pattern of daily activity of wild Santa Cruz Island foxes needs to be assessed, and compared to the activity of captive and captive-reared foxes that are released into the wild. If captive-reared foxes are more active during diurnal and crepuscular periods than their wild counterparts, it is probable that captive-reared foxes reintroduced into the wild will suffer higher mortality owing to golden eagle predation.

There has been only a single study that has examined dispersal in island foxes (Roemer *et al*. 2001b) and the number of dispersal events recorded was small (n=8). Additional information on island fox dispersal patterns on different islands and during periods of high and low density are needed.

Core literature

Collins 1991a,b, 1993; Crooks and van Vuren 1996; Laughrin 1977; Moore and Collins 1995; Roemer 1999; Roemer *et al*. 2001a,b, 2002; Roemer and Wayne 2003; Wayne *et al*. 1991b.

Reviewers: Lyndal Laughrin, David K. Garcelon, Paul Collins. **Editors:** Claudio Sillero-Zubiri, Deborah Randall, Michael Hoffmann.

4.5 Kit fox *Vulpes macrotis* Merriam, 1888

Least Concern (2004)

R. List and B.L. Cypher

Other names

English: desert fox; **German:** wüstenfuchs; **Spanish:** zorra del desierto, zorra norteña.

Taxonomy

Vulpes macrotis Merriam, 1888. Type locality: "Riverside, Riverside County, California" [United States, *c.* 34°00'N, 117°15'E].

The kit fox has been considered conspecific with the swift fox, *V. velox*, based on morphometric similarities and protein-electrophoresis (Clutton-Brock *et al*. 1976; Hall 1981; Dragoo *et al*. 1990). Others have treated *V. macrotis* as a distinct species based on multivariate morphometric data (Stromberg and Boyce 1986) and more recently based on mitochondrial DNA (Mercure *et al*. 1993).

Chromosome number not known.

Description

The kit fox is one of the smallest foxes in the Americas (Table 4.5.1). The most conspicuous characteristic is the large ears. The fur is short, with yellowish to greyish head, back and sides; the shoulders and the outside of the legs are brown-yellow; the belly and the inner side of legs are white-yellowish; the tip of the tail is black. The neck, legs and belly may have buffy highlights. The hair is dense

Table 4.5.1 Body measurements for the kit fox from Janos, Chihuahua, Mexico (List and Jimenez Guzmán in press).

HB male	537mm (485–520) n=7
HB female	501mm (455–535) n=5
T male	308mm (280–340) n=8
T female	289mm (250–305) n=5
E male	82mm (71–95) n=8
E female	80mm (74–95) n=6
WT male	2.29kg (1.7–2.7) n=8
WT female	1.9kg (1.6–2.2) n=6

Rurik List

Adult kit fox, sex unknown, standing at the entrance of its burrow. Janos, Chihuahua, Mexico, 2001.

between the foot-pads. Dental formula: 3/3-1/1-4/4-2/3=42. Mean cranial measurements from 35 specimens of *V. m. mutica* were: condylobasal length 114.4mm; zygomatic breadth 62.1mm; palatal length 57.8mm; interorbital breadth 23.1mm; postorbital breadth 21.4mm (Waithman and Roest 1977).

Subspecies Eight subspecies have been recognised (McGrew 1979). Fewer taxonomic studies have been conducted on kit foxes in Mexico, and therefore the taxonomy of kit foxes in Mexico is less certain.

— *V. m. arsipus* (south-eastern California, southern Arizona, and northern Sonora)
— *V. m. devia* (southern Baja California)
— *V. m. macrotis* (south-western California – extinct)
— *V. m. mutica* (San Joaquin Valley of California)
— *V. m. neomexicana* (New Mexico, western Texas, and north-west Chihuahua)
— *V. m. nevadensis* (Great Basin of the U.S.)
— *V. m. tenuirostris* (northern Baja California)
— *V. m. zinseri* (north central Mexico).

Similar species Swift fox, *Vulpes velox*: Sympatric with the kit fox only in a small contact zone (*c.*100km wide); shorter, more rounded ears that are set farther apart on the head, and a shorter tail relative to body length.

Current distribution

The kit fox inhabits the deserts and arid lands of western North America (Figure 4.5.1). In the United States, it occurs from southern California to western Colorado and western Texas, north into southern Oregon and Idaho. In Mexico, it occurs across the Baja California Peninsula and across northern Sonora and Chihuahua to western Nuevo León, and south into northern Zacatecas (McGrew 1979; Hall 1981).

Range countries Mexico, USA (Hall 1981).

Relative abundance

The species is common to rare. Density fluctuates with annual environmental conditions, which are dependent upon precipitation (Cypher *et al*. 2000). In Utah, density ranged from 0.1–0.8/km^2 (Egoscue 1956, 1975). In California, density varied from 0.15–0.24/km^2 over a period of three years on one study site (White *et al*. 1996) and from 0.2–1.7/km^2 over 15 years on another study site (Cypher *et al*. 2000). Kit fox densities in prairie dog town complexes in Mexico were 0.32–0.8/km^2 in Chihuahua (List 1997) and 0.1/km^2 in Coahuila and Nuevo Leon (Cotera 1996).

Estimated populations/relative abundance and population trends In Mexico, data on which to base a population estimate for kit foxes are only available from two localities with very specific characteristics (presence of prairie dog towns). Therefore, the estimation of a population size for the country or even population trends is not possible with current information. However, because natural habitats occupied by the kit fox are being transformed, it is safe to assume that, overall, populations of the kit fox in Mexico are declining. In the past 10 years, about 40% of prairie dog towns in Coahuila and Nuevo Leon were converted to agriculture (L. Scott and E. Estrada unpubl.).

Figure 4.5.1. Current distribution of the kit fox.

In the United States, kit fox abundance is unknown. Population trends are assumed to be relatively stable in Texas, New Mexico, Arizona, Utah, and Nevada where harvests for fur continue. Populations in Idaho, Oregon, and the Mojave Desert in California also may be relatively stable due to a lack of significant threats. Populations are potentially increasing in Colorado where foot-hold trapping was recently banned. Populations of the 'endangered' San Joaquin kit fox in the San Joaquin Valley of California are likely still declining due to continuing habitat loss, fragmentation, and degradation (USFWS 1998).

Habitat

The kit fox inhabits arid and semi-arid regions encompassing desert scrub, chaparral, halophytic, and grassland communities (McGrew 1979; O'Farrell 1987). It is found in elevations ranging from 400–1,900m a.s.l., although kit foxes generally avoid rugged terrain with slopes >5% (Warrick and Cypher 1998). Loose textured soils may be preferred for denning. Kit foxes will use agricultural lands, particularly orchards, on a limited basis, and kit foxes also can inhabit urban environments (Morrell 1972).

Food and foraging behaviour

Food Kit foxes primarily consume rodents, leporids, and insects. Primary prey includes kangaroo rats (*Dipodomys* spp.), prairie dogs (*Cynomys* spp.), black-tailed jackrabbits (*Lepus californicus*), and cottontails (*Sylvilagus* spp.). Other items consumed include birds, reptiles, and carrion (Egoscue 1962; Jiménez-Guzmán and López-Soto 1992; White *et al*. 1995; List 2003; Cypher *et al*. 2000). Plant material is rarely consumed, although cactus fruits are occasionally eaten (Egoscue 1956).

Foraging behaviour Kit foxes mostly forage solitarily. They are mainly active by night and occasionally exhibit crepuscular activity (List 1997).

Damage to livestock and game There is no evidence that kit foxes significantly impact game or livestock populations.

Adaptations

Kit foxes are well adapted to a life in warm, arid environments. To dissipate heat while conserving water, they have a large surface area to body mass ratio and large ears which favour non-evaporative heat dissipation and can vary panting rates (Klir and Heath 1992). Predominantly nocturnal activity and diurnal den use also reduce water loss. Kit foxes can obtain all necessary water from their food, but to do so must consume approximately 150% of daily energy requirements (Golightly and Ohmart 1984).

Social behaviour

Kit foxes are primarily monogamous with occasional polygyny (Egoscue 1962). Pairs usually mate for life (Egoscue 1956). Young from previous litters, usually females, may delay dispersal and remain in natal home ranges where they may assist with raising the current litter (List 1997; Koopman *et al*. 2000). Kit foxes are not strongly territorial and home ranges may overlap, although core areas generally are used exclusively by one family group (White and Ralls 1993; Spiegel 1996). Home range size is variable, even within similar vegetation types, and ranges from 2.5km² (Knapp 1978) to 11.6km² (White and Ralls 1993).

Kit foxes sometimes bark at approaching predators or to recall pups, and they sometimes emit a "hacking growl" during intraspecific encounters. Foxes in dens or captivity make a closed-mouth vocalisation during times of anxiety (Egoscue 1962). Scent-marking by kit foxes has not been investigated.

Reproduction and denning behaviour

Kit foxes mate from mid-December to January and give birth from mid-February to mid-March after a gestation of 49–55 days (Egoscue 1956; Zoellick *et al*. 1987). Litter size ranges from 1–7 (mean=4; Cypher *et al*. 2000). Reproductive success is considerably lower for yearling females and varies annually with food availability for all age classes (Spiegel 1996; Cypher *et al*. 2000). Pups emerge from dens at about four weeks, are weaned at about eight weeks, begin foraging with parents at about 3–4 months, and become independent at about 5–6 months (Morrell 1972; R. List unpubl.). Mean dispersal age in California was eight months (Koopman *et al*. 2000).

Kit foxes use dens year round and have multiple dens within their home ranges (White and Ralls 1993; Koopman *et al*. 1998). Although they can excavate their own dens, kit foxes frequently occupy and modify the burrows of other species, particularly prairie dog, kangaroo rats, squirrels (*Spermophilus* spp.) and badgers (*Taxidea taxus*) (Morrell 1972; Jiménez-Guzmán and López-Soto 1992; Cotera 1996; List 1997). Occasionally, they will den in man-made structures (e.g., culverts, pipes), but young are almost always born in earthen dens (Spiegel 1996; Zoellick *et al*. 1997).

Competition

Potential competitors for food and dens include coyotes (*Canis latrans*), bobcats (*Lynx rufus*), red foxes (*Vulpes vulpes*), badgers, skunks (*Mephitis* spp. and *Spilogale* spp.), and feral cats (White *et al*. 1995; Cypher and Spencer 1998; B. Cypher unpubl.). Strategies such as year-round den use, resource partitioning, and habitat partitioning allow kit foxes to mitigate competitive effects and coexist with most of these species. Non-native red foxes are increasing within the range of kit foxes (Lewis *et al*. 1993), and may present

a more significant competitive threat due to greater overlap in resource exploitation patterns and potential for disease transmission. Although coyotes compete with and even kill kit foxes, they also may provide a benefit to kit foxes by limiting the abundance of red foxes (Cypher *et al*. 2001).

Mortality and pathogens

Natural sources of mortality Predation, mainly by coyotes, usually is the main source of mortality for kit foxes and commonly accounts for over 75% of deaths (Ralls and White 1995; Spiegel 1996; Cypher and Spencer 1998). Other predators include bobcats, red foxes, badgers, feral dogs, and large raptors (O'Farrell 1987).

Persecution In Mexico, kit foxes sometimes are shot opportunistically, but they are not actively persecuted. In the USA, large numbers of kit foxes were killed during predator control programmes that targeted other species, particularly coyotes and wolves (*Canis lupus*). However, such programmes have been discontinued or are more species-specific.

Hunting and trapping for fur Kit fox fur has relatively low value, and kit foxes are usually caught incidentally in traps set for other furbearers. About 1,200 were harvested in the United States between 1994 and 1995 (International Association of Fish and Wildlife Agencies unpubl.).

Road kills Vehicles are an important source of mortality and are the primary mortality factor in some areas (Cotera 1996; B. Cypher unpubl.).

Pathogens and parasites Kit foxes frequently carry antibodies to a variety of viral and bacterial diseases indicating exposure. However, disease does not appear to be a significant source of mortality, although rabies could have contributed to a decline in one population of the San Joaquin kit fox (White *et al*. 2000). A variety of ectoparasites (e.g., fleas, ticks, lice) and endoparasites (e.g., cestodes and nematodes) have also been found in kit foxes, but no morbidity or mortality associated with these parasites has been reported.

Longevity Kit foxes on two sites in California were known to reach at least seven years of age (B. Cypher unpubl.).

Historical perspective

Because of their small size and nocturnal habits, kit foxes are relatively inconspicuous. Thus, they are not particularly important for native or modern cultures, and are not well represented in arts and crafts or traditional uses.

Conservation status

Threats The main threat to the long-term survival of the kit fox is habitat conversion, mainly to agriculture but also to urban and industrial development. In both western and eastern Mexico, prairie dog towns which support important populations of kit foxes are being converted to agricultural fields, and in eastern Mexico the road network is expanding, producing a concomitant increase in the risk of vehicle mortality. In the San Joaquin Valley of California, habitat conversion for agriculture is slowing, but habitat loss, fragmentation, and degradation associated with industrial and urban development are still occurring at a rapid pace.

Commercial use In Mexico, kit foxes are occasionally sold illegally in the pet market. Kit foxes are harvested for fur in some states in the USA, but otherwise are not used commercially.

Occurrence in protected areas

- In Mexico, kit foxes are found in the Biosphere Reserves of El Vizcaino, Mapimi and El Pinacate, in the Area of Special Protection of Cuatro Ciénegas, and are probably found in another eight protected areas throughout their range.
- In the United States, they occur in numerous protected areas throughout their range. The 'endangered' subspecies *V. m. mutica* occurs in the Carrizo Plain National Monument and various other federal, state, and private conservation lands.

Protection status CITES – not listed (considered a subspecies of *V. velox*).
The kit fox is considered 'vulnerable' in Mexico (SEDESOL 1994). In the United States, the San Joaquin kit fox (*V. m. mutica*) is federally classified as 'endangered', and as 'threatened' by the state of California (USFWS 1998). In Oregon, kit foxes are classified as 'endangered'.

Current legal protection Harvests are not permitted in Idaho, Oregon, or California, and the kit fox is a protected furbearer species (i.e., regulated harvests) in Utah, Colorado, Arizona, New Mexico, and Texas.

Conservation measures taken In Mexico, the 'vulnerable' status of the kit fox grants conservation measures for the species, but these are not enforced. In the United States, state and federal protections for kit foxes are being enforced.

Efforts are underway to protect the prairie dog towns of both eastern (Pronatura Noreste) and western Mexico (Institute of Ecology from the National University of Mexico), which are known to be strongholds for the kit fox, but no specific actions focused on the kit fox are being undertaken in Mexico. In the United States, a recovery plan has been completed (USFWS 1998) and is being implemented for the San Joaquin kit fox. Recovery actions include protection of essential habitat, and

demographic and ecological research in both natural and anthropogenically modified landscapes.

Occurrence in captivity

No captive breeding efforts are currently being conducted for kit foxes. Facilities such as the Arizona-Sonora Desert Museum in Tucson, Arizona, California Living Museum in Bakersfield, California, and several zoos keep live kit foxes for display and educational purposes. Also, Humboldt State University in Arcata, California maintains a small number of kit foxes for research and education.

Current or planned research projects

R. List (Institute of Ecology, National University of Mexico) is currently assessing the abundance of kit foxes in the prairie dog towns of north-western Chihuahua to compare the densities to those in 1994 to 1996. He is also planning to map the current distribution in Mexico using GIS.

B. Cypher, D. Williams, and P. Kelly (California State University-Stanislaus, Endangered Species Recovery Program – ESRP) are conducting a number of investigations on the San Joaquin kit fox, including ecology and demography in agricultural lands and urban environments, use of artificial dens, kit fox-red fox interactions, highway impacts, pesticide effects, and restoration of retired agricultural lands.

K. Ralls and colleagues (Smithsonian Institution, Washington D.C., USA), in collaboration with the ESRP, are conducting range-wide genetic analyses for the San Joaquin kit fox and investigating the use of tracker dogs (to find scats) in gathering information on kit fox presence and ecology.

Two working groups of the National Center for Ecological Analysis and Synthesis (University of California, Santa Barbara, USA) are conducting population modelling studies and investigating conservation strategies for the San Joaquin kit fox.

The California State University, San Luis Obispo and the California Army National Guard are investigating the effects of military activities on the San Joaquin kit fox and monitoring kit fox abundance on military lands in California.

R. Harrison (University of New Mexico, Albuquerque) is investigating kit fox ecology in New Mexico.

The U.S. Army is sponsoring an investigation of military effects and kit fox ecology on the Dugway Proving Grounds in Utah.

Gaps in knowledge

In general, demographic and ecological data are needed throughout the range of the kit fox so that population trends and demographic patterns can be assessed. In Mexico, information available on the kit fox is scarce. The most important gaps in our knowledge of the species are the present distribution of the species and population estimates throughout its range. General biological information is needed from more localities in the Mexican range of the kit fox. In the United States, information is required on the San Joaquin kit fox including assessing the effects of roads and pesticides on kit foxes, investigating dispersal patterns and corridors, determining metapopulation dynamics and conducting viability analyses, developing conservation strategies in anthropogenically altered landscapes, assessing threats from non-native red foxes, and range-wide population monitoring.

Core literature

Cypher *et al.* 2000; Egoscue 1962, 1975; McGrew 1979; O'Farrell 1987; Spiegel 1996.

Reviewers: Mauricio Cotera, Patrick Kelly, Ellen Bean. **Editors:** Claudio Sillero-Zubiri, Michael Hoffmann, Deborah Randall.

4.6 Swift fox *Vulpes velox* (Say, 1823) Least Concern (2004)

A. Moehrenschlager and M. Sovada

Other names

French: renard véloce; **German:** flinkfuchs; **Indigenous names:** senopah (Blackfeet Tribe, Canada and USA).

Taxonomy

Canis velox Say, 1823. James, Account of an Exped. from Pittsburgh to the Rocky Mtns, 1:487. Type locality: "camp on the river Platte, at the fording place of the Pawnee Indians, twenty-seven miles below the confluence of the North and South, or Paduca Forks."

The swift fox is phenotypically and ecologically similar to the kit fox (*Vulpes macrotis*) and interbreeding occurs between them in a small hybrid zone in west Texas and eastern New Mexico (Rohwer and Kilgore 1973; Mercure *et al*. 1993; Rodrick 1999). Some morphometric comparisons and protein-electrophoresis have suggested that these foxes constitute the same species (Ewer 1973; Clutton-Brock *et al.* 1976; Hall 1981; Dragoo *et al.* 1990; Wozencraft 1993). Conversely, other multivariate morphometric approaches (Stromberg and Boyce 1986), as well as mitochondrial DNA restriction-site and sequence analyses (Mercure *et al.* 1993; Rodrick 1999) have concluded that they are separate species. Swift and kit foxes are most closely related to Arctic foxes (*Alopex lagopus*), and this genetic association is the closest among the *Vulpes*-like canids (Wayne and O'Brien 1987), although Arctic foxes are classified in a different genus.