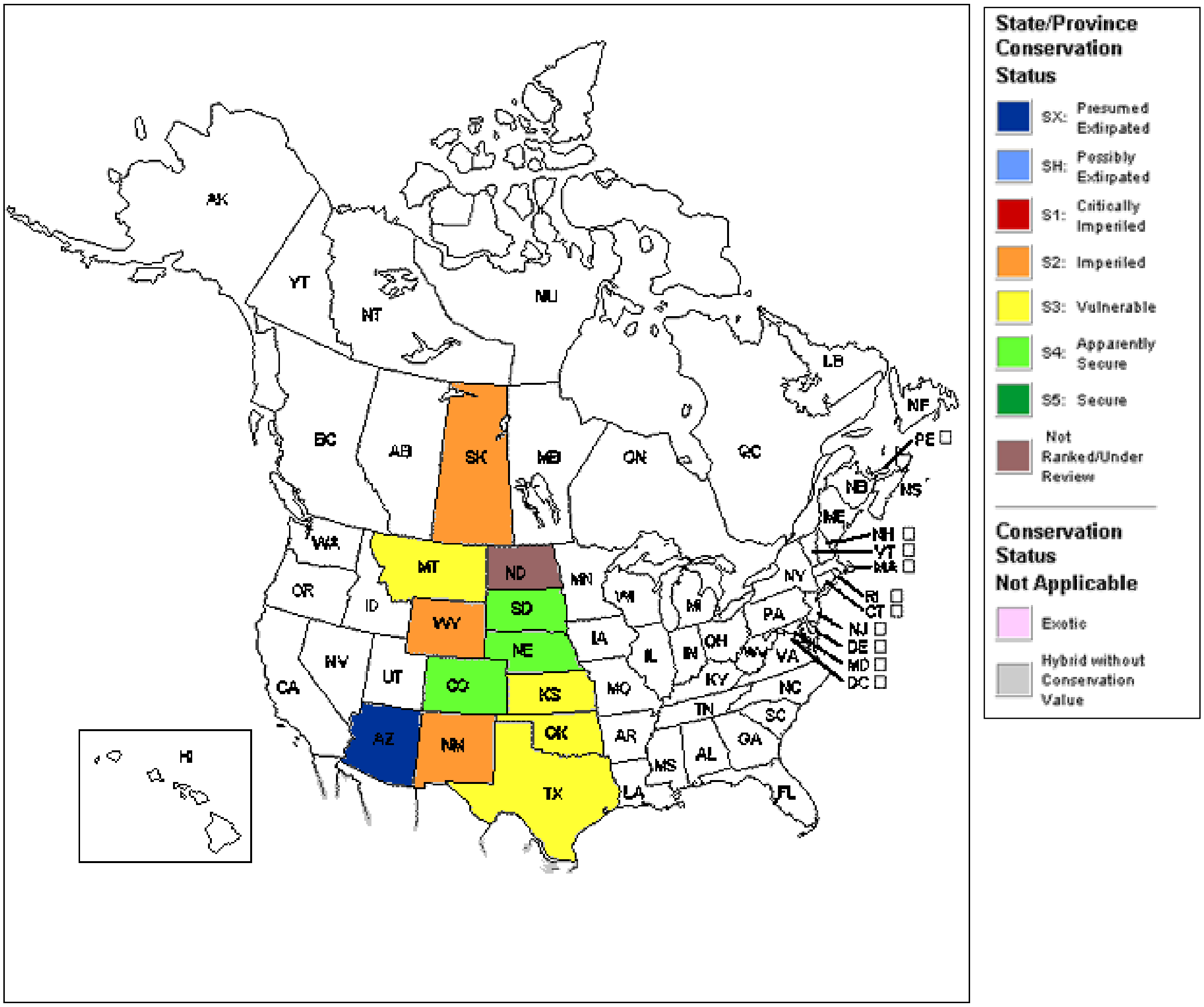
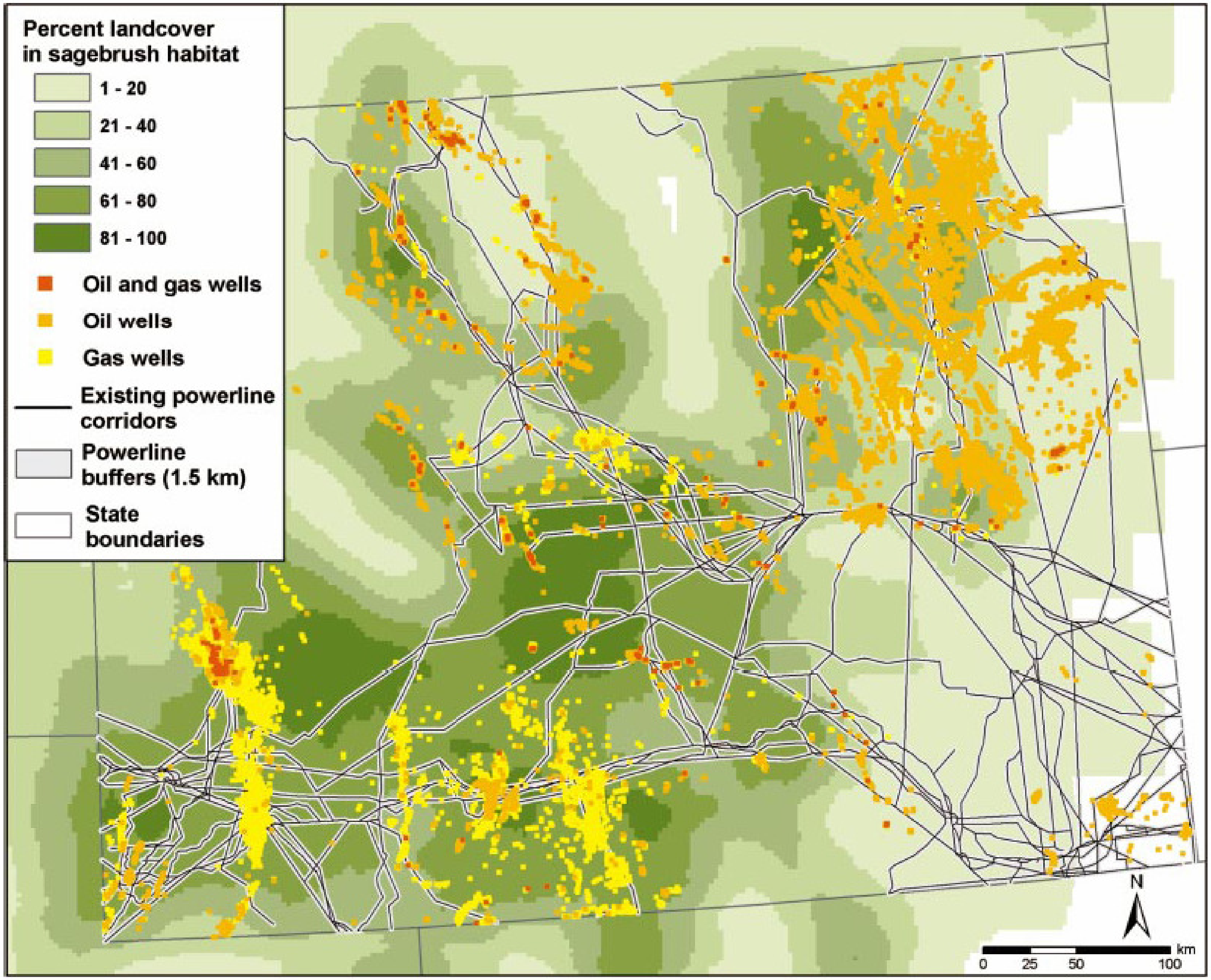


Figure 8: Existing oil and gas developments in Wyoming (Knick et al. 2003, p. 619). Note the amount of development in the northeast section of Wyoming, where the largest populations (acreage) of C. ludovicianus have been reported.



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