RELATIVE ABUNDANCE OF ENDANGERED SAN JOAQUIN KIT FOXES (*VULPES MACROTIS MUTICA*) BASED ON SCAT-DETECTION DOG SURVEYS

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ABSTRACT—Although the San Joaquin kit fox (*Vulpes macrotis mutica*) has been a federally protected subspecies since 1967, current information on its status throughout much of its historical range is lacking. Since 1983, only 5 surveys have been conducted, and a recent recovery plan emphasized the need for better information on the status of this subspecies. Between 2001 and 2003, we attempted to obtain new information on this kit fox on specific public and private properties in 8 counties in the San Joaquin Valley, California, where knowledge of its current status was limited or poorly understood. We used a trained detection-dog to survey for kit fox, red fox (*V. vulpes*), and gray fox (*Urocyon cinereoargenteus*) scats on selected properties, followed by species identification based on genetic analysis of DNA extracted from all scats collected. Despite extensive survey efforts (539 km), kit fox was only detected in Merced County, in the area of Santa Nella, where a small kit fox population was previously documented. Red fox scats were located in Alameda, San Joaquin, and Merced counties, and gray fox scats were located in Fresno County. Our results suggest that if kit foxes are present on the properties surveyed, they either occur at extremely low densities, rendering detection difficult, or only occur intermittently in these areas. In striking contrast, our previous surveys conducted with the same method in the southern part of the range found large numbers of kit fox scats in various areas, particularly in Kern and San Luis Obispo counties. We recommend that future conservation plans focus on preserving additional habitat in areas where kit foxes are relatively abundant, specifically western Kern County and the Ciervo-Panoche region.

RESUMEN—A pesar de que la zorrita de San Joaquín (*Vulpes macrotis mutica*) ha sido una subespecie protegida bajo estatutos federales desde 1967, no existe información actualizada sobre su distribución a través de su rango histórico de distribución. Desde 1983, sólo se han llevado a cabo 5 muestreos, y un plan de recuperación reciente enfatizó la necesidad de disponer de mejor información sobre la situación de esta subespecie. Entre 2001 y 2003 intentamos conseguir nueva información de estas zorritas en propiedades públicas y privadas en 8 condados del Valle de San Joaquín, California, donde se tenía conocimiento muy pobre o limitado de su situación actual. Utilizamos un perro entrenado para detectar heces de zorritas de San Joaquín, zorras rojas (*V. vulpes*) y zorras grises (*Urocyon cinereoargenteus*) en terrenos seleccionados, seguido por la identificación de especies basada en análisis genéticos del ADN extraído de todas las heces recogidas. A pesar de una investigación minuciosa (539 km), la presencia de zorritas de San Joaquín solamente fue detectada en el condado de Merced, en el área de Santa Nella, donde una población pequeña de zorritas ya había sido registrada. Heces de zorras rojas fueron localizadas en los condados de Alameda, San Joaquín y Merced, y heces de zorras grises en el condado de Fresno. Nuestros resultados sugieren que si las zorritas están presentes en las áreas investigadas, éstas se encuentran, ya sea, en densidades sumamente bajas, haciendo su detección difícil, o sólo intermitentemente. En contraste, en nuestras investigaciones conducidas anteriormente usando el mismo método en la parte sur de su rango de distribución, encontramos grandes cantidades de heces de zorritas de San Joaquín en varias áreas, particularmente en los condados de Kern y de San Luis Obispo. Recomendamos que los planes futuros de conservación se enfoquen en la preservación de más hábitat en áreas donde las zorritas son relativamente abundantes, específicamente en el oeste del condado de Kern y en la región de Ciervo-Panoche.

The San Joaquin kit fox (*Vulpes macrotis mutica*) is a small, arid-land fox endemic to the San Joaquin Valley, California. Although kit foxes were abundant historically, their populations and habitat have since been reduced by human impacts, such as agricultural and industrial developments, urbanization, water impoundment and diversion, and historical predator and pest control (United States Fish and Wildlife Service [USFWS], 1998). It is estimated that approximately 95% of valley floor natural lands have been converted to other uses (USFWS, 1998). Currently, kit foxes are known to exist in 3 geographically distinct core and several satellite populations in a heavily fragmented landscape (USFWS, 1998).

Previous local surveys, research projects, and incidental sightings indicated that kit foxes inhabited areas throughout the valley floor and its surrounding foothills. The recent distribution is thought to extend from 1) southern Kern County north to Contra Costa, Alameda, and San Joaquin counties on the west side of the valley and to Stanislaus County on the east side; 2) in some of the larger, uncultivated valley-floor land parcels in Kern, Tulare, Kings, Fresno, Madera, and Merced counties; and 3) westward in 5 counties in the interior coastal range (USFWS, 1998; Fig. 1).

Despite having been listed for over 30 years (United States Department of Interior, 1967), the current status and relative abundance of the kit fox throughout much of its historical range are poorly known. A recent recovery plan emphasized the need for better information on status of kit foxes, particularly in the northern and eastern counties of the San Joaquin Valley, and specified the goal of periodically monitoring kit fox populations (USFWS, 1998). Only 5 surveys have been conducted following a 1983 recovery plan: 3 in the northern range and 2 in the central range of the fox (Orloff et al., 1986; Williams, 1990; Bell, 1994; H. Bell and K. Ralls, unpubl. data; Endangered Species Recovery Program (ESRP), unpubl. data). In these surveys, Orloff et al. (1986) reconfirmed the occurrence of kit fox in Alameda and San Joaquin counties, but were unable to document the presence of kit foxes in Contra Costa County. Bell (1994) found that sites where she detected kit foxes were significantly closer to historical kit fox sightings than sites where kit foxes were not detected. From 1991 to 1992, she observed kit foxes at 3 sites in Contra Costa County, and 1 site in San Joaquin County, and a probable kit fox track was recorded at one site that encompassed both Alameda and San Joaquin counties. However, subsequent work in Alameda and Contra Costa counties with baited cameras on public land and spotlight surveys on roads through potential kit fox habitat found no evidence of kit fox presence, even in areas where they had been documented earlier (H. Bell and K. Ralls, unpubl. data). Williams (1990) documented smaller populations and isolated sightings of kit foxes in western Madera and eastern Stanislaus counties. Finally, sightings were recorded in western Stanislaus, Merced, and Fresno counties and in eastern San Benito County (ESRP, unpubl. data).

The goal of our study was to assess relative abundance of kit foxes within the northern, central, and southern range of the fox and gather specific information on kit fox status on public and private lands within these areas. To eliminate the challenges associated with surveying low-density populations and species with elusive behaviors, we used a noninvasive monitoring method that was not highly dependent on animal density and visual detectability. We conducted scat surveys followed by verification of species depositing scats with DNA analysis. Fecal DNA analysis can provide accurate information on carnivore presence (Kohn et al., 1999; Ernest et al., 2000; Lucchini et al., 2002). Furthermore, collection of scats of various canid species has been shown to be a successful technique for estimating relative abundance (Cavallini, 1994; Sovada and Roy, 1996; Olson et al., 1997; Kamler et al., 2003). Recently, collection of scats followed by genetic analysis was

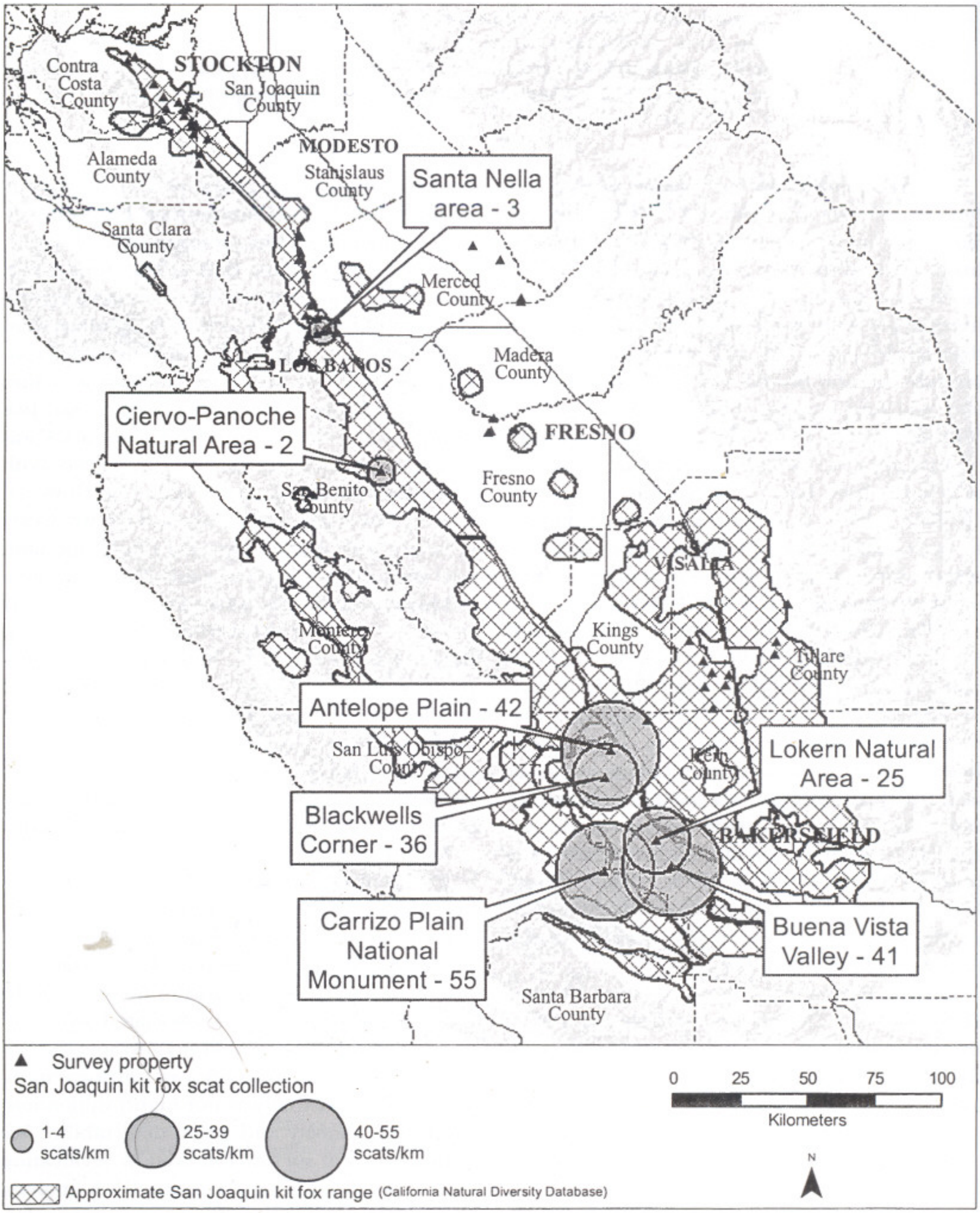

FIG. 1—Properties surveyed for scats of kit fox (*Vulpes macrotis mutica*) within the northern, central, and southern range of the fox in the San Joaquin Valley, California. Locations where scats of kit fox were found and rates of detection (scats/km) for each survey area are indicated. Symbol sizes for each area are proportional to the rate of detection of scats.

found to be the most efficient method to estimate relative abundance of swift foxes (*V. velox*), surpassing scent stations, trapping, searching for tracks, spotlighting, and calling (Harrison et al., 2002).

We attempted to enhance recovery of scats of kit fox during surveys by using a trained detection dog to locate kit fox scats. It has been previously demonstrated that dogs trained to locate scats of target species can provide a successful method of scat recovery (U. Breitenmoser and C. Breitenmoser-Wursten, unpubl. data; P. Paquet, unpubl. data; Smith et al., 2001, 2003; Wasser et al., 2004). One of the main advantages of using a detection dog to locate scats is that the dog can detect both old as well as fresh scats, and thus, recent past as well as current presence in an area can be determined. Our prior studies showed that dogs are capable of locating kit fox scats that are several weeks to several months old (D. A. Smith et al., unpubl. data).

To determine the reliability of surveys using detection dogs for inventorying kit foxes throughout their range, we evaluated the effectiveness of a trained dog to locate scats in core and satellite population areas with various densities and different habitat conditions. We found that scat-detection dog surveys consistently detected the presence of kit foxes in each population area searched regardless of relative fox density and habitat type (Smith et al., 2005).

Here, we report on surveys using a trained dog to detect kit fox scats on public and private lands in 8 counties within portions of the geographic range described for the kit fox where knowledge of its status was limited or poorly understood. We combine these data with results of our prior surveys using detection dogs to gain a more complete picture of the relative abundance of San Joaquin kit foxes within the northern, central, and southern range.

METHODS—*Study Area*—Our surveys were conducted in the San Joaquin Valley, which occupies the southern two-thirds of the Central Valley of California (USFWS, 1998) (Fig. 1). The climate is semiarid with hot, dry summers and cool, wet winters. Precipitation occurs as rainfall primarily between November and April in quantities (usually <31 cm) that vary greatly year to year (USFWS, 1998). Annual precipitation increases from south to north in the San Joaquin Valley. Mean annual precipitation is 15.4 cm in Bakersfield at the southern end of the valley and increases to 30.9 cm in Stockton at the northern end of the valley (Haight et al., 2004).

We divided the study area into 3 zones covering 8 counties: the northern range (Alameda, Contra Costa, San Joaquin counties); the central range (Stanislaus, Merced, Fresno counties); and the southern range (Tulare, Kern counties). Within each county, we selected public and private properties for surveys based on 3 criteria. First, we had to obtain access permission from the property owner(s) or manager(s). Due to the significant challenges of gaining access to private lands in the study area, we conducted the majority of surveys on public lands and placed particular emphasis on surveying natural areas, ecological reserves, wildlife areas, and national wildlife refuges within each county. Second, we required each property to have historical or recent kit fox sightings in the area based on records in the California Natural Diversity Database (California Department of Fish and Game, Sacramento, California). Finally, each property had to possess suitable kit fox habitat. Before being selected for survey, we visited each property to determine whether suitable kit fox habitat was present. It is important to note that properties selected for surveys in the southern range were specifically located outside of the 2 southern core areas, the Carrizo Plain National Monument and the Lokern Natural Area, and adjacent lands, where kit foxes are known to exist in relatively high densities (USFWS, 1998).

Dog Training and Species Identification—Because gray foxes (*Urocyon cinereoargenteus*) and nonnative red foxes (*V. vulpes*) are sympatric with the kit fox in some parts of its range, and red foxes have replaced the kit fox in other areas (Ralls and White, 1995; Cypher et al., 2003), we wanted to determine the occurrence of these 3 fox species simultaneously on each survey property. Hence, for this study, we used a dog that was initially trained to locate scats of kit fox, and subsequently taught to detect scats of red and gray fox (see training methods, Smith et al., 2003). We used mitochondrial DNA analysis on all scats collected during surveys to identify species depositing scats (Paxinos et al., 1997).

Sample Collection and Preparation—We conducted scat searches opportunistically from 31 May 2001 to 25 February 2003. We surveyed 51 properties: 24 in the northern range, 18 in the central range, and 9 in the southern range. All survey properties in the northern and southern range had historical kit fox sightings within 10 km. Ten and 8 survey properties in the central range had kit fox sightings within 10 and 20 km, respectively. Survey routes on each property were based on geographical representation and, in part, on logistical considerations (Kendell et al., 1992). To optimize effort, we created transect routes that were looped or continuous, did not require backtracking, and covered an adequate representation of the suitable kit fox habitat present on the property. Our prior research indicated detection dogs found scats at a mean distance of 4.8 ± 6.7 m from the transect line (maximum distance = 38.40 m; Ralls and Smith, 2004). Length of survey routes on each property varied depending on the amount of, and access to, suitable kit fox habitat (mean = 10.57 km, range = 1 to 37 km) (Table 1). Previously, we found that scat collection on 30, 1-km transects in 6 areas with known kit fox populations revealed approximately 29.83 ± 36.60 scats per km (range = 1 to 130) (D. A. Smith et al., unpubl. data). Thus, we chose 1-km transects as the minimum to be searched.

Transect routes used both unpaved roads and vegetation available on survey properties. We chose to survey unpaved roads because, in areas with known kit fox populations, a high proportion of scats were deposited along unpaved roads (Smith et al., 2005). Also, we searched in vegetation because, unlike humans searching for scats, dogs can easily locate scats under those conditions (Smith et al., 2001, 2003).

A detection dog-handler team and a navigator walked all survey transects. When the dog registered the presence of a fox scat, it was geo-referenced with a global positioning system (GPS). Scats collected for DNA analysis were stored in plastic bags containing one teaspoon of silica gel for desiccation (Fisher Scientific, Pittsburgh, Pennsylvania) and were shipped within 7 days of collection to the Genetics Program at the Smithsonian Institution for storage at −20°C.

Genetic Analysis—As described by Smith et al. (2003), DNA was extracted from every scat sample by using a QIAGEN DNeasy DNA extraction kit (Qiagen, Valencia, California) following a modified protocol (Eggert et al., 2005). Extractions were carried out in a separate room under quasi-clean conditions to prevent contamination. Each sample was isolated a minimum of 2 times and then subjected to a species identification test based on mitochondrial DNA. Negative controls (no scat material added to the extraction) accompanied each set of extractions and were used to check for contamination. Once DNA was extracted, PCR amplification and restriction enzyme analyses were performed using a modified version of the protocol and reagents described in Paxinos et al. (1997) as follows: a 350-bp fragment of the mitochondrial cytochrome-*b* gene was amplified using a canid specific light STRAND primer (Canid L1, Paxinos et al., 1997) and a universal heavy STRAND primer (H15915, Irwin et al., 1991) in a 50-μL polymerase chain reaction including 0.5 units AmpliTaq Gold (Perkin-Elmer, Inc., Wellesley, Massachusetts), 2.5 mM $MgCl_2$, 1X reaction buffer (Perkin-Elmer), 200μM each dNTP, 1.0 mg/mL—Fraction-V BSA, and 1μM each primer. Reactions were run for 30 cycles (1 min denaturing at 95°C, 1 min annealing at 55°C, and 2 min extension at 70°C) in a PTC programmable thermocycler (MJ Research Corp., Waltham, Massachusetts). We screened PCR products with 3 species-diagnostic restriction enzymes (ALU I, HINF I, and Taq I) as specified in Paxinos et al. (1997). Positive controls for kit fox, coyote (*Canis latrans*), domestic dog (*C. familiaris*), red fox, and gray fox were used for comparison in the restriction analysis. Scat samples that failed to produce PCR amplification products after the second extraction attempt were deemed unusable for genetic analysis.

Results—We surveyed 539 km on 51 properties in 8 counties within the range of the kit fox (Table 1; Fig. 1). We collected 44 scats in 4 of these counties. We isolated DNA from 27 of the 44 scats, of which 3 were kit fox, 22 were red fox, and 2 were gray fox.

In the northern range, we surveyed 213 km on 24 properties. Fox scats were located in Alameda and San Joaquin counties. We isolated DNA from 16 of 32 scats collected in Alameda County, and from the one scat collected in San Joaquin County; all 17 came from red fox.

In the central range, we surveyed 222 km on 18 properties. Fox scats were located in Merced and Fresno counties. We isolated DNA from 8 of 9 scats collected in western Merced County: 3 were kit fox and 5 were red fox. Two scats collected in Fresno County yielded gray fox DNA.

In the southern range, we surveyed 104 km on 9 properties. No fox scats were located on survey properties in these counties. However, in prior surveys in the southern part of the range (Smith et al., 2001, 2003, 2005), the dogs found numerous kit fox scats at various other sites, including the Lokern Natural Area in Kern County and the Carrizo Plain National Monument in San Luis Obispo County (Table 1; Fig. 1).

Discussion—Our combined results indicated that kit foxes were either absent on the specific public and private properties we surveyed within their historical range or only occurred intermittently in these areas. It is also possible that extremely low densities rendered detection difficult. We found no evidence of kit foxes on these properties in the northern portion of the range. In the central portion of the range, scats of kit foxes were detected on only one property in western Merced County, and in our previous surveys, in the same area of Santa Nella and farther south in the Ciervo-Panoche Natural Area in Fresno and San Benito counties. In marked contrast, our previous surveys showed kit foxes had relatively high abundance and were easily detected with scat surveys in many parts of the southern range, although our current surveys found they were absent from several relatively small properties that were geographically isolated from the large population core areas in western Kern County and the Carrizo Plain in adjacent San Luis Obispo County (USFWS, 1998). The absence of kit foxes from smaller, more isolated properties in the southern part of the range strongly highlights the increased risk of extirpation associated with habitat fragmentation. This emphasizes the need to conserve large blocks of habitat and to maintain or establish connectivity between distinct properties with suitable habitat.

Thus, the relative abundance of kit foxes in the San Joaquin Valley seems extremely variable, with greatest abundance occurring in a limited number of populations concentrated in the southern part of the range. This pattern decreases overall population viability and increases risk of local extinction.

Many formerly extant kit fox populations in the areas we surveyed in the northern and central ranges might be nearly or are already extirpated, because local rarity is a good predictor of future local extinction (Araujo et al., 2002). Recently, kit foxes might have occurred only intermittently in these areas when favorable environmental and demographic conditions (e.g., high prey base and high fox reproductive success) resulted in dispersing foxes from core populations reaching these areas. Perhaps this also was true historically in some areas, particularly in the northern range, with some occupied areas likely constituting population "sinks" (Pulliam, 1988). Regardless, population fragmentation and habitat loss now make population supplementation or recolonization difficult, even in years of high productivity and survival of kit foxes. In recent years, casual sightings of kit foxes and recovery of road-killed animals have only occurred on rare occasions in the northern range. This is consistent with our results and further suggests that kit foxes might be extremely rare or even absent in this region.

The only substantial kit fox population known to occur outside of the core areas and the properties surveyed for this and previous studies is in the city of Bakersfield in central Kern County (Cypher and Warrick, 1994; Cypher et al., 2003); kit foxes also are present on grazing and oilfield lands just east and north of Bakersfield. We did not survey locations in northern San Luis Obispo and southern Monterey counties to the west of the San Joaquin Valley, where populations of kit foxes once occurred (USFWS, 1998), but confirmed kit fox sightings in that region have been rare in the past decade (R. Stafford, pers. comm.).

Red fox scats were located on properties in 2 counties (Alameda and San Joaquin) in the northern range of the kit fox, and one county (Merced) in the central range. The presence of nonnative red foxes is potentially detrimental to kit foxes. Red foxes have been known to kill kit foxes, displace kit foxes from their dens and habitat, and compete for food resources, and could potentially transmit diseases to kit foxes (Ralls and White, 1995; Cypher et al., 2001; Clark et al., 2005). Thus, the presence of red foxes likely increases competitive pressure on kit foxes, which would reduce the suitability of an area for kit foxes.

Red foxes have been documented previously in the northern and central range of the kit fox (Orloff et al., 1986; H. Bell and K. Ralls, unpubl. data) and were detected in these areas during our surveys. Red foxes also are known to occur in the southern range (B. Cypher, unpubl. data), but fortunately seem to be absent or rare in the Lokern Natural Area and Carrizo Plain National Monument. Population trends of red foxes in the Central Valley of California are unknown, but based on casual reports of sightings and road-kills, this species seems to be increasing in the San Joaquin Valley. Red foxes probably benefit from anthropogenic water sources, such as stock ponds, reservoirs, canals, and agricultural and urban irrigation (Kamler and Ballard, 2002). Indeed, many of the red fox scats located in this study were found near water sources. Red foxes also likely benefit from the decreased coyote abundance associated with agricultural, residential, and industrial development, because coyotes

TABLE 1—Summary of properties currently surveyed for scats of kit fox (*Vulpes macrotis mutica*), red fox (*V. vulpes*), and gray fox (*Urocyon cinereoargenteus*). * = data from previous surveys.

Survey property	Distance searched (km)	Number of kit fox scats located	Additional fox species detected
NORTHERN RANGE			
Alameda County			
Bethany Reservoir	8	0	red fox
Haera Conservation Bank	11	0	red fox
Interstate 580 undercrossings	3	0	
California Aqueduct	8	0	red fox
USBR Delta Mendota Canal	15	0	red fox
Brushy Peak Regional Preserve	22	0	
Borges parcel	2	0	
Bruns parcel	5	0	
Kelso/Bruns parcel	3	0	
Lawrence Livermore National Laboratory (Site 300)	7	0	
Contra Costa County			
Los Vaqueros Reservoir	4	0	
Black Diamond Mines Regional Preserve	30	0	
Round Valley Regional Preserve	10	0	
Contra Loma Regional Park	4	0	
Vasco Caves Regional Preserve	9	0	
Cowell Ranch	13	0	
Byron mitigation parcel	15	0	
California Aqueduct	6	0	
USBR Delta Mendota Canal	4	0	
San Joaquin County			
Haera Conservation Bank	2	0	
Union Pacific Railroad right-of-way	18	0	
USBR Delta Mendota Canal	3	0	red fox
Carnegie State Vehicular Recreation Area	2	0	
Lawrence Livermore National Laboratory (Site 300)	9	0	
CENTRAL RANGE			
Stanislaus County			
USBR Delta Mendota Canal	14	0	
Merced County (East)			
Cunningham Ranch	20	0	
Flynn Ranch	13	0	
Ichord Ranch	30	0	
Knapp Ranch	15	0	
Merced County (West)			
San Joaquin Valley National Cemetery	5	0	
San Luis dam face parcel	5	0	
San Luis Reservoir State Recreation Area	6	0	
USBR sewage plant adjacent parcel	6	0	
California Aqueduct	3	0	
DWR CA Aqueduct	26	0	
Billie Wright Road	1	3	red fox
USBR Delta Mendota Canal	37	0	red fox
San Luis Wasteway	17	0	
*Santa Nella Area	12	38	

TABLE 1—Continued.

Survey property	Distance searched (km)	Number of kit fox scats located	Additional fox species detected
Fresno County			
Mendota Wildlife Area	11	0	
Alkali Sink Ecological Reserve	4	0	
Kerman Ecological Reserve	8	0	
San Joaquin River	1	0	gray fox
*Ciervo-Panoche Natural Area (bordered Fresno and San Benito counties)	12	19	
SOUTHERN RANGE			
Tulare County			
Pixley National Wildlife Refuge (main parcel)	23	0	
Pixley National Wildlife Refuge (horse pasture unit)	6	0	
Pixley National Wildlife Refuge (Los Feliz unit)	6	0	
Pixley National Wildlife Refuge (Dickey Tract)	3	0	
Colonel Allensworth State Historic Park	7	0	
Allensworth Ecological Reserve	37	0	
Friant-Kern Canal	7	0	
Deer Creek	6	0	
Kern County			
Kern National Wildlife Refuge	9	0	
*Antelope Plain	4	166	
*Blackwell's Corner	4	143	
*Buena Vista Valley	8	326	
*LoKern Natural Area	8	203	
*San Luis Obispo County			
Carrizo Plain National Monument	4	221	
Totals			
Northern Range	213	0	red fox
Central Range	246	60	red fox-gray fox
Southern Range	132	1,059	

depress populations of red foxes (Voigt and Earle, 1983; Sargeant et al., 1987).

We found gray fox scats along the San Joaquin River in Fresno County, in the central range of the kit fox. Recorded interactions between gray fox and kit fox are rare. The 2 species are spatially segregated based on habitat preferences, with gray foxes favoring more mesic, agricultural, brushy, and forested communities and kit foxes favoring more arid scrublands and grasslands (Cypher, 2003). The presence of gray fox along this degraded riparian corridor in Fresno County suggests that the habitat in this area was probably not suitable for kit foxes.

San Joaquin kit foxes are endangered primarily because of profound habitat loss and fragmentation (USFWS, 1998), and continuing habitat conversion within the range of the kit fox will further reduce habitat availability. Importantly, this conversion might be destroying former dispersal corridors, thereby decreasing the probability that kit foxes dispersing from southern populations will successfully reach the central and northern portions of their historical range. Finally, increasing abundance of red foxes is likely reducing suitability for kit foxes in the remaining habitat in the northern and central portions of the range. All of these factors negatively affect the probability of maintaining viable kit fox populations outside of the southern portion of the range and increase the overall risk of extinction for San Joaquin kit foxes.

In summary, kit foxes currently have relatively low abundance or might be absent in specific areas throughout large portions of their historical range. This has 2 important implications for kit fox conservation. First, it seems that robust kit fox populations occur in only a few locations. Second, given this heterogeneous pattern, it is imperative that conservation efforts be focused on areas where these robust populations (i.e., core populations) occur and, to the extent possible, the lands that connect those populations. Specifically, the Carrizo Plain National Monument, western Kern County, and the Ciervo-Panoche region warrant particular emphasis. The Carrizo Plain kit fox population is relatively secure because it primarily occurs on national monument lands administered by the United States Bureau of Land Management. The primary management need for this population is to maintain conditions suitable for kit fox prey by controlling nonnative grasses (Germano et al., 2001). However, a majority of the lands with kit foxes in western Kern County and the Ciervo-Panoche region are privately owned, and formal habitat conservation measures currently are lacking. Indeed, Haight et al. (2004) determined through cost-benefit optimization modeling that conserving additional habitat in these 2 regions would greatly decrease kit fox extinction risk. We recommend that future conservation efforts give a high priority to preserving additional habitat in these 2 regions, which would significantly enhance kit fox conservation and long-term persistence.

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