SPECIES CONSERVATION ASSESSMENT FOR BLACK FOOTED FERRET (*MUSTELA NIGRIPES*) IN WYOMING

prepared by

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Introduction

The black-footed ferret (*Mustela nigripes*) is arguably the most critically endangered mammal in North America. It is an extreme habitat- and prey-specialist, limited to living in prairie dog (*Cynomys* spp.) burrows and eating prairie dogs almost exclusively. The status of the species has been and remains inextricably linked to the status of prairie dogs. An elusive creature, black-footed ferrets were believed to be nonexistent or extinct several times over the past century.

The black-footed ferret was first described in 1851 by Audubon and Bachman in *The Quadrupeds of North America*, based on a single specimen found in Wyoming. This specimen became lost and no others were reported for 25 years, leading to accusations that Audubon fabricated the species to sell books. In 1877 several additional black-footed ferret pelts were collected, but sightings of wild ferrets remained scarce due to the species' nocturnal and fossorial habits. Early naturalists considered the species rare (Cahalane 1967). Fossil evidence and current field data on both ferrets and prairie dogs suggests a historical abundance of 500,000 - 1,000,000 (Clark 1989). Those numbers were drastically reduced throughout the 20th century, to the point where black-footed ferrets were considered extinct in the early 1960's. A small population was subsequently found in South Dakota in 1964 (Henderson et al. 1969). This population was studied for ten years until it disappeared, and once again the species was believed extinct.

In 1981 a small population was found near Meeteetse, Wyoming, and was studied for 4 years until it began a sharp decline. Eighteen ferrets were then removed from this population for captive breeding, and all black-footed ferrets known to exist today descend from these 18 individuals. Following the first successful captive birth of a black-footed ferret in 1987 (Clark 1989, Miller et al. 1996) the USDI Fish and Wildlife Service conducted an aggressive campaign of captive breeding and reintroduction (USDI Fish and Wildlife Service 2002). All existing ecological knowledge of wild black-footed ferrets comes from studies on the South Dakota (1964-1974) and Meeteetse (1981-1986) populations. Although 8 reintroduced, free-ranging populations now exist in Wyoming, 6 other U.S. states, and northern Mexico, black-footed ferrets continue to be threatened by the rarity and ongoing loss of large prairie dog complexes, pervasive diseases such as sylvatic plague and canine distemper, and chronically low population sizes with attendant genetic and demographic limitations.

Natural History

Morphological Description

The black-footed ferret is similar in size to the mink (*M. vison*) but is much lighter in pelage, and more slender and weasel-like (Fortenbery 1972; Figure 1). Adult male measurements: mass 650-1400 g, total length 500-533 mm; tail length 114-127 mm; hind foot 60-73 mm; ear 29-31 mm. Females are 10% smaller in linear measurements and weigh ca. 68% of males (Hillman and Clark 1980, Clark et al. 1983, Anderson et al. 1986, Miller et al. 1996). Ferrets are short-legged with large, well-developed claws on the front paws (Henderson et al. 1969). The skull is more massive, with orbits more broadly spaced and larger eyes and ears, than other comparably-sized mustelids (Fortenbery 1972). Ferrets have a slight odor, similar to mink or wet dog when disturbed, but undetectable otherwise (Henderson et al. 1969).

Pelage is generally yellowish-buff, with whitish undersides, forehead, muzzle and throat. The very distinct facemask, as well as the feet, legs and tail tip, are black (Hillman and Linder 1973, Hillman and Clark 1980). Black-footed ferrets do not change color in the winter (Fortenbery 1972). Male ferrets have a black/ brown-black longitudinal stripe in the pubic region, which is very faint or nonexistent in females and can be used as a reliable field identifier for gender. It is visible when ferrets stand on their hind legs (Henderson et al. 1969).

Although rare, skulls found in the field are significant indicators of presence and should be investigated further. The dental formula of the black-footed ferret (as well as other ferrets and mink) is I 3/3, C 1/1, P 3/3, M 1/2, for a total of 34 teeth that are set close together but do not overlap (Anderson et al. 1986). Ferret skulls can be distinguished from mink skulls by looking at the basicranium. Black-footed ferret skulls have a well-defined tube enclosing the foramen ovale and extending postero-laterally to the anterior margin of the auditory bulla; mink skulls do not have this tube (Anderson et al. 1986). Also, the distance between the upper canines in the black-footed ferret is greater than or equal to the width of the basioccipital as measured between foramina situated midway along medial sides of the auditory bullae. In mink, the distance between the upper canines is less than the width of the basioccipital (Hoffman and Pattie 1968).

The black-footed ferret is closely related to the European ferret (*M. putorius*), which is sometimes kept as a pet in North America. The black-footed ferret is the only ferret native to North America, and European ferrets rarely become established in the wild (Henderson et al. 1969). The European ferret is not as slender as the black-footed ferret (though equal in mass), has longer and coarser guard hairs, and has less contrast between its body pelage and dark facemask. The black-footed ferret is also very similar in appearance and skull morphology to its Old World ancestor the Siberian ferret (*M. eversmanni*) (Hillman and Clark 1980), but the two species do not overlap in range and confusion between the two is highly unlikely.

To distinguish ferrets from the more common long-tailed (*M. frenata*) and short-tailed (*M. erminea*) weasels, note that ferrets are larger, lighter in body pelage, and have a more angular mastoid process. In addition, weasels (and mink) lack the distinctive facial markings of ferrets (Hillman and Clark 1980). Long-tailed weasels can co-occur with ferrets on prairie dog colonies. Both species of weasel turn white with a black-tipped tail in winter, and may possess a semblance of a brown mask while changing color (Fortenbery 1972).

There is no difference in the morphology of extant and Pleistocene black-footed ferrets. No subspecies are known for the black-footed ferret, nor are there any substantial morphological differences between ferrets that associate with different species of prairie dog. There is evidence of a north-south cline in size of both genders when looking at fossil and skeletal remains across the historic range (Anderson et al. 1986). However, note that all modern black-footed ferrets descend from the Meeteetse, Wyoming, population and thus derive from the approximate center of that cline.

Taxonomy and Distribution

The taxonomic classification of black-footed ferrets is as follows: Order Carnivora, Family Mustelidae, Genus Mustela, Subgenus Putorius, Species nigripes, no subspecies. Fourteen species exist in Genus Mustela (ferrets, weasels, and minks). Three species exist in Subgenus Putorius (ferrets): black-footed ferret, Siberian ferret, and European ferret (*M. putorius*) (Hillman and Clark 1980, Clark 1989, Anderson et al. 1986). The black-footed ferret's closest relative is the Siberian ferret (Fortenbery 1972, Anderson et al. 1986, Clark 1989). The Siberian ferret is postulated to have migrated across the Bering land bridge (Fortenbery 1972) in the late Pleistocene and given rise to the black-footed ferret, which advanced southeast to the Great Plains through ice-free corridors (Hillman and Clark 1980, Anderson et al. 1986) at a rate of 7.5 km per year. The black-footed ferret has probably been present in North America for 100,000 years (Anderson et al.

1986). By 30,000 years ago, modern black-footed ferrets could be found throughout the Great Plains (Miller et al. 1996).

Black-footed ferrets have long been tightly associated with prairie dogs, to the extent that black-footed ferret distribution was, and remains, determined by the distribution of prairie dogs (Henderson et al. 1969, Fortenbery 1972, Hillman and Linder 1973, Hillman and Clark 1980). Black-footed ferrets associate with 3 of the 5 species of prairie dog: black-tailed (*Cynomys ludovicianus*), white-tailed (*C. leucurus*), and Gunnison's (*C. gunnisoni*). They are not known to have ever occurred with *C. parvidens* (Utah prairie dog) or *C. mexicanus* (Mexican prairie dog) (Anderson et al. 1986). The relative homogeneity of the environment created by prairie dogs is likely a factor in the lack of subspeciation in the black-footed ferret (Anderson et al. 1986, Miller et al. 1996).

Historical range of the black-footed ferret has been estimated at 40 - 100 million ha (Clark 1989, Miller et al. 1996; Figures 2, 3), covering much of the western Great Plains and adjacent high-basins from Southern Alberta and Saskatchewan on the north to southern Arizona and Texas on the south, and from ca. the 100th meridian on the east into Utah and central Arizona on the west (Henderson et al. 1969, Fortenbery 1972, Hillman and Linder 1973, Hillman and Clark 1980, Clark 1989). Several factors have combined over the past 130 years to drastically reduce the ranges of black-footed ferrets and prairie dogs (especially *C. ludovicianus*): habitat conversion and fragmentation from cultivation, urbanization, and roads; diseases, including the exotic sylvatic plague (affecting both prairie dogs and ferrets) and canine distemper (affecting ferrets); widespread poisoning and other methods of deliberate prairie dog control and eradication; and recreational shooting of prairie dogs.

Currently, free-ranging black-footed ferrets occur only in 8 reintroduction sites established by the USDI Fish and Wildlife Service since 1991 (Figure 3): Shirley Basin (Wyoming); Badlands National Park/ Conata Basin/ Buffalo Gap National Grassland (South Dakota); Charles M. Russell National Wildlife Refuge/ neighboring lands (Montana); Fort Belknap Indian Reservation (Montana); Aubrey Valley (Arizona); Cheyenne River Sioux Tribal lands (South Dakota); Coyote Basin (Colorado/ Utah); and Janos (Chihuahua, Mexico) (USDI Fish and Wildlife Service 2002).

All following numbers are current as of 2004: Close to 2000 individual black-footed ferrets have been released to these 8 sites (P. Marinari, unpublished data). Wild-born litters have been produced at all the sites as well (USDI Fish and Wildlife Service 2002). Approximately 500 animals are estimated currently alive in the wild, with perhaps 250 at Conata Basin, South Dakota (P. Marinari, unpublished data; S. Wisely, personal communication). Data from monitoring efforts on the reintroduction sites are inconsistent, precluding exact counts.

In Wyoming, 228 ferrets were released in Shirley Basin between 1991 and 1994. Based on spotlight surveys, the Shirley Basin population was estimated at a minimum of 19 ferrets (9 adults with 3 litters totaling 10 kits) in 2001 (Grenier 2001), and 12 ferrets in 2002 (B. Schmidt, personal communication). Recent years have seen rather impressive increases: minimum of 52 individuals including 10 litters in fall 2003; minimum 88 individuals and 21 litters in fall 2004 (M. Grenier, personal communication).

Habitat Requirements

General

Black-footed ferrets are much more habitat specialized than other mustelids, being restricted essentially entirely to occupied prairie dog colonies. Ferrets are found away from prairie dog towns only very briefly during dispersal between adjacent towns. They eat prairie dogs almost exclusively, and depend on prairie dog burrows for thermal cover, predator escape, hunting sites, parturition sites, and rearing of young (Henderson et al. 1969, Clark 1974, Hillman and Clark 1980). Prairie dog towns are typically found in short and mid-grass prairies, and semi-desert areas with mosaics of grass and shrubs.

Black-tailed prairie dogs typically occupy hard, flat (<10% slope) ground in the Great Plains proper; white-tailed and Gunnison's prairie dogs can occupy slightly steeper (15%) slopes (Miller et al. 1996), and are found in the Wyoming Basins ecoregion and Four Corners region, respectively. Most prairie dogs are associated with late Cretaceous shales or unconsolidated sediment. Shale parent materials may provide clay soils which are structurally more stable for burrow construction; a base of unconsolidated gravels provides good drainage (Clark 1989). Ferret-occupied black-tailed prairie dog towns in South Dakota and Montana were typically on level ground of clay and silt soils (Henderson et al. 1969). Vegetation is typically of the wheatgrass-needlegrass type, including buffalo grass, blue grama, western wheatgrass, green needlegrass, and patches of forbs and mixed shrubs. Vegetation at the Chihuahua, Mexico, ferret reintroduction site consists of short grasses including grama grasses, muhley grasses, awns, and prostrate herbs (Miller et al. 1996).

White-tailed prairie dog towns tend to be at higher elevations, and have more shrubs and topographic heterogeneity, than black-tailed prairie dog towns (Clark 1978, Miller et al. 1996). The white-tailed prairie dog complex at Meeteetse, Wyoming, includes low rolling hills and flat plains bordered by higher mountains at a mean altitude of 2,083 m. Soils are generally alkaline Aridosols, ranging in texture from clay-loams to unconsolidated gravels. Vegetation includes junegrass, wheatgrass, needlegrass, and grama, with relatively high numbers of sagebrush and rabbitbrush shrubs (Heller 1991). The Shirley Basin, Wyoming, site is somewhat unique in that it is primarily mixed-grass prairie, similar to black-tailed prairie dog range to the east, but occupied exclusively by white-tailed prairie dogs.

It is generally understood that black-tailed prairie dog colonies are higher quality habitat for black-footed ferrets than are colonies of the other 2 prairie dog species. Reintroduced ferrets achieve higher densities, higher reproductive output, and have higher survival on black-tailed prairie dog colonies. This is probably due primarily to black-tailed prairie dogs existing at higher densities than the other prairie dog species, and remaining active year-round as opposed to hibernating as do white-tailed and Gunnison's prairie dogs. It may also be secondarily determined by the generally higher productivity, longer growing season, and milder climate of the Great Plains region relative to the cold-desert basins to the west (Figure 2).

Area Requirements

Free-ranging black-footed ferrets on black-tailed prairie dog colonies occupy home ranges of 40-60 ha, changing burrows frequently in summer and less frequently in winter; at least 40 ha are required to support a litter (Clark 1989). The minimal area required to sustain a ferret is 37-95 ha in black-tailed prairie dog habitat (15 prairie dogs/ ha), and 167-355 ha in white-tailed prairie dog habitat (4 prairie dogs/ ha) (Stromberg et al. 1983), indicating a rather strong and predictable relationship between ferret area requirements and prairie dog density.

Landscape Pattern

The USDI Fish and Wildlife Service is currently attempting to determine the size and juxtaposition of prairie dog towns required for long-term ferret survival (USDI Fish and Wildlife Service 2002). This information will be highly valuable for management and persistence of extant free-ranging ferret populations, as well as for positioning future reintroduction efforts. The longest distance that a single ferret was observed to travel in 1 day at Meeteetse, Wyoming, was 7 km. In the absence of other data, this distance has been used to select reintroduction sites; i.e., the inter-colony distance between prairie dog towns on reintroduction sites is generally no more than 7 km (Miller et al. 1996).

All prairie dog colonies expand and contract in response to many natural and anthropogenic factors (USDI Fish and Wildlife Service 2002). This dynamism likely did not present a substantial challenge to historic populations of black-footed ferrets: inter-colony distances were short, dispersal to adjacent colonies was easily achieved, and the large number of ferrets maintained high population viability. However, the current distribution of prairie dogs (especially *C. ludovicanus*) is extremely fragmented, effectively precluding immigration and emigration of ferrets between extant wild populations. Demographic supplementation of ferret populations is now possible only through human-mediated translocations and production/ release of captive born animals (Figure 3).

Movement and Activity Patterns

Dispersal

Juvenile ferrets disperse in September or October (Clark 1989). Longer movements (1 - 7 km) are undertaken by males, which typically leave their natal prairie dog colony and settle into a different colony within the same complex. Shorter movements (<300m) are characteristic of females, who often remain on their natal colony (Miller et al. 1996).

Dispersal of released ferrets was measured at the first reintroduction site in Shirley Basin, Wyoming. Seventeen of 37 radio-collared ferrets, including members of both genders, dispersed immediately after release, with several moving >10 km in one night. The average straight-line movement distance was 9 km (USDI Fish and Wildlife Service 1992). In later releases, preconditioned ferrets (i.e., ferrets held for a time in enclosures at the release site, prior to release, in order to condition them to the area) did not disperse as far (Miller et al. 1996).

As discussed previously, the 8 extant wild populations are too distant from one another to exchange dispersing individuals (Figure 3).

<u>Migration</u>

Black-footed ferrets are non-migratory.

<u>Daily Activity</u>

Black-footed ferrets live in prairie dog colonies year-round and are solitary, except during brief periods of the breeding season and when kits are still trailing their mothers. They are strongly nocturnal and spend much of the day below ground, appearing aboveground mostly at night. They exhibit a bimodal activity pattern, being most active in the first few hours after sundown (1700-2400) and in the early morning (0300-0600), but can be found aboveground any time of night (Clark et al. 1983, Clark 1989, Marinari 1992). Individual ferrets usually do not return to the same burrow every morning, but rather relocate frequently.

The size and shape of black-footed ferret home ranges are strongly determined by distribution and density of prairie dogs. This appears to be especially true of females. Male home ranges, while tracking prairie dogs as well, also appear to be positioned to overlap the home ranges of several females. Home range boundaries are typically well-defined and individuals attempt to exclude others of the same gender. Boundaries are delineated by scent-marking, which expresses the individual's identity, sexual condition, and social status. Male ferrets will mark and patrol their home ranges more diligently in February and March as breeding season approaches. This causes them to spend more time and travel greater distances on the surface, making them more vulnerable to predation (Miller et al. 1996). Aggression is rarely observed in the black-footed ferret, suggesting that scent marks are effective signals.

Winter/ Spring

Black-footed ferrets are rarely observed from December to March, being much less active at this time of year. Snow-tracking studies have revealed that ferrets are active ca. 2/3 of all nights in winter (Clark 1989, Miller et al. 1996) and more frequently as March approaches, breeding season nears, and the weather gets warmer. A ferret travels an average of 1,406 m in a night. Movement is highly non-linear with many sharp and rapid turns and burrow investigations. Nightly activity areas range 0.4 - 137 ha, with an average of 68 burrows encountered (mean inter-burrow distance 23 m). Both black-tailed and white-tailed prairie dogs may plug themselves inside their burrows at night, requiring ferrets to dig to find prey. Digging behavior occurs year-round, but occurs most frequently in December, gradually reducing in frequency until March. By April, digging rates are very low and remain low until the next winter (Clark 1989, Miller et al. 1996).

Ferret activity is not limited by weather. Ferrets are active in temperatures of -39^{o}C, during snow and rainstorms, and in winds up to 50 kph. Movement from one colony to another is very rare in winter (Clark 1989).

Summer/Fall

Ferret activity is more crepuscular in summer than in winter (Clark et al. 1983, Clark 1989, Marinari 1992, USDI Fish and Wildlife Service 1992, Miller et al. 1996). A ferret may lie near the crown of its burrow for several hours at a time, basking in the mid-morning sun (Henderson et al. 1969).

Black-footed ferret activity significantly increases as kits emerge from their burrows in July. At this point they are 2 months old, completely dependent upon their mother, and remain in one burrow while the mother occupies another nearby (Henderson et al. 1969, Miller et al. 1996). Soon they begin trailing their mother on hunts and forays, and will occupy different burrows as the summer progresses. From June - mid-July the mother and her litter remain in the same general area of the natal prairie dog town. In mid-July, as kits are weaning, they increase their area of activity and frequency of relocation. In early August the mother separates kits into different burrows, and some begin independent hunting. In late August to early September kits have reached full size and begin to disperse (Henderson et al. 1969).

Reproduction and Survivorship

Breeding Behavior

During the breeding season (February - April) individual ferrets range much more widely than at other times of the year. Long nighttime forays are common, and individual activity areas begin to overlap extensively. Presumed “scent marks” and other marking in snow have also been observed mid-March (Clark 1989).

Courtship behavior is usually very simple, involving males and receptive females locating each other and undergoing only very brief interactions prior to copulation, which may last up to 4 hours (Hillman and Clark 1980, Miller et al. 1996).

Breeding Phenology

Female black-footed ferrets are sexually mature at 9 months (Clark 1989); prime breeding age is 1-3 years old. Black-footed ferrets breed once a year, in March or early April, with both males and females entering breeding condition in response to lengthening daylight (Hillman and Clark 1980, Miller et al. 1996). Captive females enter breeding condition in late February - early March. Proestrus lasts 21-28 days. Females remain in estrus for one month; if not impregnated during the first cycle, females can enter a second cycle. Pseudopregnancies have been observed (Miller et al. 1996).

Gestation lasts 42-45 days (Hillman and Linder 1973, Hillman and Clark 1980). Kits are born April - June and are rather altricial (Fortenbery 1972, Miller et al. 1996). Male ferrets do not exhibit paternal behaviors (Hillman and Linder 1973, Clark 1974). The mother cares for the kits alone and directs their activities until they disperse (Henderson et al. 1969). Kits are rarely observed aboveground before July, at which point they are 50 - 75% of adult size. Initially the mother keeps all kits in one burrow while she resides in a separate burrow. She moves kits from burrow to burrow frequently during the summer, carrying them by the napes of their necks when they are very young. Later in the summer the mother places kits into separate burrows; at this stage kits begin to follow the mother through the prairie dog town as she hunts. Kits are independent by September, and disperse late September - early October. Males usually disperse to different prairie dog towns while females inhabit burrows near their mother's home range (Henderson et al. 1969, Hillman and Linder 1973, Clark 1989).

Fecundity and Survivorship

Black-footed ferrets have rather low fecundity, with an average of 1-4 ova/ female/ year and a mean litter size of 3-4 (range 1-5) (Henderson et al. 1969, Fortenbery 1972, Hillman and Linder

1973, Clark 1974, Hillman and Clark 1980, Clark 1989, Miller et al. 1996). High population turnover rates, short life expectancies, and >50% juvenile mortality are common in mustelids, and the black-footed ferret is no exception. The maximum reproductive life for a black-footed ferret is only 3 years, with a mean life expectancy across all age classes of <1 year. Observations suggest generally high rates of mortality and emigration in free-ranging populations; annual losses from all causes at Meeteetse, Wyoming, was approximately 67% (Clark 1989).

Population Demographics

Limiting Factors

Wild black-footed ferret populations appear to be strongly limited by habitat (= prairie dog towns) availability, connectivity, and quality (= prairie dog density). Diseases such as sylvatic plague and canine distemper exact high mortalities on ferrets themselves as well the prairie dog populations on which they depend. Predation, most notably by badgers (*Taxidea taxus*), coyotes (*Canis latrans*), and raptors can be substantial, especially given the small size of extant wild populations of black-footed ferrets. It is likely that, under current conditions, most existing wild ferret populations will require continual supplementation with captive born stock to remain viable.

Metapopulation Dynamics

The current distribution of black-footed ferrets consists of 8 reintroduced subpopulations that are completely geographically isolated from one another (USDI Fish and Wildlife Service 2002) (Figure 3). Natural dispersal between these subpopulations is not possible (J. Lockhart, personal communication). Each subpopulation resides on a complex of prairie dog colonies wherein each colony is generally within ca. 7 km of its nearest neighbor (Miller et al. 1996).

Genetic Concerns

All known black-footed ferrets descend from 18 individuals, and thus overall genetic diversity is very low (Clark 1989, O'Brien et al. 1989, Ray 2002). Lack of genetic diversity could cause ferrets to be extremely sensitive to disease, parasites, and other environmental stressors (Clark 1989). Evidence suggests that the Meeteetse, Wyoming, ferrets lost much genetic diversity between the 1930's (when intensive prairie dog poisoning began) and 1980's (when the population was discovered). Research also indicates that this population probably underwent an earlier bottleneck event when they first colonized that area and isolated themselves from the larger Great Plains population (Wisely et al. 2002).

The captive population has recently exhibited low sperm viability, and captive-born ferrets have been found to be smaller than wild-born ferrets. Genetic causes are suspected. Fresh genetic input from newly discovered wild populations could help (Ray 2002), but detrimental outbreeding effects would first need to be assessed (Ballou 1989, USDI Fish and Wildlife Service 2002). In any event, the likelihood of discovering previously unknown populations is rather low.

Food Habits

Food items

Black-footed ferrets eat prairie dogs almost exclusively, choosing the species that happens to occur at a particular geographic location (Figure 2). Scats found in Meeteetse and South Dakota contained 87% and 91% prairie dog remains, respectively (Hillman and Clark 1980, Clark 1989). An energetic model of black-footed ferrets, based on data from similar species, estimates that one ferret requires 186-214 prairie dogs annually (Stromberg et al. 1983).

Alternate food sources include ground squirrels (*Spermophilus* spp.), deer mice (*Peromyscus maniculatus*), sagebrush voles (*Lemmiscus curtatus*), meadow voles (*Microtus pennsylvanicus*), cottontail rabbits (*Sylvilagus* spp.), white-tailed jackrabbits (*Lepus townsendii*), and various birds, snakes, and insects. The Meeteetse, Wyoming, ferrets, whose main prey source was white-tailed prairie dogs, did not show seasonal patterns in use of alternate prey (Clark 1989), indicating that ferrets continue to prey upon white-tailed prairie dogs while the prairie dogs are hibernating.

Black-tailed prairie dogs, occupying the Great Plains, are generally larger and form larger and denser colonies than either of the more western, higher elevation species (*C. leucurus* and *C. gunnisoni*). Black-tailed prairie dogs are also active year round. White-tailed and Gunnison's prairie dogs live in drier, rockier, and less-productive terrain, and hibernate during 4 months of the year. They seldom have over 100 individuals within a colony (Clark 1974).

Wild ferrets have never been observed drinking water; it is assumed they obtain water solely from their prey (Henderson et al. 1969, Miller et al. 1996).

Foraging Strategy

Prairie dogs are larger than black-footed ferrets, requiring specialized hunting and killing strategies to maximize success and avoid injury. Ferrets are ineffective at killing prairie dogs on the ground surface, and indeed are often chased and even attacked by prairie dogs during surface encounters. Prairie dogs have been seen chasing black-footed ferrets into burrows and then plugging the burrow with dirt, from which the ferrets apparently dig free rather easily (Henderson et al. 1969, Fortenbery 1972, Hillman and Linder 1973).

The majority of instances where ferrets kill prairie dogs kills occur inside of burrows where ferrets can brace themselves to gain leverage. Kills are also most often made at night when prairie dogs are sleeping and more easily approached closely. Sleeping prairie dogs have reduced core body temperatures, perhaps inducing a state of mild torpor (Clark 1974, Miller et al. 1996).

Ferrets search from burrow to burrow to find their prey, typically eating in the burrow where a kill was made but sometimes dragging prey to another burrow to eat (Miller et al. 1996). Ferrets follow a typical mustelid neck-biting pattern, killing prairie dogs by biting their throats or the back of their necks (Henderson et al. 1969, Miller et al. 1996, USDI Fish and Wildlife Service 1992).

Foraging Variation

Black-footed ferret foraging behavior appears generally similar whether they are pursuing black-tailed or white-tailed prairie dogs. The former species, along with Gunnison's prairie dog, hibernates during the winter, probably leading to subtly different approaches to hunting these types during the winter.

Community Ecology

Clearly, black-footed ferrets are completely dependent on prairie dogs for cover (burrows) and food (and water, considering it is acquired almost exclusively from prairie dog consumption). No other species exhibits a stronger dependence on prairie dogs than does the black-footed ferret. Prairie dog colonies have been described as "oases" of biological diversity, supporting many higher numbers of plants, invertebrates, and vertebrates than in surrounding, unoccupied prairie (Henderson et al. 1969, Hillman and Clark 1980, Heller 1991, Miller et al. 1996). This spatial concentration of species and individuals has important implications to ferret populations.

Many carnivores appear attracted to prairie dog colonies by the abundance of prey, and some of these carnivores also take black-footed ferrets when possible. The main mammalian predators of the black-footed ferret are badgers and coyotes, with bobcats (*Lynx rufus*) and domestic dogs and cats also taking ferrets occasionally (Henderson et al. 1969, Hillman and Clark 1980, USDI Fish and Wildlife Service 1992, Miller et al. 1996, USDI Fish and Wildlife Service 2002). Many raptors can also take ferrets; diurnal raptors such as golden eagles (*Aquila chrysaetos*) and ferruginous hawks (*Buteo regalis*) probably take fewer than the nocturnal great horned owl (*Bubo viginianus*). Most of these predators also compete with ferrets for prairie dogs as prey.

High densities of mammals on prairie dog colonies, and high rates of contact between mammals using prairie dog burrows, sets the stage for rapid transmission of parasites and disease organisms. Black-footed ferrets are subject to infestations of parasites such as flies (including bot flies and flesh flies) (USDI Fish and Wildlife Service 2002), ticks, lice, and fleas.

The latter are of major importance as they carry and transmit the bacterium *Yersinia pestis* which causes sylvatic plague that can devastate populations of ferrets through direct mortality and mortality on prairie dogs. Major flea vectors include *Neopsylla inopina*, *Oropsylla tuberculata cynomuris*, *O. idahoensis*, and *O. labis.* These fleas infest a variety of mammals that occur on and near prairie dog colonies, including many that use prairie dog burrows such as ground squirrels, cottontail rabbits, and deer mice, as well as ferrets and prairie dogs themselves. Deer mice appear highly resistant to plague and may serve as maintenance hosts for the disease, allowing plague to persist in a community. Fleas can exist independently in the soil of the burrows and be transmitted between hosts as they travel through the burrows. Some fleas have survived in the nests of hibernating prairie dogs or ground squirrels for 3-4 months, lying dormant until their hosts revive and then causing new outbreaks of plague. Plague-positive fleas have even been found in burrows as late as a year following a plague epizootic which eradicated their prairie dog hosts.

The role of wider-ranging carnivores, such as badgers and coyotes, in spreading or maintaining plague is uncertain (Heller 1991).

Canine distemper, a viral condition with virtually 100% mortality to black-footed ferrets, is another very important disease. The last known indigenous population of ferrets at Meeteetse, Wyoming, was devastated by canine distemper, prompting the capture of as many remaining animals as possible for captive breeding purposes. Coyotes and badgers are thought to be the main carriers of the disease in the wild.

Recently, some prairie dog colonies in South Dakota have been threatened by an invasion of Canada thistle, which outcompetes native grasses and forbs and causes prairie dog numbers to decline. Wildlife managers have had to work diligently and proactively to control this noxious weed (Albertson 2000).

Conservation

Conservation Status

Federal Endangered Species Act

The legal status of the black-footed ferret as "endangered" precedes the Endangered Species Act of 1973 (ESA). In 1964, the U.S. Bureau of Sport Fisheries and Wildlife included the black-footed ferret on the first published list of rare and endangered wildlife. In 1967 the species was listed under the Endangered Species Preservation Act (P. L. 86-699); in 1970 it was listed under the Endangered Species Conservation Act (P. L. 91-135); and in 1973 it was listed under the current ESA (P. L. 93-205). Because the ferret was already designated Endangered before the passing of ESA, it was not assigned a recovery priority number, nor were the 5 listing factors identified for it. This was rectified in 2002 when the USDI Fish and Wildlife Service outlined threats and recovery in more detail (USDI Fish and Wildlife Service 2002).

All 7 reintroduced populations in the U.S. have been designated "experimental non-essential" under Section 10(j) of the ESA.

USDI Bureau of Land Management

The black-footed ferret does not appear on USDI Bureau of Land Management (BLM) Sensitive Species lists. By design, these lists do not include species already designated as formally Threatened or Endangered; i.e., the BLM defers to the more legally-restrictive designation.

USDA Forest Service

Similar to the BLM, the USDA Forest Service (USFS) does not list the black-footed ferret as Sensitive due to the precedence of the formal Endangered designation.

State Wildlife Agencies

The black-footed ferret is classified as "Native Species Status 1" by the Wyoming Game and Fish Department; this is the highest conservation priority ranking given by this Department.

Heritage Ranks and Wyoming Contribution Rank

The black-footed ferret has been assigned a rank of **G1/ S1** by the Wyoming Natural Diversity Database (WYNDD, University of Wyoming; Keinath et al. 2003). The **G1** rank indicates an extremely high probability of rangewide extinction, which is appropriate for a species with a total wild population of ca. 350 individuals occupying ca. 1-5% of its historic range; **S1N** indicates that the species is at extreme risk of extinction from Wyoming. Captive black-footed ferrets number approximately 300 (Garell and Marinari 2000; P. Marinari, unpublished data).

The Wyoming Contribution rank for black-footed ferrets is **Very High**. This is based on a ranking system developed by WYNDD (Keinath and Beauvais 2003) that measures the contribution of Wyoming populations of a taxon to the rangewide persistence of that taxon, and considers several factors. For the black-footed ferret, the **Very High** rank is a consequence of 1 of the 8 reintroduced wild populations (Shirley Basin) occurring in the state. With so few populations extant, any state supporting one or more contributes very highly to the overall persistence of black-footed ferrets.

Biological Conservation Issues

Abundance

Following numbers are current as of 2004: There are currently about 500 black-footed ferrets existing in the wild (P. Marinari, unpublished data) and over 300 ferrets in captivity in breeding programs and educational exhibits (Garell and Marinari 2000). In fall 2004 the Wyoming Game and Fish Department counted a minimum of 88 individual ferrets, including 21 litters, in Shirley Basin, Wyoming (M. Grenier, personal communication).

Trends

Abundance Trends

The long-term trend in black-footed ferret abundance is clearly and sharply downward, from well over 400,000 historically to a known low of 18 in 1985. Since that low point, when all known black-footed ferrets were brought into captivity, there has been an increase to about 500 animals in reintroduced, wild populations and about 300 in captivity (Ray 2002). The Wyoming population in Shirley Basin is still extant, with wild-born litters having been observed in most years since the original reintroduction in 1991 (Grenier 2001; B. Schmidt, personal communication) The continued existence of plague has precluded further reintroduction of ferrets into Wyoming (B. Schmidt, personal communication; USDI Fish and Wildlife Service 2002).

Habitat Trends

The long-term trend in habitat availability, as measured by occupied prairie dog colonies, has also been clearly and sharply downward, especially for the Great Plains-centered black-tailed prairie dog. Conversion and fragmentation of colonies and native prairie by cultivation, disease outbreaks (most notably sylvatic plague), poisoning and other attempts at deliberate prairie dog eradication, and recreational shooting of prairie dogs have reduced black-tailed prairie dog range to ca. 1-5% of its historic extent (Ray 2002, USDI Fish and Wildlife Service 2002). Combined with less dramatic, but still substantial, declines in white-tailed and Gunnison's prairie dogs, these factors have reduced occupied black-footed ferret range to a similar 1% of historic area (Figure 3). Although most of the negative effects continue, multi-state efforts are currently underway to conserve prairie dogs and several states have established mechanisms to regulate prairie dog control. This may reduce the future loss of prairie dogs and may or may not increase prairie dog populations to levels that can support black-footed ferrets (Ray 2002).

Population Extent and Connectivity Trends

The historic situation was likely a large area of interconnected and closely-spaced prairie dog colonies, and thus a large and connected population of black-footed ferrets, stretching across most of the Great Plains and adjacent high basins. Currently, however, black-tailed prairie dogs exist in isolated and localized sites with very little inter-site connectivity. Wild black-footed ferrets now occur only in 8 geographically isolated subpopulations, with no natural connectivity between subpopulations (Ray 2002, USDI Fish and Wildlife Service 2002) (Figure 3).

Range Context

Historical ferret range included lands which are now within the jurisdictions of Mexico, Canada, twelve U.S. States, several Tribes, several Federal agencies, many local governments, and myriad private landowners. Currently wild ferrets have been reintroduced on Federal, Tribal and private lands in 6 U.S. States, and on private and communal lands in Chihuahua, Mexico (USDI Fish and Wildlife Service 2002) (Figure 3). Land within historical ferret range has been developed for human habitation, agriculture, ranching, and oil and gas drilling. Oil and gas drilling had begun on the Meeteetse, Wyoming, ferret site just a few months before that population was discovered (Clark 1989).

Historically, black-tailed prairie dogs occupied most of the eastern third of Wyoming, and white-tailed prairie dogs occupied the basins in the rest of the state (Figure 2). These 2 species still approximate this arrangement, although they are lower in density and occur in much more fragmented patterns now. It is thought that all of these areas were also once occupied by black-footed ferrets. The state probably supported a large enough area of occupied habitat to be considered "core" ferret range historically. Currently, with much of the eastern portion of historic prairie dog range under cultivation and 1 of the 8 reintroduced populations of black-footed ferrets in Shirley Basin, there is little doubt that Wyoming forms part of the core of the species' range.

Extrinsic Threats and Reasons for Decline

Anthropogenic Impacts

Historically, colonies of all 3 prairie dog species were widespread across their respective ecoregions, with black-tailed prairie dogs being extremely widespread and abundant in the Great Plains. There were likely high rates of exchange in genes and individuals (for both prairie dogs and ferrets) between colonies, and a rather contiguous coverage of colonies from Canada to Mexico. Over the past 130 years this situation has been highly fragmented by cultivation agriculture, with further local fragmentation by cities and roads (Henderson et al. 1969, Hillman and Linder 1973, Hillman and Clark 1980, Clark 1989). Estimates of the percent of historic range still occupied by black-tailed prairie dogs, and black-footed ferrets, range from <1 - 5%. All reintroduced populations of black-footed ferrets, and most remaining centers of occurrence of black-tailed prairie dogs, are geographically isolated from one another (Marinari 1992, Miller et al. 1996, Ray 2002) (Figure 3). White-tailed and Gunnison's prairie dogs have undergone analogous declines, but probably not to the same extent by virtue of their drier and higher-elevation habitats being less suitable for cultivation.

Overlain on this widespread habitat conversion and fragmentation are effects of disease. Prairie dog populations can suddenly contract to the point of extirpation due to outbreaks of sylvatic plague, a disease transmitted by fleas carrying the exotic bacterium *Yersinia pestis* (hypothesized to have entered the U.S. in the late 1800s via ship traffic from Asia). Black-footed ferrets not only decline in response to prairie dog losses but are also directly infected and killed by the same pathogen. Canine distemper, a viral disease carried primarily by coyotes and badgers, can exact additional mortality on ferrets (effectively 100% of infected ferrets die).

Further overlaying habitat fragmentation and disease are the effects of deliberate poisoning and shooting of prairie dogs by people. There is a long tradition of prairie dog control and outright eradication attempts in western North America, many of them ongoing and with government support, with predictable effects on the distribution and abundance of both prairie dogs and ferrets. As with habitat conversion, these effects have been heaviest on black-tailed prairie dogs, with lighter but still substantial application to the 2 more western species.

Genetic Factors

Genetic diversity decreased dramatically as populations were extirpated across the Great Plains, especially after 1974 with the loss of the South Dakota population. Genetic evidence indicates that the Meeteetse, Wyoming, population had existed as a satellite population, isolated for perhaps as many as 30 generations from the core Great Plains population by desert shrub communities. This isolation caused it to lose many alleles which were present in the last South Dakota population. By the time the Meeteetse ferrets were discovered in 1981, they were extremely inbred (Ballou 1989) and lacked heterozygosity (O'Brien et al. 1989, Clark 1989). This may have increased their susceptibility to disease when the population was exposed to canine distemper in 1985 (Clark 1989). There was additional, but less dramatic, loss of genetic diversity when the Meeteetse population plummeted in 1985 and the last 18 individuals were removed for captive breeding (Wisely et al. 2002).

Stochastic Factors

Although large black-footed ferret populations are not generally susceptible to stochastic factors like weather extremes, most of the reintroduced populations are small enough to be sensitive to almost any perturbation.

Natural Predation

As with stochastic events, most of the reintroduced populations are small enough that any increases in predation rates may reduce their viability.

Intrinsic Vulnerability

Habitat Specificity and Fidelity

Black-footed ferret habitat consists entirely of prairie dog colonies and, for brief periods, the area that must be traversed to get from one prairie dog colony to another. The association is so obligatory that the fate of black-footed ferrets is determined first and foremost by the fate of prairie dogs (Henderson et al. 1969, Fortenbery 1972, Hillman and Clark 1980, Clark 1989).

Territoriality and Area Requirements

Black-footed ferret populations require large complexes of prairie dog colonies, on the order of ca. 37 - 95 ha of black-tailed prairie dog colony/ ferret or 167 - 355 ha of white-tailed prairie dog colony/ ferret (Stromberg et al. 1983, Clark 1989, Miller et al. 1996). Today, most occupied prairie dog habitat appears to consist of relatively small complexes which are not large enough to support viable black-footed ferret populations (USDI Fish and Wildlife Service 2002). Repeated outbreaks of sylvatic plague will likely keep prairie dog coverage and densities rather low, such that complexes large enough to support ferrets will be increasingly rare without major management intervention.

Susceptibility to Disease

Black-footed ferrets are very susceptible to sylvatic plague and canine distemper; both are essentially 100% fatal to ferrets. No treatments are available for either disease. A recombinant vectored vaccine for canine distemper is currently under development by Merial Corporation for use in black-footed ferrets. The National Wildlife Health Laboratory in Wisconsin is attempting to develop a plague vaccine that protects both prairie dogs and ferrets and can be delivered orally via baits. Several studies have been conducted to proactively treat prairie dog colonies with insecticides to control fleas and the spread of plague (USDI Fish and Wildlife Service 2002). Dusting burrow entrances with pesticides appears effective in the short-term, as do bait boxes that dust rodents entering the box (Heller 1991). Further research is needed on the dynamics of fleas that transmit sylvatic plague and pneumonic transmission of plague (USDI Fish and Wildlife Service 2002).

The first ferret found to be infected with, and subsequently die from, sylvatic plague was discovered in 1993 (Williams et al. 1994). The disease is now known as a direct threat to ferrets in addition to being an indirect threat that reduces its obligate prey. The dynamics of sylvatic plague outbreaks are still poorly understood (USDI Fish and Wildlife Service 2002). Although some insect and mammal vectors of the disease organism are known, it is unclear how or why the disease cycles across the landscape. White-tailed prairie dog colonies may suffer a plague epizootic every 3-5 years, and it is not known how the vectors persist or reappear in that time frame (Heller 1991).

The only disease-related policies currently in place are (1) intervention to trap surviving ferrets when disease episodes threaten reintroduced populations, and (2) vaccination of ferrets with appropriate available vaccines (USDI Fish and Wildlife Service 2002).

Dispersal Capability

Dispersal capability is limited in the sense that successful dispersal must occur from one active prairie dog colony to another.

Reproductive Capacity

Black-footed ferrets have short reproductive lives, low reproductive output, and high juvenile mortality (Clark 1989).

Sensitivity to Disturbance

Black-footed ferrets have not shown significant sensitivity to disturbance.

Protected Areas

All 8 reintroduced populations are protected by ESA regulations, and most are on public lands with at least some explicit conservation mission. The idea of a protected grassland "reserve" dedicated to prairie dogs and ferrets, such as a National Wildlife Refuge or privately owned conservation ranch, has been proposed and is being considered (Bischoff 2002). The Wyoming population at Shirley Basin occupies a mosaic of land management types dominated by USDI Bureau of Land Management parcels intermingled with privately-held lands. The USDA Forest Service - Thunder Basin National Grassland, often mentioned as a possible reintroduction site pending recovery of black-tailed prairie dog populations, is a similar mosaic of multiple-use federal and private land.

Population Viability Analyses

No complete, formal population viability analysis exists for black-footed ferrets (Ray 2002). Based on genetic information, the minimum viable population size for the black-footed ferret is estimated at 214 individuals. Computer modeling of demographic and environmental stochasticity has estimated a minimum viable population of 120 individuals. Both of these estimates are for short-term viability. For long-term viability, these numbers must be multiplied by at least 10, yielding an estimate of 1,200 – 2,140 individuals (Clark 1989).

Conservation Action

Existing or Future Conservation Plans

All 7 reintroduced populations in the U.S. have been designated "experimental non-essential" under Section 10(j) of the ESA. This has enabled reintroduction projects to proceed in areas that otherwise would not have garnered State or local support. However, the process of completing a Section 10 special rule is cumbersome and time consuming and does not afford a great deal of flexibility in redirecting reintroduction efforts in response to rapidly changing habitat conditions. Critical habitat cannot be formally designated for any non-essential, experimental population. Because only a few large prairie dog complexes remain, there is support for designating these complexes as essential to ferret recovery. However, much suitable, but currently unoccupied, habitat remains for prairie dogs. Management actions that re-populate these areas with prairie dogs in densities and patterns suitable for ferrets will probably be important for full recovery of the black-footed ferret (USDI Fish and Wildlife Service 2002).

In 2001 the USDI Fish and Wildlife Service determined that the black-tailed prairie dog was a legitimate candidate for listing as threatened under ESA. This determination prompted a multi-state effort to conserve the black-tailed prairie dog, as well as other species of prairie dog (Ray 2002). The ESA listing of black-tailed prairie dogs was subsequently denied, as was the potential ESA listing of the white-tailed prairie dog. The effectiveness of state-led efforts at prairie dog conservation remains to be seen.

1988 Black-footed Ferret Recovery Plan, U.S, Fish and Wildlife Service

The 1988 Recovery Plan is the current guidance document for black-footed ferret recovery. Revision of this plan began in 2002 and is ongoing, with the intended result of a formalized

Recovery Plan that incorporates new knowledge of ferret biology and recent management developments. The main goals of this original plan are: (1) ensure reproductive success and survival of captive black-footed ferrets; (2) locate, evaluate and maintain potential black-footed ferret habitat (prairie dogs) in North America; (3) locate additional populations of black-footed ferrets; (4) begin continuous releases of black-footed ferrets into reintroduction sites when captive populations have reached or approach a sustainable census size of 200; (5) manage reintroduced and other populations, and; (6) establish organizational arrangements to accomplish tasks and increase communication (Ray 2002, USDI Fish and Wildlife Service 2002). Goal (1) was accomplished in 1995, when the captive population was stabilized at over 200 breeding adults; reintroductions relevant to goal (4) began in 1991 (starting with Shirley Basin, Wyoming), and there are currently 8 reintroduced populations in six U.S. states and northern Mexico (Figure 3).

This plan stated a down-listing goal of establishing a pre-breeding census population of 1500 free-ranging black-footed ferret breeding adults in 10 or more populations with no fewer than 30 breeding adults in any population by the year 2010. De-listing goals were deferred until such time as adequate information was available on ferret population dynamics.

2002 Recovery Outline, U.S. Fish and Wildlife Service

The 2002 Recovery Outline formally describes the 5 ESA listing factors, key threats, recovery objectives, and associated tasks for the black-footed ferret. It provides a structure and statement of issues out of which the formal recovery plan will be developed, while providing management guidance in the interim (Bischoff 2002). Key threats identified in the 2002 Recovery Outline include: (1) the known population is small with limited genetic diversity; (2) disease epidemics are common, devastating, and poorly understood; (3) habitat for long term population persistence is limited; (4) prairie dog management strategies based on control and eradication are clearly detrimental to ferret recovery, and; (5) recovery will require sustained efforts by many public and private recovery partners.

Tentative recovery objectives are: (1) maintain a captive population of optimal size and structure to support genetic management and reintroduction efforts; (2) complete a search for previously unknown ferrets to support genetic management and reintroduction efforts; (3) reduce threats related to disease in wild populations; (4) ensure sufficient habitat to support a wide distribution of self-sustaining ferret populations; (5) establish free-ranging populations of ferrets to meet down-listing and de-listing goals, and; (6) promote partner involvement and adaptive management through regular programmatic review and outreach (Ray 2002).

Reintroduction Site Management Plans

Each potential reintroduction site must submit a proposal and management plan when it requests formal consideration from the USDI Fish and Wildlife Service (USDI Fish and Wildlife Service 2002).

Multi-State Prairie Dog Conservation Plan

A multi-state prairie dog conservation plan was drafted in July 2002. It was not created as a joint prairie-dog/ black-footed ferret conservation plan, but it will be referenced in black-footed ferret recovery efforts (Bischoff 2002). A major motivation for formulating the multi-state prairie dog plan was to ensure the USDI Fish and Wildlife Service that black-tailed prairie dogs were under adequate management without ESA involvement. The effectiveness of state-led efforts at prairie dog conservation remains to be seen, especially now that the black-tailed prairie dog is no longer under formal consideration for ESA listing.

Conservation Elements

Inventory and Monitoring

Reintroduced ferret populations are typically censused one month after release (to evaluate short-term survival), in late winter (to get a pre-breeding census), and in late summer-early fall (to document reproduction) (USDI Fish and Wildlife Service 2002). There are various ways to monitor and detect black-footed ferrets, including: radio telemetry, mark/ recapture, spotlighting, snow-tracking, trained dogs, and visual searches for trench diggings, snow marking, scats, ferret skulls and carcasses, and punctured prairie dog skulls (Albertson 2000, Grenier 2001, Bibles 2001, USDI Fish and Wildlife Service 2002).

Radio telemetry provides the most detailed information, including important data on dispersal and mortality, which is not available through other techniques. It is labor-intensive and more invasive and risky to ferrets, who may suffer injuries such as neck abrasions as a result of wearing the collars. However, the wealth of information available through telemetry makes it a valuable tool, and special precautions and equipment can reduce injury risk (USDI Fish and Wildlife Service 1992, Miller et al. 1996, USDI Fish and Wildlife Service 2002).

Spotlighting is frequently used to document productivity and perform annual censuses. It is currently the most effective method of finding ferrets. The eyes of black-footed ferrets reflect a bright green eyeshine when exposed to direct artificial light. Basic USDI Fish and Wildlife Service Guidelines for conducting spotlight surveys for black-footed ferrets include :

1. Surveys are to be conducted between July 1 and October 31.
2. The prairie dog town is to be continuously surveyed using spotlights. Surveys should begin at dusk and continue until dawn on each of at least 3 or 5 consecutive nights.

3. Large prairie dog colonies should be divided into tracts of 320 ac and each tract systematically searched throughout 3 consecutive nights. Rough uneven terrain and dense vegetation may require smaller tracts to result in effective coverage of the town.
4. Observations on each prairie dog town or tract searched should begin at a different starting point on each successive night to maximize the chance of overlapping the black-footed ferret's nighttime activity period(s).
5. A survey crew consists of 1 vehicle and 2 observers equipped with 2 200,000-300,000 candlepower spotlights (USDI Fish and Wildlife Service 1989, as cited in Marinari 1992).

There are more details and preparation necessary to performing successful spotlighting surveys, and the latest versions of USDI Fish and Wildlife Service guidelines should be consulted prior to going afield. It has been suggested that spotlighting techniques may be profitably adapted to using modern night-vision equipment (Henderson et al. 1969).

Mark/ recapture techniques have been used to study reintroduced ferret populations. As with most studies of this type, attention must be paid to type and durability of marks applied to animals. Ferrets have been known to remove ear tags, and tattoos can fade and become difficult to read (Miller et al. 1996, USDI Fish and Wildlife Service 2002). Ferrets have been marked with dyes with some success (USDI Fish and Wildlife Service 1992; 2002). The most effective technique for individual identification thus far is the use of subdermal transponder tags. Each reintroduced ferret has a transponder tag implanted in the back of its neck and on its rump. The tags are read by placing a transponder ring at the mouth of the ferret's burrow, which scans the tags as the ferret emerges or descends (USDI Fish and Wildlife Service 2002).

Snowtracking is a useful and frequently-used survey technique (Albertson 2000, Grenier 2001, Bibles 2001, USDI Fish and Wildlife Service 2002). Aerial survey following a fresh snowfall is a standard practice to help determine ferret distribution over reintroduction sites (USDI Fish and

Wildlife Service 2002). Because the ground is very hard in a prairie dog colony, tracks are not often seen on the soil surface but are very evident in fresh snow (Henderson et al. 1969). Snowtracking is best performed within an hour of dawn immediately following a snowfall where the snow was on the ground all night with no or very little wind (Clark et al. 1983, USDI Fish and Wildlife Service 1992, Miller et al. 1996). There are many considerations of site conditions, survey effort, and search pattern that need to be addressed to perform adequate snow-tracking surveys. Additionally, tracks of black-footed ferrets are not necessarily easily distinguished from tracks of mink or long-tailed weasels under field conditions; behavioral clues and accessory signs such as trenches and scats are often needed to identify tracks to species.

Trained scent dogs have been used experimentally and may eventually provide a very effective and economical way of evaluating habitat and finding ferrets, but the USDI Fish and Wildlife Service has been constrained from fully evaluating and implementing a scent dog program (USDI Fish and Wildlife Service 2002).

Accessory signs such as trenches, scats, scent/ snow markings, and punctured skulls of prairie dogs can suggest presence of black-footed ferrets, and are most helpful in association with other survey techniques. Trenches resulting from ferrets digging into prairie dog burrows can be diagnostic (Henderson et al. 1969, Fortenbery 1972, Hillman and Linder 1973, Clark 1989, Miller et al. 1996). Trenches have been observed most frequently in black-tailed prairie dog colonies, and occur most often in winter. An average of 0.6 diggings/ night, or 0.8 diggings/ km of travel, have been recorded in winter; spring, summer and fall rates are much lower (Clark et al. 1983, Clark 1989, Miller et al. 1996). Ferret trenches may persist for 1-2 months in the winter when the ground is frozen and prairie dogs are inactive (Henderson et al. 1969, Fortenbery 1972, Hillman and Linder 1973, Clark et al. 1983, Clark 1989). Generally, a ferret trench is a longitudinal lobe of dirt dug from, and extending from, a prairie dog burrow. The lobe has a narrow trough along its center as a result of the ferret's body drag, and an opening ca. 8-9 cm wide in the burrow itself. Both long tailed weasels and badgers also dig at prairie dog burrows, but make smaller and larger trenches and openings, respectively. Trench surveys should be preceded by a thorough review of trench appearance and variations.

Other accessory signs include markings in the snow, including "circular patches" (20-60 x 25-90 cm diameter) scraped in the snow; "snow stampings" (20-60 cm diameter) trampled but not scraped into the snow; and "shrub stampings" directly around and through small shrubs. These markings can be found anywhere on the ferret's nightly travel route. Markings are occasionally associated with urinations and sometimes had a strong musk odor without any visible sign of emissions. Scats are similar to mink scats and are seldom observed on the surface; presumably ferrets defecate underground (Henderson et al. 1969, Fortenbery 1972). Prairie dog skulls with dual puncture marks on the back, consistent with ferret killing behavior, are rarely found, as are black-footed ferret skulls themselves (Clark et al. 1983, Clark 1989).

Habitat Preservation and Restoration

In 1988 it was thought that ca. 30 sites were suitable for black-footed ferret reintroduction. For a variety of reasons, with sylvatic plague-induced reductions in prairie dog density and distribution being a major one, many of those sites are unsuitable today. Since 1988, several states, Tribes, Federal agencies, and conservation organizations have undertaken prairie dog mapping over portions of the black-footed ferret's historic range in an attempt to locate and evaluate reintroduction areas (USDI Fish and Wildlife Service 2002).

Large, high density complexes of black-tailed prairie dogs are most likely to support viable ferret populations and are favored reintroduction sites. However, black-footed ferrets have been reintroduced into white-tailed and Gunnison's prairie dog complexes as well. Most large (>10,000 acres) black-tailed prairie dog complexes in North America have been identified, and ferret reintroductions have occurred on many of these sites. Large black-tailed prairie dog complexes which are still potentially suitable for ferret reintroduction occur on Crow Tribal lands in southeastern Montana, Thunder Basin National Grasslands in northeastern Wyoming, Rosebud Sioux Tribal lands in south central South Dakota, and Ogallala Tribal lands in southwestern South Dakota. It is unlikely that other black-tailed prairie dog complexes as large as these exist. There appear to be some smaller (approximately 5,000 acres) black-tailed prairie dog complexes in Colorado, South Dakota, Montana and Wyoming that may support limited ferret recovery efforts. Less is known about the number and locations of suitable white-tailed and Gunnison's prairie dog complexes. Considerable work remains regarding the identification of a sufficient number of appropriately configured prairie dog complexes for ferret recovery. An eleven state effort to map black-tailed prairie dog acreage is currently underway. Soon similar efforts will attempt to map the acreage of white-tailed and Gunnison's prairie dogs as well (USDI Fish and Wildlife Service 2002).

Proposed reintroduction sites are evaluated and ranked on many criteria, and a myriad of data are collected on them including prairie dog density and productivity, disease presence in fleas and carrier mammals, and the likelihood of wild ferrets already occupying the site (USDI Fish and Wildlife Service 2002).

Recently more interest has focused on conserving and enhancing prairie dog complexes (USDI Fish and Wildlife Service 2002), with some suggesting the re-establishment of prairie dogs in formerly-occupied areas that remain suitable.

Captive Propagation and Reintroduction

The first ferret propagation program was initiated in 1971 at the USDI Fish and Wildlife Service Patuxent Wildlife Research Center in Laurel, Maryland, using ferrets captured from South Dakota. Ten kits were produced, of which 8 were still born and 2 died within two days of birth. Breeding difficulties and pathological complications indicated that the population may have been very highly inbred. While still optimistic that ferrets could be bred in captivity if genetically heterozygous breeding stock could be located, the last wild South Dakota ferret was seen in 1974 and the last captive ferret from that population died in 1979, with no successful litters having been produced (Clark 1989, Miller et al. 1996). Since then many new techniques have been developed to aid captive propagation of black-footed ferrets, including embryo manipulation and genetic engineering, gamete and embryo storage, endocrine control of reproduction and encouragement of successful lactation, and neonatal survival. Also, the nutritional quality of the captive diet was evaluated. After adjusting the captive diet to correct vitamin deficiencies, the ferrets captured from Meeteetse, Wyoming, produced 2 litters in captivity in 1987 (Clark 1989). In 1988 13 litters were produced, with a total of 34 surviving kits, at which point captive stock was dispersed to multiple facilities.

Captive breeding remains successful at many facilities in the U.S. and is tightly monitored and controlled in an attempt to maintain existing levels of genetic diversity and fitness. Detailed protocols and techniques are in place to facilitate successful captive reproduction; similarly detailed protocols exist to raise and condition young in ways that increase their success when released into the wild. Research and management teams have even developed contingency plans to incorporate new stock into the captive population in the unlikely event that new wild ferrets are found.

Black-footed ferrets were first reintroduced into the wild in 1991 at Shirley Basin, Wyoming. Initially, they were to be reintroduced at the Meeteetse, Wyoming, where the last wild ferrets were discovered in the early 1980's. However, sylvatic plague continued to decimate prairie dogs there, rendering the area unsuitable for ferrets. Black-footed ferrets were released exclusively in Wyoming's Shirley Basin until 1994, when releases occurred in Montana and South Dakota as well. In 1995, the quality of the Shirley Basin site degraded rapidly due to a sylvatic plague epizootic (Miller et al. 1996). Additional reintroductions have since occurred, resulting in a current total of eight distinct reintroduced populations in North America: Shirley Basin (Wyoming), Badlands National Park (South Dakota; includes the Conata Basin and Buffalo Gap National Grassland sub-sites), Cheyenne River Sioux (South Dakota), Charles M. Russell National Wildlife Refuge (Montana), Fort Belknap Indian Reservation (Montana), Coyote Basin (Colorado/ Utah), Aubrey Valley (Arizona), and Janos (Chihuahua, Mexico).

Currently, only one population is self-sustaining (Conata Basin, within Badlands National Park, South Dakota). This population contributes wild-born kits to other reintroduction sites. Quarantine protocols for transfers of wild-born kits have not yet been developed. It is intended that reintroduction sites will be eventually stocked using wild-born rather than captive-born kits (USDI Fish and Wildlife Service 2002).

Other

The political structure surrounding management, research, captive propagation, reintroduction, and monitoring of black-footed ferrets is extremely complex, and interfaces closely with a similarly complex political structure encompassing prairie dog management. In general, The USDI Fish and Wildlife Service has primary control over black-footed ferret issues due the species' Endangered status under ESA. Given the ecological situation, this is unlikely to change in the near future. Many other federal agencies, state agencies, universities, and non-profit groups are involved in aspects of ferret management. Details of this involvement are beyond the scope of this document.

Information Needs

Most of the information needed to improve management and recovery of black-footed ferrets applies rangewide; that is, information needed for current and future Wyoming populations is largely the same as information needed across the species' range. The only exception pertains to prairie dog species: whereas black-tailed prairie dogs occupy the eastern ca. 1/3 of Wyoming, basins in the rest of the state are occupied by white-tailed prairie dogs (Figure 2). The 2 species are rather different, with the latter forming less dense colonies in rockier, steeper, and shrubbier habitats, and hibernating for 4 months of the year. Research and information specific to one species may not translate well to the other.

Wyoming encompasses some of the largest remaining complexes of either prairie dog species (especially the black-tailed complex in Thunder Basin, and the white-tailed complex in Shirley Basin). The state also represents ca. 70% of the global range of white-tailed prairie dogs, and supports much rangeland currently unoccupied, but likely still suitable, for both species. These characteristics suggest that Wyoming has an important future role to play in ferret recovery, and that research in this context should be directed to the state.

Basic Ecology and Life History

As expected for a species that was so poorly understood prior to reaching Endangered status, there are a myriad of basic ecological questions that could be answered to assist recovery. More data on dispersal behavior and distances, home range size and territoriality, the role of alternate (i.e., non-prairie dog) prey, and habitat features that enhance predator avoidance would all contribute to management of black-footed ferrets (USDI Fish and Wildlife Service 2002). Much of this data is being collected, and should continue to be collected, via radio-telemetry of released individuals, and will be invaluable to parameterization of demographic and genetic models that will help optimize reintroductions and population supplementations.

Disease

The dynamics of sylvatic plague are being investigated but remain poorly understood. Research is needed on the mechanisms of direct transmission of the disease to both prairie dogs and ferrets, as well as the role of other mammals as reservoirs of the disease. A model that predicts the timing and spread of plague outbreaks, and their likely effects on prairie dog and ferret densities, would greatly assist management. Research into the transmission and outbreak patterns of canine distemper would similarly assist habitat managers.

General ecological principles suggest that well-connected populations have a greater viability than fragmented ones, but that may not be the case with black-footed ferrets because of the devastating effects of these 2 diseases. Some population fragmentation may need to be deliberately maintained in order to minimize disease spread. Research that addresses this issue and elucidates specific fragmentation metrics (i.e., size of occupied patches, separation distance between patches) is needed.

Habitat Pattern

Repeated mapping of occupied prairie dog colonies across black-footed ferret range is necessary to inform management of current reintroduction sites as well as to plan for and locate new ones. Furthermore, spatially-explicit modeling of suitable, but currently unoccupied, prairie dog habitat is necessary to inform active prairie dog reintroductions to establish new ferret populations or enhance existing ones.

Black-tailed prairie dog colonies are visible on aerial photos, and thus are relatively easy to map and monitor. However, this is not the case for white-tailed and Gunnison's prairie dogs, which form more diffuse colonies in steeper and shrubbier landscapes with more naturally-bare ground. More research into techniques that efficiently and effectively map these 2 prairie dog species is required.

A major piece of needed information is the landscape-scale configurations of occupied prairie dog colonies that promote ferret reproduction and survival. This clearly intersects with the disease and population fragmentation issues raised above. It is likely that the optimal configuration of prairie dog colonies for black-footed ferrets will be a compromise between the configuration that best promotes short-term reproduction and survival in the absence of disease, and the configuration that maintains long-term reproduction and survival by helping to isolate the inevitable disease outbreaks.

Physiology and Captive Breeding

The captive population has recently exhibited low sperm viability, and captive-born ferrets have been found to be smaller than wild-born ferrets. The causes behind these effects need to be discovered and, if possible, eliminated.

Reintroduction

There are many points in the reintroduction process that could be researched to formulate more effective releases. For example, experience has demonstrated that preconditioning ferrets to a release site heightens their post-release survival. Future research should focus on details of preconditioning, including the effectiveness of placing kits in preconditioning burrows at different ages (e.g., at 15, 30, or 60 days) (USDI Fish and Wildlife Service 2002).

Demographic and genetic models of free-ranging populations could help test alternative reintroduction and population supplementation scenarios. Such models are rather data-hungry; as mentioned previously, radio-telemetry studies of free-ranging ferrets should focus on data types most needed to populate these models.

Figures

Figure1 . Black-footed ferrets, showing typical pelage and postures.

Figure 2. Original range of black-footed ferrets in North America (encompassed by thick black line). Horizontal barring shows range of black-tailed prairie dogs; vertical barring shows range of white-tailed prairie dogs; diagonal barring shows range of Gunnison's prairie dog. All range maps modified from Patterson et al. 2003.

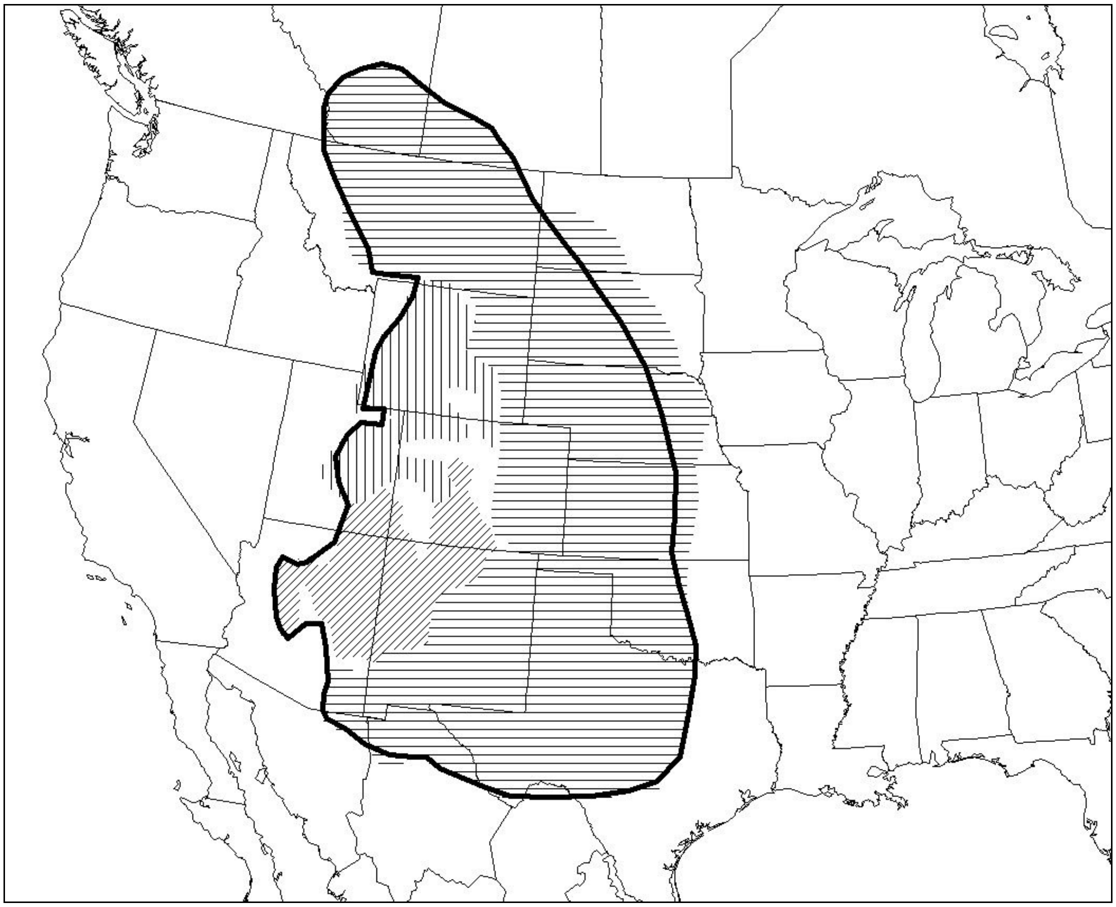
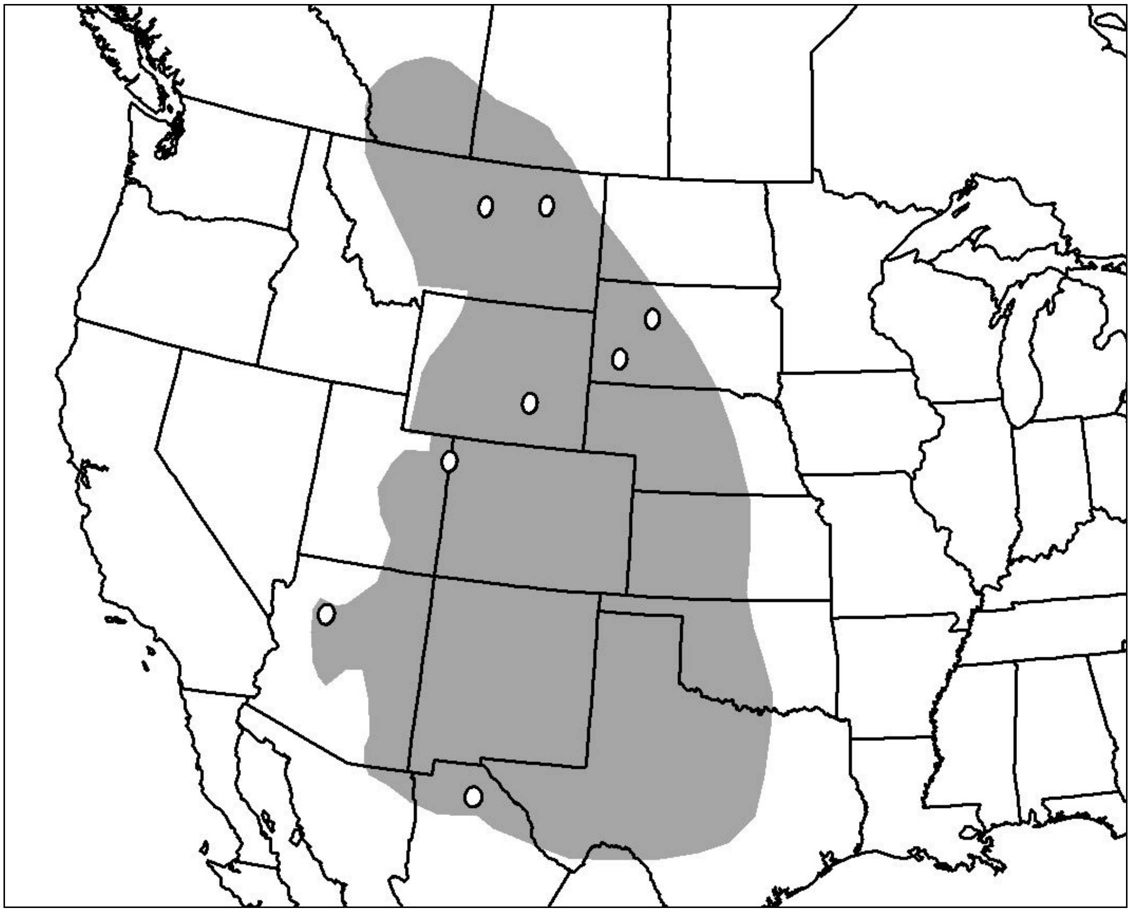


Figure 3. Original range of black-footed ferrets in North America (gray polygon), overlain by the 8 reintroduced populations extant in 2005 (white dots; note dots are not to scale). Range map modified from Patterson et al. 2003.



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