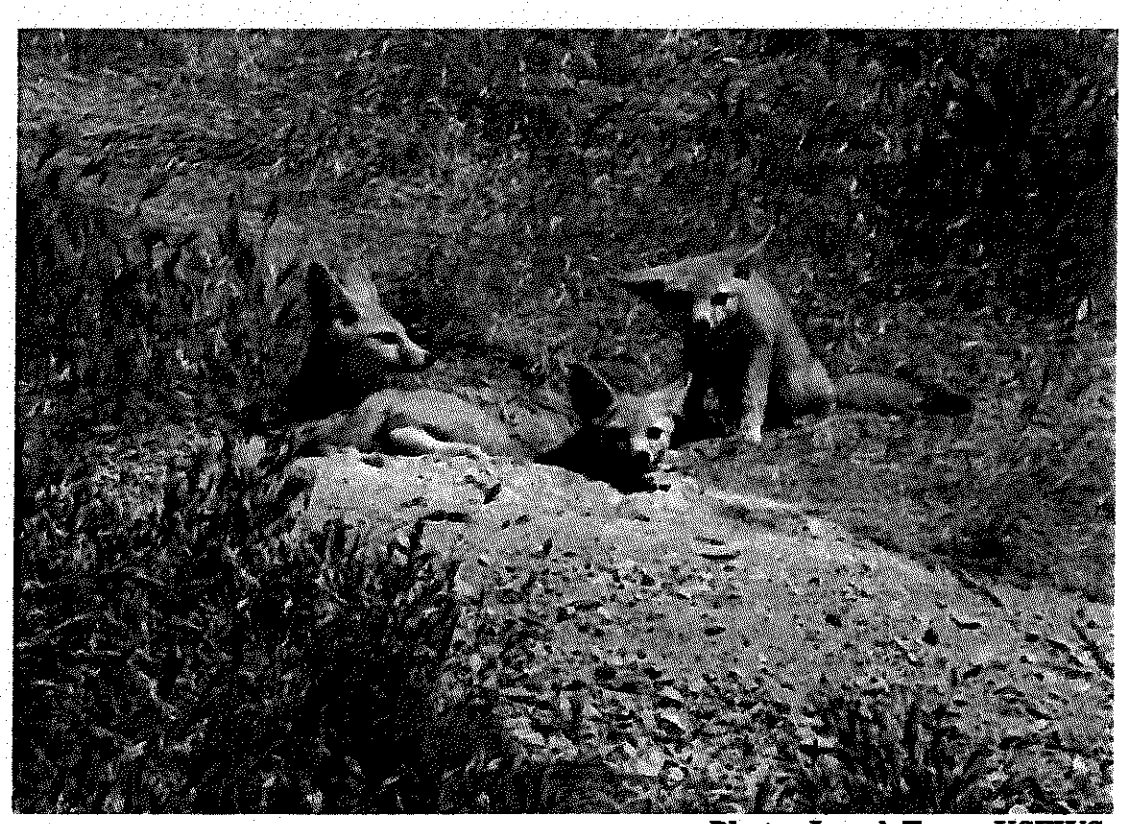
San Joaquin Kit Fox
(*Vulpes macrotis mutica*)

5-Year Review:
Summary and Evaluation



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U.S. Fish and Wildlife Service
Sacramento Fish and Wildlife Office
Sacramento, California

Date Signed at Sacramento FWO

5-YEAR REVIEW

San Joaquin Kit Fox (*Vulpes macrotis* ssp. *mutica*)

I. GENERAL INFORMATION

Purpose of 5-Year Reviews:

The U.S. Fish and Wildlife Service (Service) is required by section 4(c)(2) of the Endangered Species Act (Act) to conduct a status review of each listed species at least once every 5 years. The purpose of a 5-year review is to evaluate whether or not the species' status has changed since it was listed (or since the most recent 5-year review). Based on the 5-year review, we recommend whether the species should be removed from the list of endangered and threatened species, be changed in status from endangered to threatened, or be changed in status from threatened to endangered. The San Joaquin kit fox (kit fox) was listed as endangered under the Endangered Species Preservation Act in 1967, so was not subject to the current listing processes and, therefore, did not include an analysis of threats to the kit fox. However, a review of Federal and State agency materials written at the time of listing indicates that listing was in fact based on the existence of threats that are attributable to one or more of the five threat factors described in section 4(a)(1) of the Act, and we must consider these same five factors in any subsequent consideration of reclassification or delisting of a species. In the 5-year review, we consider the best available scientific and commercial data on the species, and focus on new information available since the species was listed or last reviewed. If we recommend a change in listing status based on the results of the 5-year review, we must propose to do so through a separate rule-making process defined in the Act that includes public review and comment.

Species Overview:

The San Joaquin kit fox, *Vulpes macrotis mutica,* is the larger of two subspecies of the kit fox, *Vulpes macrotis*, the smallest canid species in North America. The San Joaquin kit fox, on average, weighs 5 pounds, and stands 12 inches tall. It has a small slim body, large close-set ears, and a long bushy tail that tapers at the tip. Depending on location and season, the fur coat of the kit fox varies in color and texture from buff to tan or yellowish-grey. The tail is distinctly black-tipped.

Kit fox are an arid-land-adapted species and typically occur in desert-like habitats in North America (Cypher 2006). Such areas have been characterized by sparse or absent shrub cover, sparse ground cover, and short vegetative structure (Cypher 2006). The subspecies historically ranged in alkali scrub/shrub and arid grasslands throughout the level terrain of the San Joaquin Valley floor from southern Kern County north to Tracy in San Joaquin County, and up into more gradual slopes of the surrounding foothills and adjoining valleys of the interior Coast Range. Within this range, the kit fox has been associated with areas having open, level, sandy ground (Grinnell *et al.* 1937) that is relatively stone-free to depths of about 3 to 4.5 feet. The San Joaquin kit fox utilizes subsurface dens, which may extend to 6 feet or more below ground surface, for shelter and for reproduction (Laughrin 1970). Kit fox subspecies are absent or scarce in areas where soils are shallow due to high water tables, impenetrable hardpans, or proximity to parent material, such as bedrock (Jensen 1972; Morrell 1972, O'Farrell and

Gilbertson 1979, O'Farrell *et al.* 1980, McCue *et al.* 1981, all as cited in Service 1983). The kit fox also does not den in saturated soils or in areas subjected to periodic flooding (McCue *et al.* 1981, as cited in Service 1983).

The San Joaquin kit fox is primarily nocturnal. Although the kit fox was thought to subsist primarily on kangaroo rats (*Dipodomys* spp.) historically (Laughrin 1970) and kit fox populations appear to be most robust where kangaroo rats persist (Cypher *et al.* 2000), the kit fox diet currently varies geographically, seasonally, and annually. It includes nocturnal rodents such as kangaroo rats, white-footed mice and pocket mice (*Peromyscus* spp.), California ground squirrels (*Spermophilus beecheyi*), rabbits (*Sylvilagus* spp.) and hares (*Lepus* spp.), San Joaquin antelope squirrels (*Ammospermophilus nelsoni*), and ground-nesting birds (Scrivner *et al.* 1987). Insects appear to be important seasonal prey items for at least some populations (Briden *et al.* 1992; see also Cypher *et al.* 2000).

Although some yearling female kit fox will produce young, most do not reproduce until 2 years of age (Spencer *et al.* 1992; Spiegel and Tom 1996; Cypher *et al.* 2000). The young are born in large natal dens, and generally disperse in August or September, when 4 or 5 months old. Reproductive success appears to be correlated with prey abundance (Egoscue 1975, as cited in Service 1998) and may be negatively affected by weather conditions that are either too wet or too dry.

Methodology Used to Complete This Review:

This review was prepared by the Sacramento Fish and Wildlife Office (SFWO), following the Region 8 guidance issued in March 2008. We used information from the *Recovery Plan for Upland Species of the San Joaquin Valley, California* (Recovery Plan) (Service 1998), survey information from experts who have been monitoring various localities of this species, and the California Natural Diversity Database (CNDDB) maintained by the California Department of Fish and Game (CDFG). The Recovery Plan, published literature, agency reports, biological opinions, completed Habitat Conservation Plans (HCPs), and personal communications with experts were our primary sources of information used to update the species' status and threats. No previous status reviews have been conducted for this species. This 5-year review contains updated information on the species' biology and threats, and an assessment of that information compared to that known at the time of listing. We focus on current threats to the species that are attributable to the Act's five listing factors. The review synthesizes all this information to evaluate the listing status of the species and provide an indication of its progress towards recovery. Finally, based on this synthesis and the threats identified in the five-factor analysis, we recommend a prioritized list of conservation actions to be completed or initiated within the next 5 years.

Contact Information:

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Federal Register (FR) Notice Citation Announcing Initiation of This Review: The Service published a notice announcing initiation of the 5-year review of this taxon and the opening of a 60-day period to receive information from the public in the Federal Register on March 22, 2006 (71 FR 14538). We received one comment each from the public and from Fort Hunter Liggett Army Reserve Training Site in response to our Federal Notice initiating this 5-year review.

Listing History:

Original Listing
FR Notice: Federal Register 32:4001
Date of Final Listing Rule: March 11, 1967, under the Endangered Species Preservation Act of 1966*
Entity Listed: San Joaquin Kit Fox, *Vulpes macrotis mutica.* The San Joaquin kit fox is an animal subspecies.
Classification: Endangered
*Note: Listing documents at this time did not use the 5 factor analysis method, and did not provide discussion of species status, or threats to the species.

State Listing
San Joaquin kit fox, *Vulpes macrotis* subsp. *mutica* was listed by the State of California as threatened on June 27, 1971.

Associated Rulemakings: There are no associated rulemakings.

Review History: 90-Day finding: A 90-day finding on a petition to delist the San Joaquin kit fox was published in 57 FR 28167 on June 24, 1992 (Service 1992a). The Service's finding was that the petition did not present substantial scientific information indicating that delisting the kit fox was warranted. The petition was based on taxonomic considerations. The Service concluded that the status of kit fox and swift fox (*Vulpes velox*) taxonomy remained a subject of ongoing scientific debate, but found that, regardless of the outcome of the continuing debate, the San Joaquin kit fox was a distinct population segment subject to protection under the Act (Service 1992a).

Species' Recovery Priority Number at Start of 5-Year Review: The recovery priority number for the San Joaquin kit fox is 3C according to the Service's 2006 Recovery Data Call for the Sacramento Fish and Wildlife Office, based on a 1-18 ranking system where 1 is the highest-ranked recovery priority and 18 is the lowest (Endangered and Threatened Species Listing and Recovery Priority Guidelines, 48 FR 43098, September 21, 1983). This number indicates that the taxon is a subspecies that faces a high degree of threat and has a high potential for recovery. The "C" indicates conflict with construction or other development projects or other forms of economic activity.

Recovery Plan or Outline

Name of Plan or Outline: *Recovery Plan for Upland Species of the San Joaquin Valley, California* (Recovery Plan)
Date Issued: September 30, 1998
Dates of Previous Revisions: San Joaquin Kit Fox Recovery Plan (**Service** 1983)

II. REVIEW ANALYSIS

Application of the 1996 Distinct Population Segment (DPS) Policy

The Endangered Species Act defines "species" as including any subspecies of fish or wildlife or plants, and any distinct population segment (DPS) of any species of vertebrate wildlife. This definition of species under the Act limits listing as distinct population segments to species of vertebrate fish or wildlife. The 1996 Policy Regarding the Recognition of Distinct Vertebrate Population Segments under the Endangered Species Act (Service 1996) clarifies the interpretation of the phrase "distinct population segment" for the purposes of listing, delisting, and reclassifying species under the Act.

The San Joaquin kit fox was listed as a subspecies. In 1992 the Service completed a 90-day finding on a petition to delist the San Joaquin kit fox (Service 1992a). The petition was based on a taxonomic review of the kit fox (*Vulpes macrotis*) and swift fox (*Vulpes velox*) species and their subspecies (see Dragoo *et al.* 1990). The petition proposed that the kit fox and swift fox were not separate species, but instead constituted the only two recognizable subspecies of one wide-ranging species, *Vulpes velox*. The authors concluded that although canid taxonomy was subject to disagreement, their data suggested that the San Joaquin kit fox should be synonymized under the subspecies, *V. v. macrotis*. The Service recognized that low genetic variation within the Order Carnivora, and particularly within the Family Canidae, led to difficulties in determining where taxonomic subdivisions should occur, but found that the Dragoo *et al.* (1992) review had in fact noted that morphometric (body measurement) data did clearly differentiate between the kit and swift fox groups, which might in fact be expected in either closely-related sister taxa or in well-differentiated subspecies of one species (Dragoo *et al.* 1990, as cited in Service 1992a). The Service concluded that delisting was not merited, as genetic information available at that time suggested that the San Joaquin kit fox would be considered a distinct population segment, regardless of it status as a recognized subspecies (Service 1992a). Preliminary results from a study of genetic subdivisions among small canids were used to support the 90-day finding (Service 1992a). That study has since been published and supports the designation of swift and kit fox as separate species, while supporting the categorization of the San Joaquin kit fox as a subspecies (Mercure *et al.* 1993). There is thus no new information that indicates that the DPS policy would apply to the San Joaquin kit fox.

Information on the Species and its Status

Species Biology and Life History

Food and foraging – Around the time of listing, kit fox presence was linked to the presence of kangaroo rats, which constituted a major prey item for the kit fox (Laughrin 1970). In fact, Laughrin (1970) found that kangaroo rat remains comprised 80 to 90 percent of fecal material at most collecting sites throughout the range of the kit fox. Starvation, especially of pups, was noted to be a likely limiting factor for kit fox populations (Morrell 1972).

Recent studies have supported early observations that kit fox appear to be strongly linked ecologically to kangaroo rats. In natural areas, kit fox density and population stability are highest in areas with abundant kangaroo rats (Speigel *et al.* 1996; Cypher *et al.* 2000; Cypher 2006; see also Bean and White 2000). Kit fox are also known to consume other small mammal species, including leporids (rabbits and hares: *Lepus* and *Sylvilagus* spp.), ground squirrels (*Ammospermophilus* and *Spermophilus* spp.), and insects (Archon 1992; Cypher and Brown 2006). Early surveys sometimes focused on presence of leporids based on the assumption that kit fox preyed heavily on these species (EG&G 1981); however, consumption of these species appears to be secondary to consumption of kangaroo rats (Cypher *et al.* 2000). In the southern San Joaquin Valley, kangaroo rats were found to be the primary small mammal present at undeveloped and moderately developed sites, while smaller rodents (California pocket mice [*Chaetodipus californicus*], San Joaquin pocket mice [*Perognathus inornatus*], deer mice [*Peromyscus maniculatus*], and house mice [*Mus musculus*]) were found most frequently at an intensively developed site (Speigel *et al.* 1996). At the undeveloped sites, the primary prey was always the kangaroo rat, whereas at the developed sites, prey consumption was a function of prey availability. Consumption of small rodent species and leporids occurred concurrently with population increases in those species, suggesting to the authors that the ability to exploit a variety of resources on an opportunistic basis would enable kit fox to persist in altered environments, and in areas subject to drought-related fluctuations in prey. Subsequently, Cypher *et al.* (2000) documented that annual finite growth rates were positively correlated with consumption of kangaroo rats and negatively correlated with consumption of other prey items, suggesting that kit fox in the area feed preferentially on kangaroo rats and that declines in kangaroo rat densities negatively affect kit fox survival. An annual finite growth rate (or annual finite rate of increase) is a measure of the relative rate of growth of a population. Local extirpation of kit fox communities has also been linked to the previous loss of kangaroo rat populations (Bean and White 2000; P. Williams, Kern National Wildlife Refuge, *in litt.* 2007).

Precipitation-mediated changes in prey availability are most often related to changes in vegetation. Low precipitation levels characteristic of droughts result in reduced seed production in the natural habitats of the San Joaquin Valley (Williams *et al.* 1993, Rathbun 1998, Germano and Williams 2005, all cited in Bureau of Land Management [BLM] 2008a). During several years of drought, seed resources for granivorous rodents, such as kangaroo rats, become scarce, resulting in declining abundance of these kit fox prey species (see Williams *et al.* 1993, Rathbun 1998, Germano and Williams 2005, all cited in BLM 2008a). Declining prey levels usually continue until higher germination of annual plants resumes with average precipitation levels (Cypher *et al.* 2000). In many locations, population abundance of kit fox responds to lower prey

abundance by declining, although there generally is a lag-time of one or more years before kit fox declines occur (Cypher *et al.* 2000; Dennis and Otten 2000). High rainfall events also are known to reduce prey abundance dramatically (B. Cypher, Endangered Species Recovery Program [ESRP] *in litt.* 2007; Williams *in litt.* 2007).

In some locations ground squirrels have been identified as the primary prey consumed by the kit fox (Orloff *et al.* 1986). California ground squirrels were found to be the most common prey item in the Bethany Reservoir area of Alameda County (Orloff *et al.* 1986). No kangaroo rats were detected at this site (Orloff *et al.* 1986), but ground squirrels have also been important food items in some areas where kangaroo rats appeared to be abundant (Balestreri 1981), although the relative densities of kangaroo rats in these areas is not known. In eastern Contra Costa County, a crash in the kit fox population was associated with extirpation of the California ground squirrel due to a ground squirrel eradication program (Orloff *et al.* 1986). To date, no studies have addressed the energetic relationships for the kit fox associated with capture effort and food value of different prey species. In the Bakersfield vicinity, urban kit fox have access to anthropogenic food resources to supplement available natural prey so, in general, food is abundant and kit fox abundance shows little inter-annual variation (Cypher *in litt.* 2007, as cited in Ralls *et al.* 2007).

Home range size - Kit fox establish home ranges that are extensive, but home range sizes vary among locations. Home range size is thought to be related to prey abundance (White and Ralls 1993; White and Garrott 1999). At the Naval Petroleum Reserves (NPRC), Cypher *et al.* (2001) determined the mean adult home range size to be 1,071.7 acres, while the mean home range for pups was 525.4 acres. (At the time this study was conducted, the study area was within the federally designated Naval Petroleum Reserves. Subsequently the reserve units have changed management or ownership, and are no longer known as the Naval Petroleum Reserves. In this document, they are referred to by this name where so referenced in the research documents cited.) Kit fox on the Carrizo Plains establish home ranges estimated to average approximately 2,866 acres in size (White and Ralls 1993). In western Merced County, Briden *et al.* (1992) found that denning ranges (the area encompassing all known dens for an individual) average 1,169 acres (1.8 square miles) in area. However, at Camp Roberts Army National Guard Training Site (Camp Roberts), the average home range was found to be 5,782 acres, based on a radio-telemetry study (Root and Eliason 2001, as cited in California Air National Guard 2008).

In the Bakersfield vicinity, kit fox selection of den sites appears to be associated with areas of open space, or areas having light or infrequent disturbance, such as canal right of ways and detention basins (Bjurlin *et al.* 2005). Urban kit fox have access to anthropogenic food sources and kit fox in this urban area have smaller home ranges than those in non-urban areas.

Predation and competition - Around the time of listing, resource competition with the gray fox (*Urocyon cinereoargenteus*) was proposed as a potential factor limiting the San Joaquin kit fox's range to more open, lower elevation habitats (Jensen 1972), but publications did not indicate that predators threatened kit fox survival within its range. In fact, early observations noted that in most localities where kit fox subspecies were numerous, coyotes (*Canis latrans*) were to be found in relatively large numbers and evidence of competition and predation was lacking. Unfortunately these early studies did not quantify the abundance of coyotes, so comparing

current and early densities is not possible. The particular association between kit fox presence and kangaroo rat colonies was noted (Grinnell *et al.* 1937).

Studies in the last 20 years have shown that predation has become a significant cause of kit fox mortality. This predation has been noted to have strong effects on the demography and ecology of kit fox, at least locally (Cypher and Scrivner 1992). Predation (by coyotes and some bobcats [*Lynx rufus*]) was the primary cause of mortality for the kit fox population at the NPRC (Cypher and Spencer 1998; Cypher *et al.* 2000). The percentage of mortality due to interactions with predators, primarily coyotes, ranged between 57 percent and 89 percent in the southern San Joaquin Valley (Cypher and Scrivner 1992; Standley *et al.* 1992; Ralls and White 1995; Spiegel and Disney 1996; Spiegel *et al.* 1996; Cypher and Spencer 1998; Cypher *et al.* 2000; Nelson *et al.* 2007), while in Western Merced County it averaged 46 percent (Briden *et al.* 1992). In some locations coyotes only infrequently consume the kit fox they kill, suggesting that coyote attacks are competitive interactions that can include prey consumption rather than a strict predator-prey interaction (Cypher and Spencer 1998; Cypher *et al.* 2000; Nelson *et al.* 2007). Free-ranging dogs (*Canis familiaris*), non-native red fox (*Vulpes vulpes*), badgers (*Taxidea taxus*), and golden eagles (*Aquila chrysaetos*) have also been documented as kit fox predators (Briden *et al.* 1992; Cypher *et al.* 2000).

The diets and habitats selected by coyotes and kit fox often overlap (Cypher and Spencer 1998; Cypher *et al.* 2001). Coyote and kit fox interactions may be reduced through habitat partitioning (use of different portions of the habitat), although research indicates natural habitat partitioning with coyotes is more likely in areas where there are differing levels of cover available (Cypher *et al.* 2000; Nelson *et al.* 2007). For example, in the Lokern area, the survival of individual kit fox was inversely related to the proportion of shrub habitat within their home ranges (Nelson 2005; Nelson *et al.* 2007). A dense cover of shrubs was found to impair the predator detection and avoidance abilities of kit fox, making the kit fox more vulnerable to coyotes. Coyotes used primarily shrub land habitats, while kit fox selectively used burned grasslands (Nelson 2005; Nelson *et al.* 2007). The two species primarily consumed the same prey (with the exception that only coyote consumed livestock carcasses), but consumed prey in different proportions. The shrublands were found to hold higher biomass of prey species than grasslands for both coyotes and kit fox, suggesting that the kit fox may have been displaced from shrublands into grassland habitats by coyotes, with diet overlap occurring at an increased mortality cost for the kit fox (Nelson *et al.* 2007).

As noted above, coyotes and kit fox partition prey resources, with the prey species making up different proportions of the kit fox and coyote diets (Cypher and Spencer 1998; Nelson *et al.* 2007). The potential for resource competition between these species varies interannually depending on relative availability of prey species (White *et al.* 1995; Cypher and Spencer 1998). Resource competition may not be significant in all areas or all years (Cypher *et al.* 2001), but may be high when prey resources are scarce, such as during droughts that are common in semi-arid, central California (Cypher and Spencer 1998). In some areas the two species may partition resources adequately to coexist, even with high predation by coyotes (Nelson *et al.* 2007). However, research suggests that coyote predation on kit fox dampens population increases of kit fox and accentuates population declines (Cypher and Spencer 1998). Coyote-related deaths of adult kit fox appear to be largely additive (i.e., in addition to deaths caused by other mortality

factors such as disease and starvation) rather than compensatory (i.e., tending to replace deaths due to other mortality factors) (White and Garrott 1997). Therefore, the survival rates of adult kit fox decrease significantly as the mortality caused by coyotes increases (White and Garrott 1997; Cypher and Spencer 1998). Increases in coyote abundance may contribute to significant declines in kit fox abundance (Cypher and Scrivner 1992; Ralls and White 1995; White *et al.* 1996). There is also some evidence that the proportion of juvenile kit fox killed by coyotes increases as kit fox density increases (White and Garrott 1999). This density-dependent relationship could provide a feedback mechanism that would reduce the kit fox population, reduce or prevent population growth, and accentuate, hasten, or prolong population declines. Data suggest that coyotes may have greater effects on kit fox populations under drought conditions and in homogeneous habitat (Cypher *et al.* 2000; Nelson *et al.* 2007).

Increases in coyote abundance may be a causal factor in past local kit fox declines (Warrick and Cypher 1998; Cypher *et al.* 2000). Kit fox are apparently excluded from steeper terrain by combined factors that reduce their detection of, and susceptibility to, predators, especially coyotes. Kit fox predators use these areas of steeper terrain and constitute a significant source of kit fox mortality (Warrick and Cypher 1998). In the former NPRC of western Kern County, researchers concluded that kit fox were able to occupy some areas of steep terrain in the early 1980s when coyote abundance was unusually low (O'Farrell 1980, as cited in Warrick and Cypher 1998) and prey populations were at high levels (Harris 1986, as cited in Warrick and Cypher 1998). However, in the 13 years after the earlier study, kit fox were found to be virtually absent from rugged terrain (Warrick and Cypher 1998).

Non-native red fox also occur within the San Joaquin Valley. Red fox and kit fox have been found to have highly overlapping diets, suggesting potential competition for prey resources (Clark *et al.* 2005). Where studied in the Lost Hills of Kern County, the two species consumed these prey items in different proportions, which suggested that prey consumption might contribute to resource partitioning (use of different segments of the available prey resources) and reduced competitive effects (Clark *et al.* 2005). Kit fox mortality from red fox may be additive to that from coyotes. Coyotes are a significant source of mortality for red fox, and have been proposed as a control on red fox abundance (Clark *et al.* 2005), although the potential effect to the kit fox has not been resolved. Red fox are rarely observed in areas where coyotes are abundant (Ralls and White 1995; Cypher *et al.* 2000).

Although the intensity of predation by large carnivores is high in non-urban areas, it is low in the urban Bakersfield area, resulting in higher survival rates among urban kit fox (Cypher *in litt.* 2007, as cited in Ralls *et al.* 2007).

Diseases - Serological surveys of the San Joaquin kit fox and co-occurring carnivores, including the coyote and red fox, have provided evidence of kit fox exposure to pathogens (McCue and O'Farrell 1988; Standley and McCue 1997; Cypher *et al.* 1998; Miller *et al.* 2000). In serological tests for disease antibodies, high numbers of kit fox test positive for canine distemper virus and canine parvovirus, indicating that they have been exposed to these diseases (McCue and O'Farrell 1988; Standley and McCue 1992). Canine distemper virus (CDV) and canine parvovirus (CPV) could be sources of mortality in kit fox populations, but population-level effects have not been studied. Although mortality due to diseases and parasites can be difficult

to detect, Cypher *et al.* (1998, 2000) found no evidence that disease was an important mortality factor at the NPRC in western Kern County based on periodic serological surveys conducted between 1981 and 1991. Serological tests of kit fox at Camp Roberts in 1989 and 1990 found antibodies to five of eight pathogens tested (Standley and McCue 1997). Infectious canine hepatitis virus (CHV), CDV, CPV, *Leptospira interrogans*, and *Toxoplasma gondii* were found in varying percentages of adult kit fox; however, only one of eight juveniles tested was positive for antibodies (to *L. interrogans*). While the authors suggested that infectious diseases may have been the ultimate cause of deaths attributed to predation or unknown causes, they did not present any data to substantiate the suggestion. Similar levels of antibodies for most of these pathogens have also been documented for kit fox at the Elkhorn Plain and the Elk Hills (McCue and O'Farrell 1988). Prevalence of antibodies against CPV, CDV, and canine adenovirus type 1 has also been found in coyotes of the NPRC (Cypher *et al.* 1998). Although coyotes are a known potential source of viral exposure for the kit fox, variation in coyote abundance was not found to influence the prevalence of antibodies in kit fox (Cypher and Scrivner 1992; Cypher *et al.* 1998). To date, however, no disease outbreaks have been documented for the kit fox (Miller *et al.* 2000; B. Cypher, ESRP, *in litt.* 2009).

Research at the California State University in Bakersfield (CSUB) campus has been conducted to address concerns about the potential for transmission of rabies and other diseases between urban kit fox and other urban carnivores (e.g., skunks, cats [*Felis domesticus*], and red fox) (S. Harrison *et al.*, ESRP, *in litt.* 2006). Den use by skunks and kit fox was found to overlap 28 percent of the time, while kit fox, feral cats, skunks, and red fox were all found to use cat feeding stations on campus, providing a means for cross-species disease transmission (Harrison *et al. in litt.* 2006). Transmission of rabies to kit fox presently appears unlikely; although rabies has been documented in bats in the Bakersfield area, it hasn't been documented in Kern County for any of the animals found at the cat feeding station (Cypher *in litt.* 2007). Although there is a potential for disease transmission in this high-density population of urban kit fox, to date there have been no disease outbreaks in the area (Harrison *et al. in litt.* 2006).

Additional information on kit fox biology and life history, including denning behavior and dispersal can be found in Appendix 1.

Spatial Distribution

To date, no comprehensive range-wide surveys have been completed to determine the status of kit fox populations throughout its historic range. The Service is aware of only six regional-scale surveys that have been conducted for the kit fox in over 30 years (Smith *et al.* 2006).

Historical distribution - The San Joaquin kit fox is endemic to California. Historically it was known to occur in semi-arid habitats of the San Joaquin Valley (valley) and in arid grasslands of the adjacent foothills, from as far north as Tracy, San Joaquin County, and La Grange, Stanislaus County, south to Kern County (Grinnell *et al.* 1937). At that time kit fox appeared to be abundant outside their current strongholds in the southwestern corner of the valley. For example, Grinnell *et al.* (1937) reported that in 1919, when kit fox were being taken for their fur, 100 kit fox were caught within one week on a 20 by 2 mile segment of the plains in western Fresno County near the base of the Ciervo-Panoche Hills (Bell 1994). By 1930, Grinnell and others

(1937) determined that the range of the kit fox had contracted to the driest plains of the southern and western parts of the valley.

Distribution at the time of listing - The Service does not have information that indicates the distribution that was considered when the San Joaquin kit fox was listed in 1967. However, State and Federal studies completed within ten years of listing provide information to indicate the likely known distribution of the kit fox at the time of listing (Laughrin 1970; Jensen 1972; Morrell 1972, 1975; Waithman 1974). This literature suggests that kit fox range boundaries had not been precisely determined prior to Federal listing (Laughrin 1970; Waithman 1974). The CDFG attempted the first delineation of range boundaries in 1969 (Laughrin 1970). In general, the range was described as extending from the Tehachapi Mountain foothills at the southern end of the San Joaquin Valley north to the area west of Los Banos, Merced County, and to the White River area south of Porterville, Tulare County, including the Carrizo Plain and the Cholame area (Laughrin 1970). The 1969 range map included areas of western Merced, Fresno, and Kings Counties, large areas of Kern County, and portions of eastern San Luis Obispo, Monterey, and San Benito Counties. The range map also indicated that small portions of the range occurred in Tulare County and in the Cuyama Valley of Santa Barbara County. Some areas, where direct evidence of kit fox was lacking, were assumed to be part of the range because appropriate native habitat, including kangaroo rat activity, remained in the location (Laughrin 1970).

Upon release of the 1969 range map, State and Federal agencies received information indicating the existence of additional kit fox localities, which led to identification of kit fox in the Hollister area of San Benito County, in areas of the Salinas River Valley of San Luis Obispo and Monterey Counties, and in a narrow band of suitable habitat in Contra Costa, San Joaquin, and northeastern Alameda (Jensen 1972; Swick 1973). Kit fox were likely present in at least some of these areas at the time of listing (Jensen 1972; Swick 1973; Waithman 1974; Balestreri 1981).

At the time of listing, the kit fox's range had been substantially reduced from its historic range, limiting areas with abundant kit fox primarily to the western and southern ends of the San Joaquin Valley and the surrounding foothills. At the same time, kit fox were suggested to be increasing in the foothills and drier Coast Range valleys adjacent to the San Joaquin Valley, potentially due to displacement from the San Joaquin Valley because of a 34 percent reduction in native habitat due to agricultural conversion (Laughrin 1970; Morrell 1975). By 1975, the kit fox was also identified in Stanislaus and Santa Clara Counties, providing a distribution that included portions of 14 counties (Morrell 1975). Localities, such as those in Santa Clara, Monterey, Contra Costa, Alameda, San Joaquin, and San Benito Counties, were apparently first identified or re-established after listing. Individual kit fox have also been identified in areas along the eastern boundary of the San Joaquin Valley, and in areas slightly outside the original delineated range in Santa Barbara County and Madera County (CNDDB 2008). As such, additional localities, particularly in the Salinas Valley and at the northern and eastern extents of the range represent an extension of the known range of the kit fox from that considered at the time of listing. In addition, localities within the Salinas Valley would appear to represent an extension of the known historic range.

Current distribution – Known historical and current distribution, as recorded in the California Natural Diversity Database (CNDDB), is illustrated in Figure 1 (less than ten CNDDB records

are from the period prior to 1970). The CNDDB currently lists a total of 949 San Joaquin kit fox occurrences (Figure 1). Fifty percent of the occurrence records are over 20 years old, while around 190 occurrence records (20 percent) have been recorded in the last 10 years (CNDDB 2008). The status of most of these occurrences is unknown, although they are all listed as "presumed extant" (CNDDB 2008). Individual CNDDB occurrences represent locations where a species has been documented to occur; they do not represent distinct populations as they are observation records of individuals, not population-level records. For the San Joaquin kit fox, a CNDDB "occurrence" is based on any documented collection, observation (sighting), or museum specimen of a kit fox, or any credible observation of its recent presence as noted by presence of one or more of the following: an active den, kit fox tracks, or kit fox scat. Animals may be observed in resident breeding areas, during dispersal from a breeding areas, or dead on the road. Each quarter quarter-section where kit fox or their sign have been observed, as described above, may be recorded and mapped separately, although if there are multiple observations/collections within 1/4 mile of each other, they are most often combined into a single occurrence. However, to avoid the description of large polygons, multiple individual observation records that are within 1/4 mile of each other are occasionally designated as separate polygons, as has been done in the Bakersfield area (D. McGriff, CDFG, *in litt.* 2008). Close to 50 percent of the CNDDB occurrences have been recorded from Kern County, with 10 percent from Tulare County, 6 percent from Kings County, 8 percent from Fresno County, and 9 percent from San Luis Obispo County. The San Joaquin kit fox has also been recorded from Alameda (1.5 percent), Contra Costa (2.5 percent), Madera (0.7 percent), Merced (4.6 percent), Monterey (5 percent), San Benito (3 percent), San Joaquin (2 percent), Santa Barbara (1 percent), Stanislaus (1 percent), and Santa Clara (0.5 percent) Counties (CNDDB 2008). Fewer animals have been observed in the more northerly portions of the San Joaquin Valley, and adjoining valleys and foothills, and records suggest a pattern of declining presence over time (see Figure 1).

By 1998, when the Recovery Plan was completed, local surveys, research projects, and incidental sightings indicated that kit fox inhabited a portion, but not all, of the areas of suitable habitat remaining in the San Joaquin Valley and lower foothills of the coastal ranges, Sierra Nevada, and Tehachapi Mountains. The boundaries of the kit fox's range still extended from southern Kern County north to Contra Costa, Alameda, and San Joaquin Counties on the west, and to the La Grange area, Stanislaus County, on the east side of the Valley (Williams 1990, as cited in Service 1998). The most northerly sighting was made at the Black Diamond Mines Regional Preserve near Antioch, Contra Costa County in the early 1990s (Bell 1994). The largest extant populations were known from western Kern County on and around the Elk Hills area and Buena Vista Valley, and the nearby Carrizo Plain Natural Area (Service 1998) where relatively level terrain is separated by narrow rugged ranges.

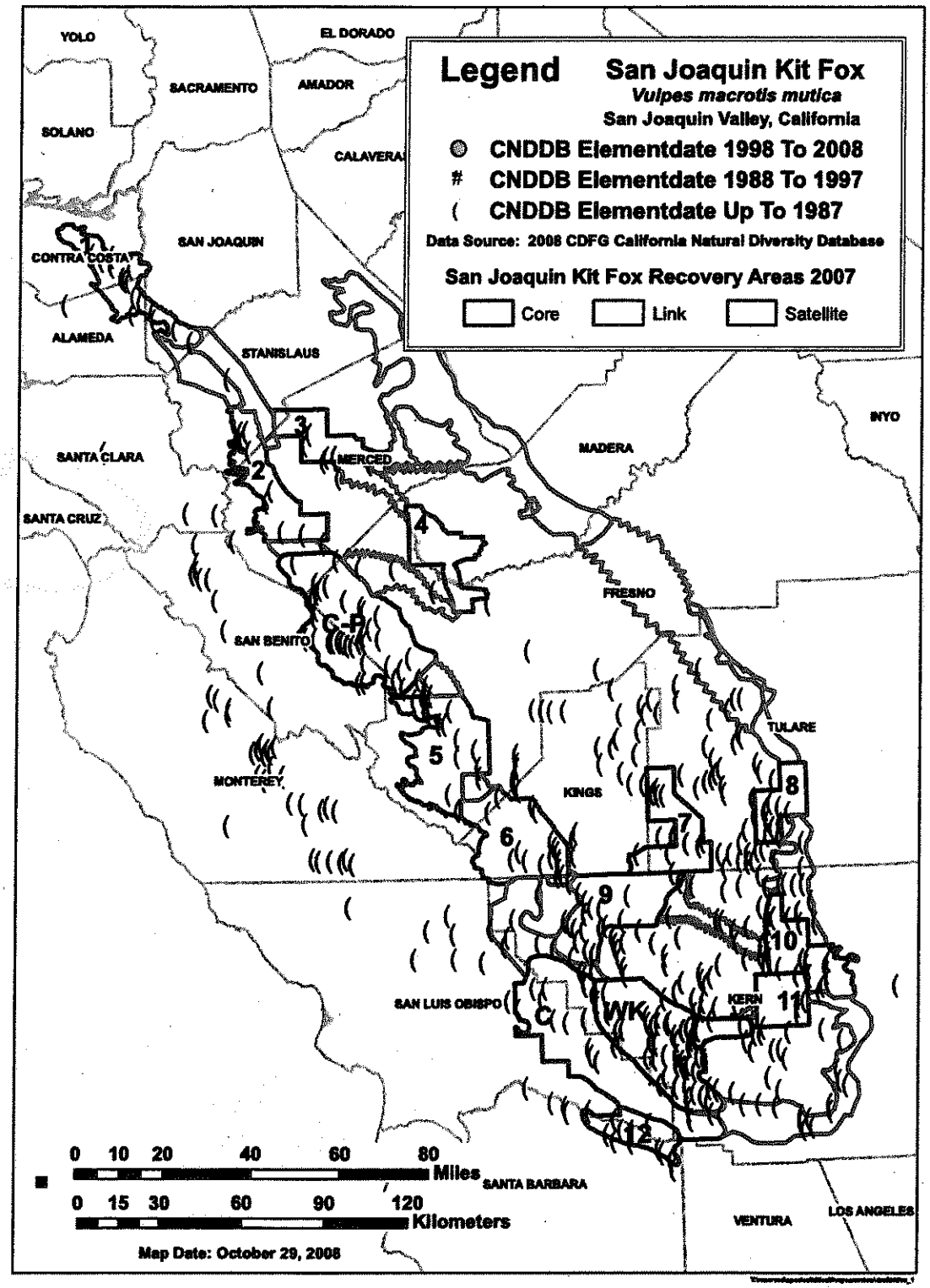
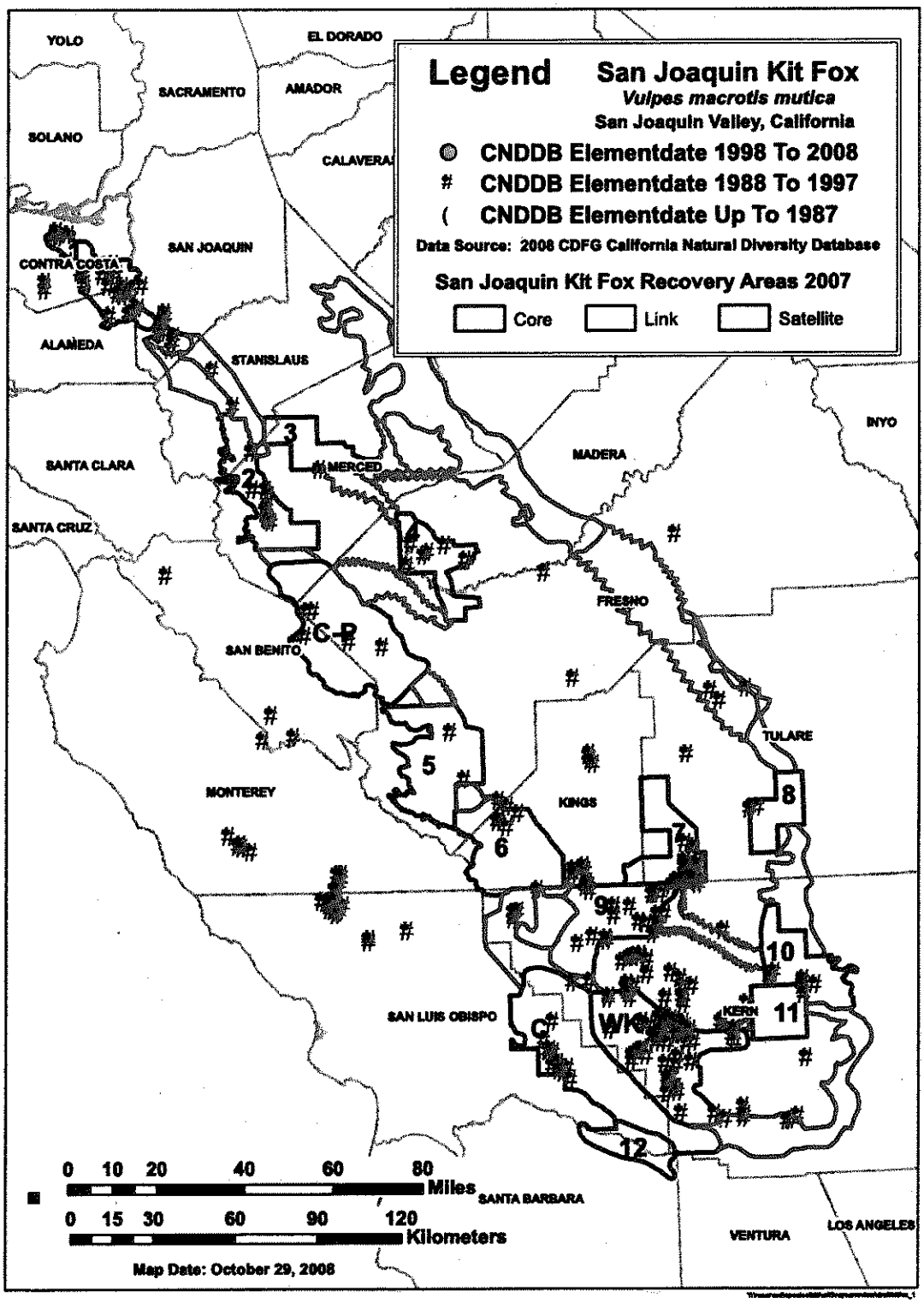


Figure 1A-C: Maps of recorded occurrences of San Joaquin kit fox, for three time periods: 1950-1987 (A), 1988-1997 (B) and 1998-2008 (C). Shown in relation to currently described Recovery Core Areas, Satellite Areas and Linkages. Core Areas: WK (Western Kern County), C (Carrizo Plains), C-P (Ciervo-Panoche); Satellite Areas: 1-12, see Table 1 for Satellite Area names. Satellite 13 (Salinas-Pajaro) has not yet been delineated.



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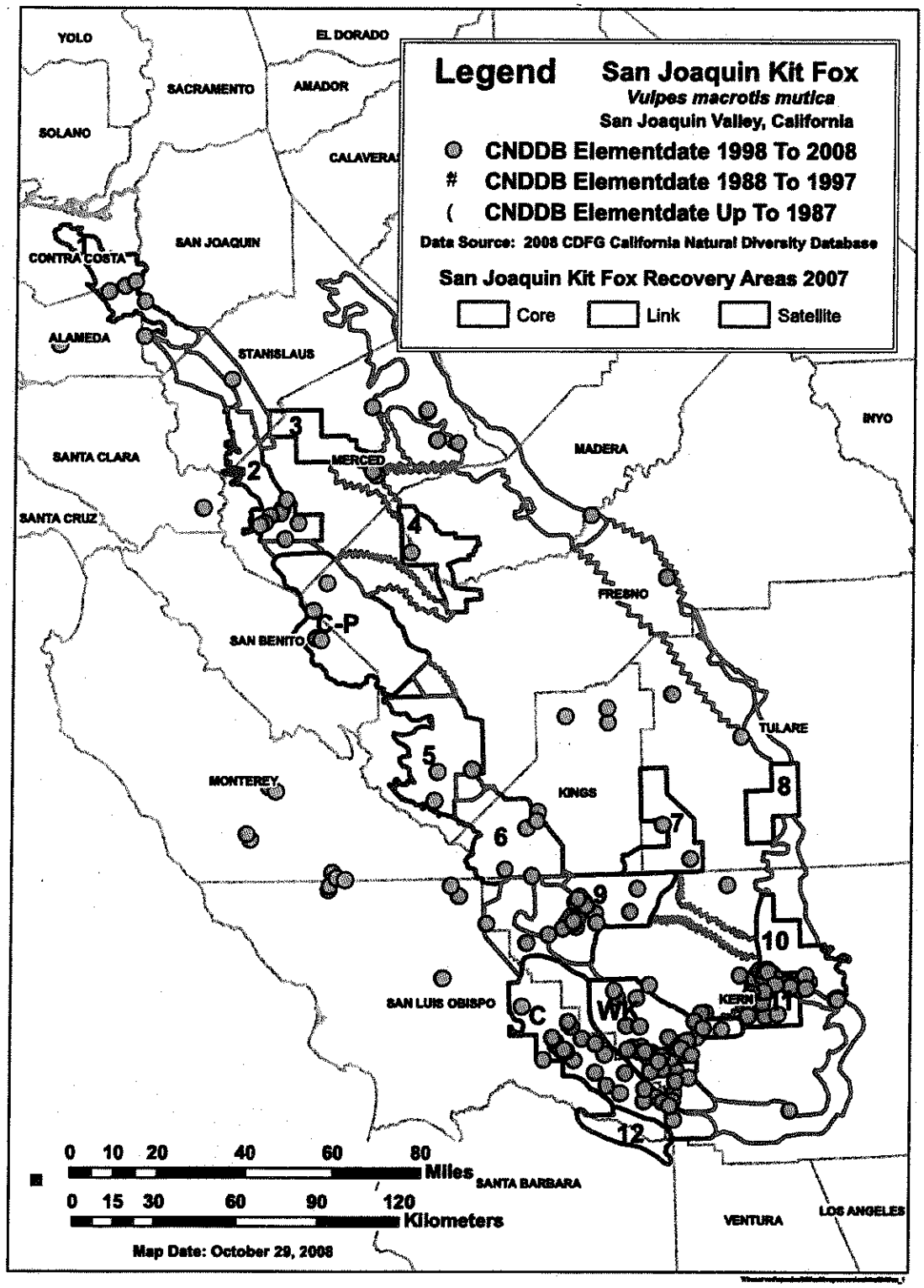

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Within the kit fox range, occupied habitat included some of the larger scattered islands of natural land on the Valley floor in Kern, Tulare, Kings, Fresno, Madera, and Merced Counties. Kit fox occurrences were known from the valleys of the interior Coast Range in Monterey, San Benito, and Santa Clara Counties (Pajaro River watershed); in the Salinas River watershed of Monterey and San Luis Obispo Counties; and in the upper Cuyama River watershed of northern Ventura and Santa Barbara Counties and southeastern San Luis Obispo County. Kit fox were also known to live within the city limits of the city of Bakersfield in Kern County (Laughrin 1970; Jensen 1972; Morrell 1975; Service 1983; Swick 1973, Waithman 1974, Endangered Species Recovery Program unpublished data, as cited in Service 1998).

Currently, the entire range of the kit fox appears to be similar to what it was at the time of the 1998 Recovery Plan; however, population structure has become more fragmented, at least some of the resident satellite subpopulations, such as those at Camp Roberts, Fort Hunter Liggett, Pixley National Wildlife Refuge (NWR), and the San Luis NWR, have apparently been locally extirpated (White *et al.* 2000; Moonjian 2007; Williams *in litt.* 2007; Cypher *in litt.* 2007; B. Parris, San Luis NWR, *in litt.* 2007; M. Moore, Camp Roberts, *in litt.* 2008), and portions of the range now appear to be frequented by dispersers rather than resident animals (Moore *in litt.* 2008; M. Mueller, Contra Costa Water District, *in litt.* 2008; Cypher *in litt.* 2009). For example, at Fort Hunter Liggett, although approximately 36,000 acres is considered to be potential kit fox habitat, the greatest number of kit fox observed in one year was 22 (in 1990), and no kit fox have been observed since 2000 (Service 2007a). Kit fox abundance appears to be below detection levels in much of San Luis Obispo County outside of the Carrizo Plains (Moonjian 2007).

Trends in spatial distribution - Spatial distribution of the kit fox has become increasingly fragmented since listing. As illustrated in Figure 1, the number of occurrences appears to have declined in recent years. Although survey efforts have likely varied over the years in some areas, kit fox sightings have declined in areas with ongoing surveys. Table 1 provides information on areas where the kit fox has declined or become locally extirpated. Both loss of habitat and habitat fragmentation have continued throughout the range of the kit fox. By 2006, kit fox were determined to be largely eliminated from the central portion of the San Joaquin Valley. San Joaquin kit fox presence on the west side of the valley is primarily limited to a relatively narrow band of suitable habitat between the Coast Range foothills and Interstate 5. Within this narrow band, constriction of available habitat and occurrence of barriers such as the San Luis Reservoir, the California Aqueduct, the Delta-Mendota Canal, and several high traffic roads, potentially limit movements of the kit fox (Clark *et al.* 2007a), especially in the northernmost portion of the band, where only one kit fox sighting was confirmed between 1996 and 2006 (Clark *et al.* 2002; Clark *et al.* 2003a, b; B. Cypher and J. Constable, ESRP, *in litt.* 2006). However, in late 2008 another kit fox was sighted in the northernmost portion of the range (Mueller *in litt.* 2008). Although kit fox were still present in the Bethany Reservoir area in the early 1980s, they were thought to have undergone a significant range reduction in Contra Costa County between 1973 and 1983 (Orloff *et al.* 1986).

Knowledge of the kit fox's status is limited in both the northern and central portions of the kit fox's range by the lack of systematic large-scale surveys. Recent surveys of specific parcels of public lands suggest that the kit fox is either absent, occurs only intermittently, or occurs at

Table 1: Core and satellite areas identified as historically and/or currently occupied by subpopulation units of the San Joaquin kit fox.

Area	Name	Current trend	Last observed	Last surveyed	Reference
W-K	Western Kern County Core Area	Inter-annual fluctuation based on environmental conditions. Slow overall decline expected due to continuing habitat loss.	2008	2008	Smith *et al.* 2006; CNDDB 2008; B. Cypher**; B. Cypher ***
C	Carrizo Plains Core Area	Inter-annual fluctuation	2006	2008	CNDDB 2008
C-P	Ciervo-Panoche Core Area	Presumed declining	2009	Area-specific surveys§ in 2009	EG&G 1981; Smith *et al.* 2006; CNDDB 2008; B. Cypher ***; M. Westphal 2010 *in litt.*
S1	Alameda, Contra Costa, and San Joaquin Counties	Have declined, no known breeding	2002	Area-specific surveys§ in 1983, 2003	Orloff *et al.* 1986; Smith *et al.* 2006; CNDDB 2008; B. Cypher**
S2	Western Merced and Stanislaus Counties	Have declined, presence in S. portion	2005	Area-specific surveys§ in 2003	CNDDB 2008; B. Cypher**
S3	Central Merced County	Presumed extirpated	2000		Parris *in litt.* 2007, 2008; CNDDB 2008; B. Cypher**
S4	Western Madera County	Presumed extirpated	1990	Area-specific surveys§ in 2003	Smith *et al.* 2006; CNDDB 2008,
S5	Southwestern Fresno County	Isolated	2005	None	CNDDB 2008
S6	Southwestern Kings County	Isolated	2005	Area-specific surveys§ 2000, 2001	CNDDB 2008; CNDDB 2008,
S7	Southwestern Tulare County	Isolated **(Pixley NWR extirpated)**	2004	Area-specific surveys§ 2004	Smith *et al.* 2006; CNDDB 2008; B. Cypher**
S8	Tulare County Foothills	Unknown	1992	Area-specific surveys§ 2004	Smith *et al.* 2006; CNDDB 2008, B. Cypher**
S9	Northwestern Kern County	Unknown	2006	Area-specific surveys§ 2004, 2005, 2006	CNDDB 2008, B. Cypher**
S10	Northeast Bakersfield	Stable	2008	Area-specific surveys§ 2002-2006	CNDDB 2008, B. Cypher**
S11	Metropolitan Bakersfield	Stable	2008	2008	CNDDB 2008, B. Cypher**
S12	Cuyama Valley (San Luis Obispo and Santa Barbara Counties)	Unknown, presumed extant	1979	1979	CNDDB 2008, B. Cypher**
S13	Salinas-Pajaro (San Luis Obispo, Monterey and San Benito Counties)	Camp Roberts: potentially extirpated **Fort Hunter Liggett (FHL): extirpated**	CR: 2007 FHL: 2000	Area-specific surveys§ at Camp Roberts: 2008 FHL: 2008	Moonjian 2007; Moore *in litt.* 2008. L. Clark pers. comm.. 2008.

Bold = extirpated, with occasional sightings of presumed dispersers. ** B. Cypher, pers. comm. 2008. *** B. Cypher *in litt.* 2008.

§ Area-specific surveys are surveys occurring in specific areas within the core or satellite area.

extremely low densities in the northern and central portions of its range and in the smaller, more isolated natural lands in the southern portion of its range (Smith *et al.* 2006; B. Parris *in litt.* 2007). For example, the kit fox population at Pixley NWR peaked in 1994, but crashed in response to a kangaroo rat population crash during the wet winter of 1995 (Cypher *in litt.* 2007; Williams *in litt.* 2007). Although kangaroo rat numbers have rebounded, kit fox have not (Williams *in litt.* 2007). Smith and co-authors (2006) were unable to locate kit fox on a variety of natural lands within the central and northern portion of the range. However, the authors had almost no success in detecting kit fox at study sites in all portions of the range, including the southern portion where kit fox populations are known, leaving open the possibility that a factor

in the study design, such as small parcel size or isolation of the specific study parcels, may have influenced their results. Therefore, the degree to which the study results may be extrapolated to most contiguous habitat remains unclear, although results in the northern region are consistent with previous studies in the northwestern portion of the range (see Orloff *et al.* 1986; Clark *et al.* 2002; Clark *et al.* 2003a, b). In eastern Merced County, within the northeastern portion of the kit fox's historic range, kit fox have been observed on several occasions within ranchlands and in orchards, leading biologists to conclude that a small subpopulation is likely to exist within the area, although surveys conducted on a small percentage of the habitat have been largely unsuccessful in detecting the kit fox (Orloff 2002).

In summary, monitoring of kit fox subpopulations has indicated that the occupied range of the kit fox is contracting and increasingly fragmented, and that kit fox have likely disappeared from areas of extant habitat within the central and northern portions of their historic range. Changes to subpopulations of the kit fox will be discussed further under the subheading, "Abundance and demography" immediately below.

Abundance and demography

Abundance at the time of listing – In the 1983 recovery plan (Service 1983), O'Farrell estimated that the range-wide population of adult kit fox prior to 1930 may have been between 8,667 and 12,134 animals, assuming an occupied range of 8,667 square miles, and assuming densities of 1.04 to 1.55 adult kit fox per square mile. Previously (1969 through 1975) various biologists had provided estimates of the total kit fox population that varied between 1,000 and 14,800 (Laughrin 1970; Waithman 1974; Morrell 1975). Early methods of estimation were coarse, leaving the accuracy of these estimates in doubt. For example, Morrell (1975) provided a total population estimate of 10,000 to 14,800 adult animals within the 14 counties comprising the kit fox's known range. He based his estimate on average kit fox den densities that he found on one percent of the study area, and then extrapolated his average results by the number of square miles of valley floor and foothill habitat contained in the 14-county area. Morrell, in fact, warned that his results must be interpreted with caution due to the limitations of his study. He also indicated that the upper limit was almost certainly too high as his estimate did not adequately account for large areas of irrigated agriculture where kit fox densities were significantly lower than in uncultivated habitat. In the 1983 recovery plan, O'Farrell adjusted Morrell's estimates to account for agricultural lands and provided a corrected population estimate for 1975 of 6,961 adult kit fox. When compared to the pre-1930 estimate, the change represented a possible population decline of 20 to 43 percent (Service 1983).

Current abundance - The Service does not have information to indicate the current overall population size or abundance for the San Joaquin kit fox (see Cypher *et al.* 2000). The status of kit fox subpopulations is summarized briefly in Table 1 below.

By 1998, the largest extant populations of kit fox were known to occur in western Kern County on and around the Elk Hills and Buena Vista Valley areas (including the former NPRC), and in the Carrizo Plain Natural Area, San Luis Obispo County. Relatively recent population estimates are only available for the NPRC and the Carrizo Plain National Monument. Surveys on the 77,000 acre NPRC in western Kern County provided population estimates that ranged from 262

down to 74 in the period from 1981 to 1983 (Harris 1987), and that fluctuated between 46 and 363 adults from 1983 to 1995 (Warrick and Harris 2001). Due to the wide and rapid fluctuations in population abundance over the 15-year study, the population was shown to be vulnerable to extinction in as little as three to four years under poor environmental conditions, and to potentially lack viability in the long-term (Cypher *et al.* 2000; Dennis and Otten 2000). Surveys within the Carrizo Plains National Monument (CPNM) have also indicated that kit fox there also exhibit large variations in abundance and distribution that make it vulnerable to extinction over time (Bidlack 2007). The only estimate for the Carrizo Plain provides an estimated population size of between 251 and 610 individuals although the estimate may be high (Bean and White 2000). The Carrizo Plain is thought to have the largest kit fox population remaining in California (B. Cypher pers. comm., as cited in Moonjian 2007).

In other areas of the state, kit fox groups appear to have been locally extirpated in a number of locations where areas of remnant habitat remain. The San Luis NWR recorded a high of 22 kit fox in 1985, with subsequent observations averaging between 5 and 6 until 2000 when kit fox were no longer observed at the refuge (Parris *in litt.* 2007, 2008). Smaller groupings and isolated sightings of kit fox were also recorded from other parts of the San Joaquin Valley floor, including Madera County and eastern Stanislaus County (Williams 1990, as cited in Service 1998). Recent surveys have generally failed to detect kit fox subpopulations in the most northerly portion of the range (San Joaquin, Alameda, and Contra Costa Counties), although individual kit fox have been observed periodically (CDFG 2008; Mueller *in litt.* 2008). Some researchers have concluded that the kit fox currently has relatively low abundance, that the kit fox might be absent in portions of their historic range, and that robust kit fox populations occur in only a few locations, which is a pattern that decreases overall population viability and increases risk of local extinction (Smith *et al.* 2006). In the Western Kern and Carrizo Plains core areas kit fox population abundance fluctuates, but may be persistent over the long term (Schwartz *et al.* 2005; Bidlack 2007) absent increased threats. In summary, although the Service lacks specific data on kit fox abundance, individual surveys suggest that range-wide kit fox abundance has declined since the estimate of 7,000 was given in 1975 (Morrell 1975; Service 1983; Bean and White 2000; Smith *et al.* 2006; L. Clark, Fort Hunter Liggett Military Reservation, pers. comm. 2008; Cypher *in litt.* 2008; Parris *in litt.* 2007, 2008; Moonjian 2009; see also B. Stafford, CDFG, *in litt.* 2009a, and others cited herein).

Additional detail on regional abundance, and on survey and monitoring methods, is located in Appendix 1.

Demographic features - At the time of listing, no intensive studies of kit fox biology had been initiated (Laughrin 1970) and life history and demographics information was not available Morrell 1972). Shortly after listing, several studies provided preliminary information on kit fox demography, including time of breeding, den use, and preliminary information on pair bonding, reproduction and mortality (Morrell 1972). Subsequent work has further increased knowledge of kit fox demography.

Currently known aspects of kit fox demography include the following information. Population abundance is influenced heavily by survival rates of adults and juveniles, and by annual fecundity rates. Both survival and fecundity for the kit fox have varied through time, as

illustrated by variation in the age distributions of study populations over a range of years (Cypher *et al.* 2000). High adult to juvenile ratios have occurred when reproductive success was low (Cypher *et al.* 2000), whereas high juvenile to adult ratios are likely due to high fecundity associated with favorable environmental conditions (Spiegel 1996; Cypher *et al.* 2000). In general, declines in population abundance have been associated with decreased prey abundance (Standley *et al.* 1992; Ralls and White 1995; Cypher *et al.* 2000). At the NPRC, Cypher *et al.* (2000) found that, over a 15 year period, annual adult survival rates fluctuated between 20 and 81 percent, with a mean of 44 percent. In concurrent studies within the kit fox's range, similar survival rates were noted, with the average annual survival rate ranging from 53 percent at Camp Roberts to 60 percent on the Carrizo Plain (Standley *et al.* 1992; Ralls and White 1995; Spiegel and Disney 1996). Further north, in Merced County, Briden *et al.* (1992) reported an average annual survival rate of 50 percent for adult kit fox. Mean juvenile survival rates were lower than those for adults, with a mean survival of 14 percent over a 9.5 month period, and inter-annual variation of between less than 1 percent (1987) and 31 percent (1989) (Cypher *et al.* 2000). In other areas, mean annual juvenile survival rates ranged from 2 to 63 percent (Standley *et al.* 1992; Ralls and White 1995; Spiegel and Disney 1996). At the NPRC, very few of the kit fox studied survived more than 46 months (Warrick and Cypher 1999).

Reproductive success and average litter size differ between populations; at the NPRC, reproductive success of adult females averaged 61 percent, with variation between 20 and 100 percent (Cypher *et al.* 2000). Similar inter-annual variation in adult reproductive success has been found at other study sites, although the studies covered different years and showed variations in the amplitude of the fluctuations (Standley *et al.* 1992; Ralls and White 1995; Spiegel and Tom 1996). Studies have shown that yearling females will bear pups. Among yearling females studied, annual reproductive success varied from 0 to 100 percent with an average of 18.2 percent, as measured by the proportion of radio-collared yearling females successfully reproducing in a given year (Cypher *et al.* 2000). Average litter size differed by area and ranged from 2.0 pups at the Carrizo Plains to 3.8 pups at the NPRC (Standley *et al.* 1992; Ralls and White 1995; Spiegel and Tom 1996; Cypher *et al.* 2000). Average litter size for yearling females was smaller; 2.5 at the NPRC (Cypher *et al.* 2000).

Summary - In summary, in many areas kit fox appear to have decreased in abundance on a range-wide basis. In some cases resident family groupings appear to have disappeared from more isolated areas of extant habitat. Kit fox populations are larger in the Bakersfield, Western Kern County, and Carrizo Plains areas than in other portions of the range, but both the western Kern County and Carrizo populations appear to be subject to marked population fluctuations that put them at risk of population loss in less than 10 years in unfavorable environmental and demographic situations. Of all known subpopulations of the kit fox, the Bakersfield animals appear to sustain the most stable population numbers, although the size of this subpopulation is not clear.

Habitat or Ecosystem

Habitat type – Around the time of listing, the kit fox's range was thought to be reduced to the semi-desert areas of the Southern San Joaquin Valley and surrounding foothills (including portions of the Temblor and Caliente Ranges, the Cuyama Valley, and the Carrizo Plain), and to

the arid and alkaline foothill areas along the western edge of the San Joaquin Valley. The southern part of the valley was typified by the alkali sink and alkali flat habitat types, with dominant plant species including *Atriplex polycarpa* (saltbush), *Allenrolfea occidentalis* (iodine bush), *Amaranthus albus* (tumbleweed), *Frankenia grandifolia* (alkali heath), and *Salicornia subterminalis* (pickleweed) widely spaced. Areas in which iodine bush was predominant were known to be poorly drained areas that did not support kangaroo rats and were not apparently utilized by the kit fox (Jensen 1972). Areas near Bakersfield with plant associations dominated by *Prosopis juliflora* (honey mesquite) and *Atriplex lentiformis* (quail bush) were observed to support large numbers of Beechey ground squirrels (*Otospermophilus beecheyi*) to the detriment of kangaroo rat abundance, and such areas were observed to support kit fox at lower densities than the saltbush habitat (Jensen 1972). In most other areas of the valley and surrounding lower foothills, kit fox were found in California annual grassland habitat typified by *Bromus spp.*(brome grass), *Festuca spp.* (fescue), *Avena fatua* (wild oats), *Hordeum spp.* (barley), and *Erodium* (filaree) (Jensen 1972). Finally, kit fox were observed in several areas that were dry farmed, including an area east of San Lucas in Monterey County and the Shandon-Cholame area in San Luis Obispo County.

In the period since listing, studies in various areas of the state have examined kit fox use of, and persistence in, other habitat types, including grasslands and altered habitat, although information on preferred vegetative types has not changed. However, studies have refined our understanding of kit fox presence in habitat with steeper slopes. Some early estimates of the kit fox's range were based in part on information indicating that suitable habitat for the kit fox included lands with slopes of up to 40 percent (EG&G 1981). Subsequent studies have shown that kit fox presence is generally negatively associated with ruggedness (Warrick and Cypher 1998); kit fox are apparently excluded from steeper terrain by combined factors that influence detection of, and increase kit fox susceptibility to, predators, especially coyotes, that use these areas and that constitute a significant source of kit fox mortality (Warrick and Cypher 1998). Cypher *et al.* (2001) have determined that, on a regional scale, kit fox are usually either absent or less abundant in areas where average slopes exceed 5 percent.

Current understanding of kit fox habitat indicates that habitat with slopes of less than 5 percent is optimal for the kit fox, while habitat with slopes of 5 to 15 percent is suitable and habitat having slopes of greater than 15 percent is unsuitable (Cypher 2006). In the northern part of the kit fox's range, Briden *et al.* (1992) found that half of all dens surveyed were located on slopes of 20 degrees or less, while 92 percent of all dens located were on slopes of less than 30 percent. In addition, 98 percent of dens were found below 1,100 feet elevation. At the NPRC, kit fox were found to be more abundant, and to live the longest when they were located in relatively flat or rolling terrain, suggesting that such terrain likely has the most potential for sustaining viable populations of the species (Warrick and Cypher 1998).

Early delineations of areas that were expected to provide optimal kit fox habitat were based in part on the location of large, contiguous parcels of relatively undisturbed Federal lands. Although, BLM lands in the Panoche Hills and Tumey Hills have often been considered to provide optimal kit fox habitat based on the size of holdings in public ownership, portions of these public lands are too rugged to be suitable for kit fox (EG&G 1981).

Habitat suitability - At the time of listing, very little was known about the habitat needs of the San Joaquin kit fox. By the 1970s, biologists had determined that kit fox would not generally inhabit areas of intensive agriculture (Jensen 1972). Although kit fox were known to be displaced by intensive agriculture, observations of animals in some agricultural cover types (e.g., mature vineyards and orchards) suggested to some biologists that kit fox would move back into such areas as agriculture became stabilized in the newly converted areas (Waithman 1974). Since listing, research and monitoring efforts have done much to describe the habitat associations of the kit fox. Both the 1983 and the 1998 recovery plans provide general information about habitat associates for the kit fox (Service 1983; Service 1998). Since completion of the latest recovery plan (Service 1998), additional studies have further clarified habitat needs of the kit fox.

Habitat suitability of agricultural lands - Monitoring, surveys, and specific studies have clarified kit fox capacity to use agricultural lands. A study of seven radio-collared kit fox that were radio-tracked for up to 14 months has indicated that kit fox are unable to occupy farmland on a long-term basis. Agricultural lands do not provide suitable habitat for the kit fox for a variety of reasons. Lands producing row crops are subjected to weekly inundation during irrigation, which impedes kit fox foraging and precludes the establishment, maintenance, and use, of earthen dens (Warrick *et al.* 2007). Prey abundance is relatively low in row crops, prey diversity is reduced, prey species composition changes, and favored prey species such as kangaroo rats disappear (Williams and Germano 1992; Clark 2001; Cypher 2006; Warrick *et al.* 2007). Although kit fox may enter the margins of row crops and further into orchards at night from natural lands, Warrick *et al.* (2007) found no evidence that kit fox were able to use farmland, even when it was the predominant available habitat. Natural lands along the California Aqueduct right-of-way have been found to provide several times the small mammal abundance of surrounding agricultural lands, and account for over 48 percent of kit fox nocturnal habitat use and 98 percent of kit fox diurnal (denning) habitat use, even though the natural lands only comprise approximately 5 percent of the available habitat in the study area (Warrick *et al.* 2007). It appears that kit fox are permanently displaced from areas where the land is intensively irrigated (Jensen 1972; Morrell 1975; Warrick *et al.* 2007).

Several additional factors reduce suitability of agricultural lands for kit fox. Agricultural lands are used more frequently (in comparison to natural lands) by red fox and dogs, which compete with or kill kit fox (Cypher *et al.* 2001; Clark *et al.* 2005; Cypher *et al.* 2005a), potentially making such agricultural lands sink habitats for the kit fox. A sink habitat is one in which an animal group does not replace itself or grow through reproduction; persistence of the animal depends on migration into the site (Hanski 1999). Pesticide applications may be harmful to kit fox, while ground squirrel eradication efforts reduce prey availability and may indirectly harm kit fox (Service 1993; USEPA 1995; Hosea 2000).

Farmlands often border and are interspersed with remaining parcels of natural habitat, fragmenting remaining habitat. Kit fox movement between parcels of native land may be impeded by the structure of some annual croplands, such as cotton, which forms a dense thicket up to 3 feet tall (Warrick *et al.* 2007). Although there is some evidence that kit fox will use artificial dens placed within agricultural lands, work to date has not demonstrated that kit fox use the artificial dens to cross agricultural lands, even where such lands form a relatively narrow strip between areas of natural habitat (Cypher *et al.* 2005a). Because kit fox exhibit only limited

capacity to utilize agricultural lands, agricultural lands also appear to constitute effective barriers to kit fox movements (Cypher *et al.* 2005a).

Although orchards and vineyards have been reported to potentially provide adequate habitat for the kit fox due to their open structure and their underlying layer of herbaceous vegetation to support a prey base, food items do not appear to be abundant in orchards and consist primarily of murid (old world) rodents in at least some locations (Clark 2001; Warrick *et al.* 2007). Ground squirrels and pocket gophers, potential kit fox prey may be actively poisoned in orchards, such as almond orchards (Heintz 2000). These factors suggest that kit fox may not have an appropriate prey base for adequate sustenance. Documented use of this habitat by kit fox appears to vary (Clark *et al.* 2005; Warrick *et al.* 2007) and its suitability in supporting kit fox appears limited.

Habitat suitability in oilfield lands - Studies conducted on oilfield lands provide mixed results as to the effects of oil development on kit fox populations (Spiegel 1996; Warrick and Cypher 1998; Cypher *et al.* 2000). The most substantial effects appear to be indirect effects of long-term habitat change. For example, on the NPRC, where 80 percent of the habitat was undisturbed and much of the disturbance was in rugged terrain thought to be suboptimal for the kit fox, Cypher *et al.* (2000) found that oilfield activities and oilfield development had little relative effect on inter-annual changes in kit fox abundance. Between 1980 and 1986, survival rates for adults were higher in developed areas than in undeveloped areas while survival rates for juveniles generally decreased in developed areas and increased in undeveloped areas (Cypher *et al.* 2000). However, after 1987 the capture rates of kit fox tended to be negatively associated with oil-field development, a relationship attributed to both loss of habitat and to changes in habitat (Warrick and Cypher 1998; Cypher *et al.* 2000). Even a moderate level of development was associated with increased dense stands of saltbush, especially along pipelines, road edges, and sumps; a change in habitat characteristics favoring kit fox predators at the expense of kit fox (Warrick and Cypher 1998). In general, kit fox capture rates were negatively associated with topographic ruggedness (as indexed by the length of contour lines within each quarter section on a 7.5-minute map). However, kit fox were able to occupy steep portions of the NPRC when coyote abundance was unusually low at the beginning of the study. Subsequently, increased development in these areas was associated with declines in kit fox abundance (and concurrent increased coyote abundance) to the point of virtual kit fox absence in rugged terrain. Kit fox had not re-occupied the area by the end of the study in 1995 (Cypher *et al.* 2000).

Over time, therefore, even moderate development of oil fields appears to reduce the abundance and distribution of kit fox (Warrick and Cypher 1998; Cypher *et al.* 2000). The most significant effect of oil-field development appears to be lowered carrying capacity for populations of both kit fox and their prey species due to changes in habitat characteristics, and to loss and fragmentation of habitat (Warrick and Cypher 1998; Cypher *et al.* 2000).

Amount of habitat available at the time of listing – In the late 1960s, approximately 2 million acres, or 3,000 square miles, of appropriate habitat were thought to remain within the delineated range of the kit fox (Laughrin 1970). During this period, much of this remaining habitat was quickly being lost to development and irrigated agriculture, resulting in a 34 percent reduction in native habitat within the kit fox's range between 1959 and 1969, and a related loss of 490,000 acres of native vegetation between 1958 and 1970 (Laughrin 1970, Jensen 1972, Morrell 1975).

In the five years after listing (1968 – 1972), approximately 178 square miles of habitat were converted in western Kern County alone, while water allotments from the Central Valley Project were expected to lead to a total loss of 360 square miles of excellent kit fox habitat (Jensen 1972). As kit fox were found in additional areas, addition acreage of potential habitat was included in assessing potential kit fox population numbers. By 1975, Morrell (1975) used 5,442 square miles (3,482,893 acres) of valley floor and foothill habitat within the range of the kit fox in determining calculations of kit fox population numbers. However, this figure included large areas of irrigated agriculture, and is not thought to be an accurate representation of kit fox habitat shortly after listing (Morrell 1975; Service 1983).

Amount of habitat currently available – Preliminary results from habitat modeling indicate that currently there are 897,510 acres of highly suitable habitat remaining for the kit fox within its range, with another 2,551,600 acres of medium suitability habitat present, primarily around the edges of the San Joaquin Valley (B. Cypher, ESRP, *in litt.* 2009). Highly suitable habitat, consisting of arid scrub and grassland habitats with relatively sparse vegetative cover and slopes under 5 percent, was found to be highly fragmented with many patches either too small or too isolated to support viable kit fox populations, while medium suitable habitat, consisting of somewhat more dense cover and/or slopes between 5 and 15 percent, was found primarily to support only intermittent kit fox populations (Cypher *in litt.* 2009). This habitat modeling (Cypher *in litt.* 2009) indicates that very little highly suitable habitat remains on the San Joaquin Valley floor. Additional studies have estimated the acreage of extant habitat available in specific areas. For example, in 2001 Gerrard *et al.* (2001) used field data and modeling to estimate that approximately 112,000 acres of potentially suitable habitat (including dryland farms and non-native grasslands) remained in Alameda and Contra Costa Counties. Likewise, Cypher *et al.* (2007) estimated that in western Fresno, Kings, and Merced Counties, under 6,000 acres of suitable and 21,000 acres of suboptimal habitat remained within the 600,000-acre San Luis Unit, a water service unit of the Central Valley Project (Cypher et al. 2007).

Summary - These studies highlight the importance of large, relatively level tracts of natural habitat having good drainage, appropriate plant communities, and the appropriate prey base in sustaining the kit fox populations (Jensen 1972; Cypher *et al.* 2001; Koopman *et al.* 2001). Kit fox presence is generally negatively associated with ruggedness (Cypher *et al.* 2001), so large natural areas with relatively steep slopes likely have limited or no value for kit fox. Although kit fox may forage at the borders of agricultural lands, in general agricultural practices appear to preclude the long-term occupancy of agricultural lands by kit fox (Cypher *et al.* 2005a; Warrick *et al.* 2007). In the eight years following listing of the kit fox as endangered, information gathered by State and Federal agencies led to recognition that low numbers of kit fox occurred as far north as Contra Costa and Alameda Counties, and within interior Coast Range valleys such as the Salinas Valley (Laughrin 1970; Jensen 1972; Morrell 1972; Swick 1973; Waithman 1974; Morrell 1975). Since that time, continuing land conversion for agriculture and development has reduced the amount of habitat available to the kit fox in the San Joaquin Valley (Kelly *et al.* 2005). The Service is not aware of any information that quantifies the current range-wide acreage of extant suitable and sub-optimal kit fox habitat, although a range-wide suitability model is in development (S. Phillips *in litt.* 2009).

San Joaquin Kit Fox (*Vulpes macrotis mutica*)

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Legal Status

State: Threatened
Federal: Endangered
Critical Habitat:
Recovery Planning: *Recovery Plan for Upland Species of the San Joaquin Valley, California* (U.S. Fish and Wildlife Service 1998)
Notes: Status not anticipated to change during permit term.

Taxonomy

The San Joaquin kit fox is a subspecies of the kit fox (*Vulpes macrotis*), the smallest member of the dog family in North America. Though there has been some debate as to the taxonomic relationship among North American arid land foxes, the San Joaquin kit fox remains a distinct subspecies due to its limited range in California. The details of this debate are outlined in Dragoo et al. (1990) and Schwartz et al. (2005). Descriptions of the species' physical characteristics can be found in McGrew (1979) and U.S. Fish and Wildlife Service (1998).

Distribution

General

Currently, kit foxes occur in some areas of suitable habitat on the floor of the San Joaquin Valley and in the surrounding foothills of the Coast Ranges, Sierra Nevada, and Tehachapi Mountains from Kern County north to Contra Costa, Alameda, and San Joaquin Counties (U.S. Fish and Wildlife Service 1998) (Figure 1). There are known occurrences in Alameda, Contra Costa, Fresno, Kern, Kings, Madera, Merced, Monterey, San Benito, San Joaquin, San Luis Obispo, Santa Barbara, Santa Clara, Stanislaus, and Tulare Counties (California Natural Diversity Database 2006). The largest extant populations of kit fox are in Kern County (Elk Hills and Buena Vista Valley) and San Luis Obispo County in the Carrizo Plain Natural Area (U.S. Fish and Wildlife Service 1998).

Occurrences within the Study Area

Historical

Although the precise historical range of San Joaquin kit fox is unknown, it is believed to have extended from Contra Costa and San Joaquin Counties in the north to Kern County in the south. By the 1930s, the range had been reduced to the southern and western portions of the Central Valley (Grinnell et al. 1937). Surveys conducted between 1969 and 1975 extended the known range of the kit fox back into portions of its historical range in the northern San Joaquin Valley, including Contra Costa, Alameda, and San Joaquin Counties (Orloff et al. 1986). At this time, kit foxes were also found in three counties outside the originally defined historical range: Monterey, Santa Clara, and Santa Barbara counties (Orloff et al. 1986).

Recent

There are four occurrences on record from 1972–2002 for the San Joaquin kit fox in Santa Clara County (California Natural Diversity Database 2006, U.S. Fish and Wildlife Service 2006). Of those records, two are based on observation of individuals and two are derived from San Joaquin kit fox range maps from 1972–1975. The two occurrences from the 1970's are not included here due to a lack of precision and because they are based on kit fox range maps and not actual observations. In 1992 a den site was found with two surviving pups (though the adult female had apparently been killed). The best description of the location of this den site is very general, stating that it is from Hollister north to Gilroy. It is included here simply as a placeholder and to acknowledge that habitat potential may exist in this area. The second observation (2002) was of a lone individual during the fall dispersal period in Henry Coe State Park (California Natural Diversity Database 2006). A third observation, which is not in the CNDDB, was of a road kill kit fox over six miles south of the Highway 152/156 junction (U.S. Fish and Wildlife Service 2006). This occurrence falls just outside of the study area.

Genetic studies have shown that individuals from the San Luis Reservoir population, southeast of the study area, interbreed with individuals from Alameda and Contra Costa Counties (Schwartz et al. 2000 in U.S. Fish and Wildlife Service 2006). It is assumed (U.S. Fish and Wildlife Service 2006) that the Pacheco-Santa Ana watershed in the southeastern part of Santa Clara County provides movement habitat between these two areas. In the recovery plan for this species the U.S. Fish and Wildlife Service restricts the range in Santa Clara County to the Pajaro River watershed (U.S. Fish and Wildlife Service 1998).