San Joaquin Kit Fox
(*Vulpes macrotis mutica*)

5-Year Review:
Summary and Evaluation

Photo: Joseph Terry, USFWS

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.

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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.

<u>Spatial Distribution</u>

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.

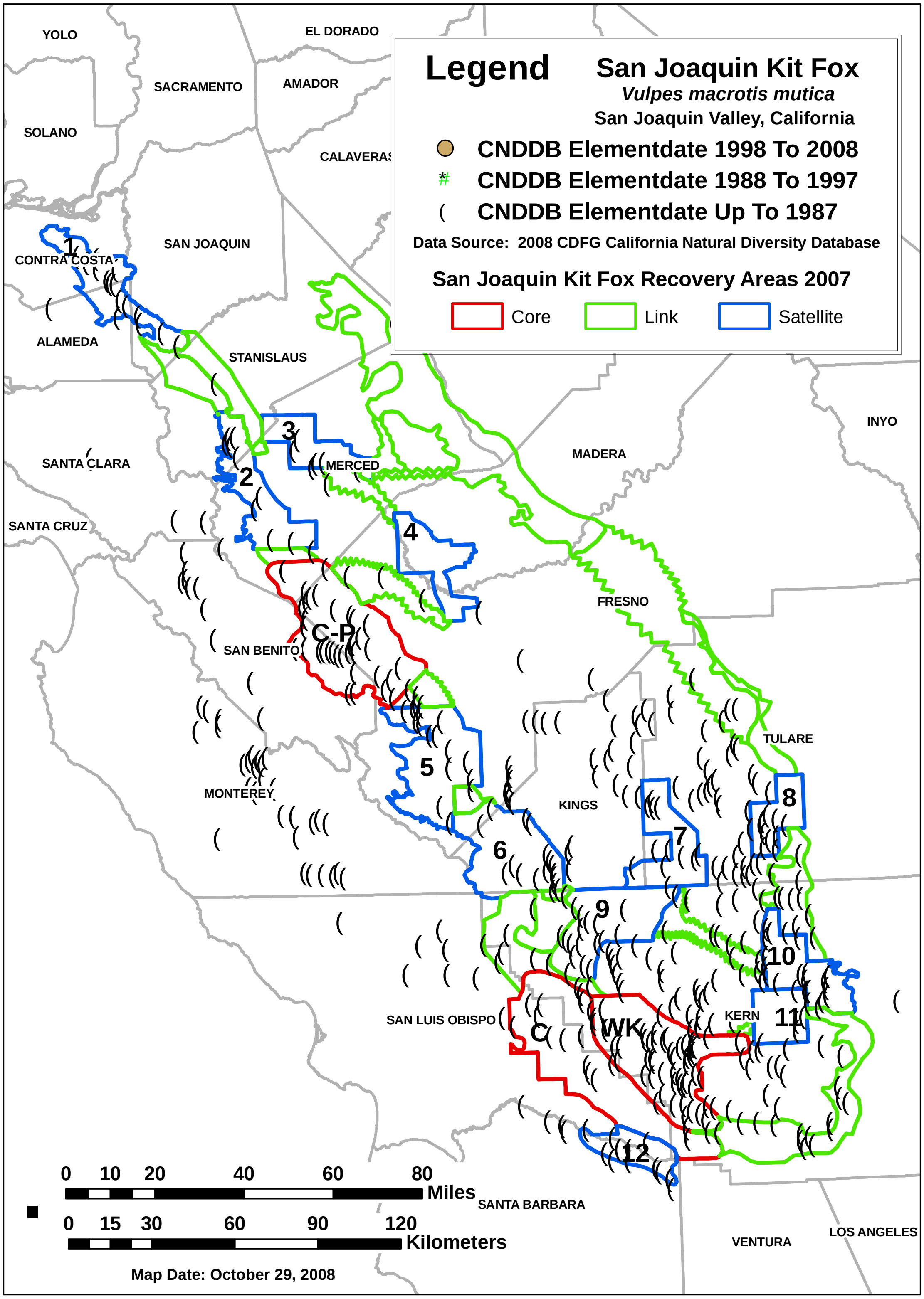
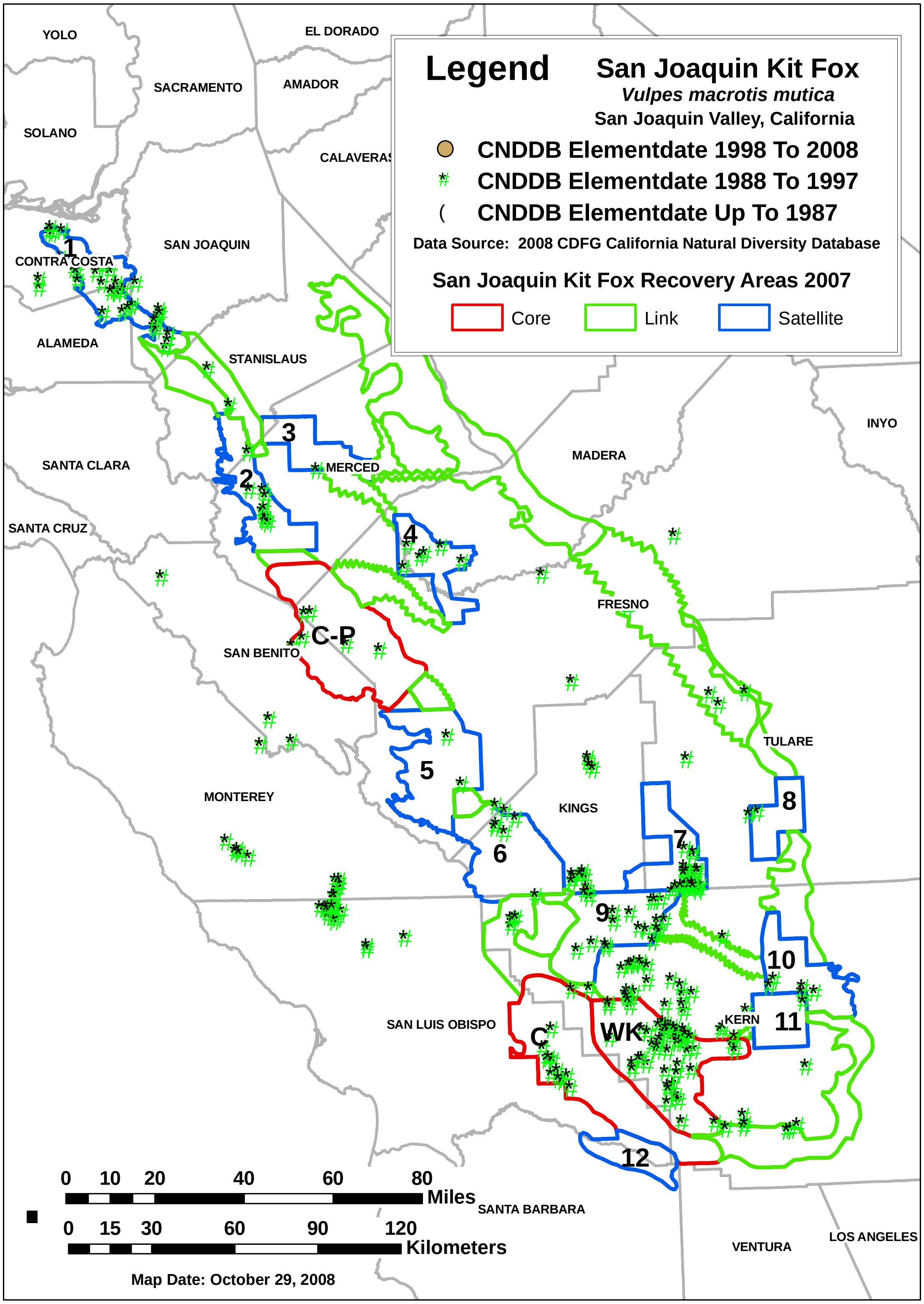


Figure 1A-C: Maps of recorded occurrences of San Joaquin kit fox, for three time periods: 1950-1987 (A), 1988-1997 (B) and 1998-2008 (C). Shown in relation to currently described Recovery Core Areas, Satellite Areas and Linkages. Core Areas: WK (Western Kern County), C (Carrizo Plains), C-P (Ciervo-Panoche);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



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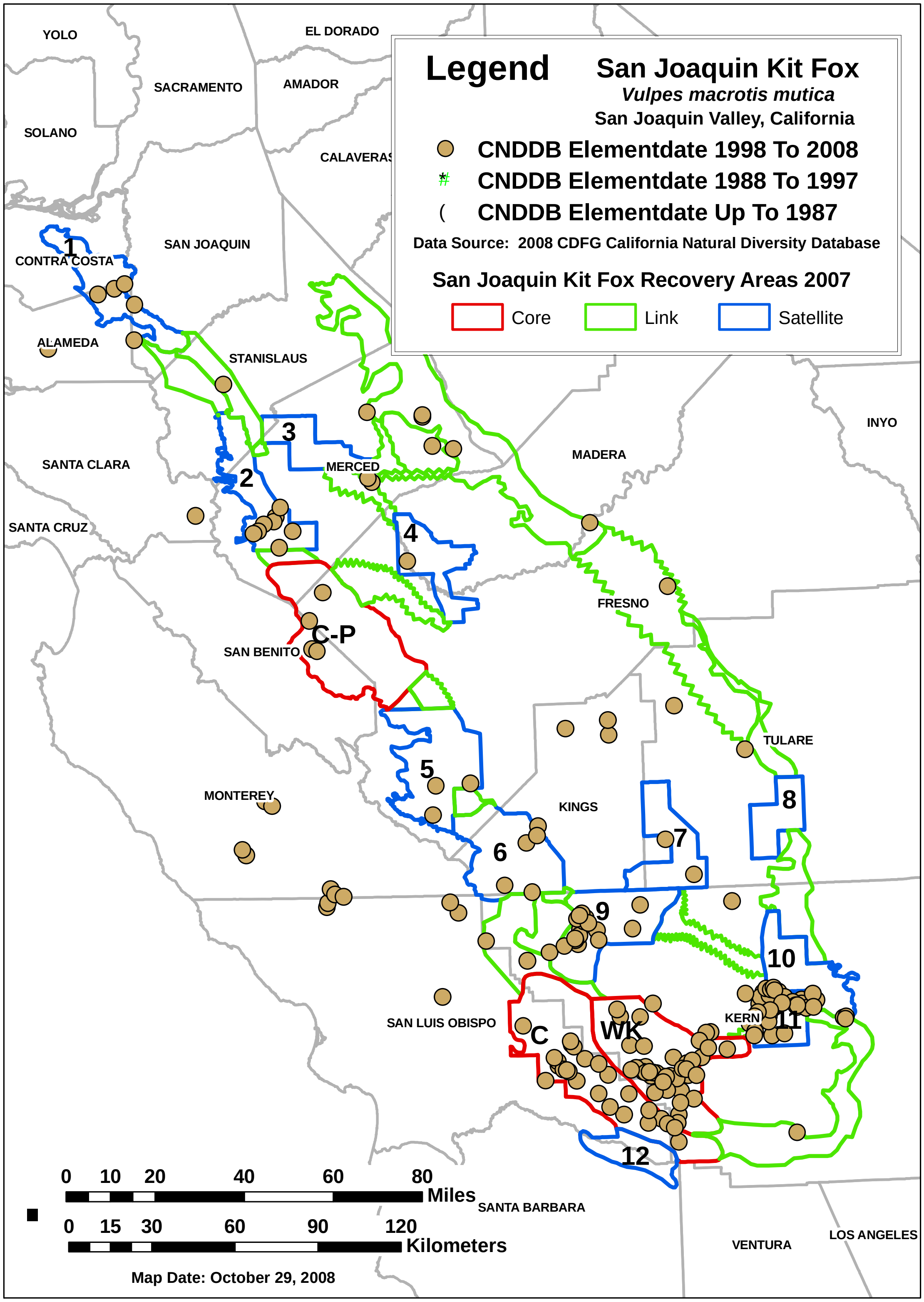

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Within the kit fox range, occupied habitat included some of the larger scattered islands of natural land on the Valley floor in Kern, Tulare, Kings, Fresno, Madera, and Merced Counties. Kit fox occurrences were known from the valleys of the interior 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 a*l. 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.

<u>Habitat or Ecosystem</u>

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).

Genetics

There have been few studies assessing the genetic variability among local San Joaquin kit fox groups and subpopulations. Prior to 1995, research focused on the relationship of the San Joaquin kit fox to other subspecies of kit fox until Mercure *et al*. (1993) utilized genetic analysis to determine that the San Joaquin kit fox was a separate subspecies of kit fox.

Historically, there was high gene flow among San Joaquin kit fox populations (Schwartz *et al*. 2005). Although Schwartz *et al*. (2005) drew preliminary conclusions regarding the levels of current genetic variation across remaining San Joaquin kit fox occurrences, additional studies are needed to determine levels of gene flow among subpopulations. Demographic research has suggested that some kit fox populations may be at considerable risk of loss of fitness due to inbreeding depression (lowering of viability due to breeding between relatives), even though they may be at greater risk of local extirpation due to either demographic or environmental stochasticity (Otten and Cypher 1998).

Species-specific Research and/or Grant-supported Activities

Early research on the San Joaquin kit fox was completed by personnel from the U. S. Fish and Wildlife Service Bureau of Sport Fisheries and Wildlife (Jensen 1972) or the CDFG and under the Federal Aid in Wildlife Restoration program (Laughrin 1970; Morrell 1972; Swick 1973). Since the species was originally listed by the State and Federal governments, information on the San Joaquin kit fox has increased greatly due to research and monitoring efforts. Monitoring required under the Act has resulted in long-term data sets that have been used to gather knowledge about kit fox demography and natural history (for examples, see Warrick and Cypher 1998; Cypher *et al*. 2000; etc.). Researchers within the Endangered Species Recovery Program (ESRP), administered by California State University, Stanislaus, have completed much of the recent research on the San Joaquin kit fox. The ESRP was established in 1992 by the Service and the Bureau of Reclamation (USBR) to assist the two Federal agencies in implementing specific terms of the Friant Biological Opinion (Service 1991; ESRP 2008), which was completed to assure that renewal of long-term water contracts in the Central Valley Project's Friant Division would not jeopardize the continued existence of federally-listed species in the San Joaquin Valley (Service 1991; ESRP 2008). Many studies have been funded jointly through Federal and State agencies (e.g., the USBR, the Service; the California Energy Commission, and the California Departments of Fish and Game, Transportation, and Water Resources), and through non-profit organizations, such as the Nature Conservancy, the National Fish and Wildlife Foundation, and Environmental Defense (for examples, see Ralls and White 1995; Ralls *et al*. 2001; Clark *et al*. 2005; Cypher *et al*. 2005a, b; Nelson *et al*. 2007; and Ralls *et al*. 2007). Other research and monitoring efforts that have improved our knowledge of the kit fox have been funded by the Department of Energy and by Chevron USA, Inc. (Chevron) through section 7 consultations on energy production facilities such as the NPRC (for examples, see Otten and Cypher 1998; Warrick and Cypher 1998; Cypher and Frost 1999; Dennis and Otten 2000; Koopman *et al*. 2000).

These studies, in total, demonstrate that kit fox 1) have large home ranges with required size dependant on local habitat and prey conditions, 2) have highly variable annual survival rates, with adult survival rates of 20 to 86 percent and juvenile survival rates of 14 to 76 percent, depending on the study population and environmental conditions, 3) depend primarily on native prey species as forage, 4) experience population fluctuations in response to prey levels in non-urban locations, 5) sustain high mortality rates due to coyote predation/competition, 6) are generally excluded from rugged terrain by coyotes, and 7) are highly reliant on successful dispersal from population strongholds into suitable habitat in order to sustain subpopulations throughout the range. These studies inform our understanding of the species biology, the important attributes of kit fox habitat, and the expected effects of loss of habitat and other threats to the San Joaquin kit fox.

Five-Factor Analysis

The following five-factor analysis describes and evaluates the threats attributable to one or more of the five listing factors outlined in section 4(a)(1) of the Act. The final ruling to list the San Joaquin kit fox as endangered did not include a discussion of the threats to the kit fox. The Service is using papers from the CDFG (Laughrin 1970 and Morrell 1972 and 1975), and the 1983 *San Joaquin kit fox recovery plan* to address threats that affected the kit fox at the time of its listing.

FACTOR A: Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

This section summarizes the threats included under Factor A, and also covers the conservation efforts implemented to reduce threats over the known range of the San Joaquin kit fox. At the time that the San Joaquin kit fox was listed, the conversion of native habitat to agriculture and industrial development was considered to be the primary threat to San Joaquin kit fox populations (Laughrin 1970, Morrell 1975).

The loss and modification of habitat due to agricultural conversion, infrastructure construction, and urban development remains the largest threat to the kit fox. Since listing, the Service has identified additional potential threats to kit fox habitat, including habitat alterations due to oil extraction and mining activities, changes in wildfire prevalence, and changes to vegetation structure due to non-native species and altered grazing regimes. The proposed siting of solar facilities in kit fox core, satellite, and linkage areas is an emerging threat that has the potential to substantially affect kit fox population viability, as discussed below under solar development.

Conversion of natural lands to agriculture has continued since the kit fox was listed. By 1979, most of the San Joaquin Valley floor had been developed, with approximately 370,000 acres out of a total of approximately 8.5 million acres remaining undeveloped (Williams 1980, as cited in Williams 1985). Land conversions contribute to declines in kit fox abundance through direct and indirect means: mortalities, displacement, reduction of prey populations and denning sites, changes in the distribution and abundance of larger canids that compete with kit fox for resources, and reductions in carrying capacity (Jensen 1972; Morrell 1975). Dens are essential for the survival and reproduction of kit fox, as the kit fox use dens year-round for shelter and escape, and in the spring for rearing young (Cypher *et al*. 2000). Kit fox may be buried in their dens during land conversion activities (Branco 2007), or permanently displaced from areas where structures are erected or the land is intensively irrigated. In addition to the direct loss of habitat for denning and foraging by kit fox, land conversion and associated human-intensive uses can bring additional stressors, including human disturbance, fire suppression, and pest control (Bunn *et al*. 2007). Furthermore, even moderate fragmentation or loss of habitat may be an important factor impacting the abundance and distribution of kit fox (Bjurlin *et al*. 2005; Warrick *et al*. 2007).

The increasing human population of California, with the concomitant high demand for limited supplies of land, water, and other resources, has been identified as the primary underlying cause of habitat loss and degradation (Bunn *et al*. 2007). Between 1970 and 2000, the human population of the San Joaquin Valley doubled in size; it is expected to more than double again by 2040 (Field *et al.* 1999; Teitz *et al*. 2005). In roughly the same period (between 1987 and 2007), the Biological Opinions and Habitat Conservation plans completed by the Service's Sacramento Fish and Wildlife Office covered projects with permanent impacts to approximately 114,000 acres of natural habitat considered to be suitable for the San Joaquin kit fox. These projects also resulted in temporary impacts to close to an additional 20,100 acres of kit fox habitat (Service files). By 2000, approximately 3.2 million acres of land were managed as irrigated farmland within the eight counties in the San Joaquin Valley (Teitz *et al*. 2005). The most extensive loss of kit fox habitat remains due to agricultural conversion.

Table 2 summarizes the acreage of kit fox habitat in the San Joaquin Valley that the Sacramento FWO addressed through HCPs and biological opinions between 1988 and 2007. Note that Table 2 includes only those projects that were reviewed under the Act, and does not account for loss of habitat, and adverse effects from habitat conversion, that was not reported to the Service. The Service works with Federal, State, and local agencies, and with private project proponents, to minimize effects to the San Joaquin kit fox, and to compensate for the loss of habitat through preservation of kit fox habitat and through creation (or restoration) of an equal or greater acreage of kit fox habitat elsewhere. The results of compensation efforts are covered below under the Habitat Conservation heading.

Loss and modification of habitat associated with urban development - Within the San Joaquin Valley, the continued increase in the human population has resulted in increased urban development. On the floor of the valley, urbanization occurs most often on previously cultivated lands, where natural habitat has been lost or degraded (Bunn *et al*. 2007). However, urbanization is also occurring along all edges of the San Joaquin Valley in areas of extant natural habitat that is important to the kit fox. Within these areas, cities that are undergoing substantial growth include, but are not limited to, Livermore, Antioch, Tracy, and Los Banos, in the northwestern portion of the kit fox's range; and Paso Robles, Tulare, and Bakersfield in the southern portion of the range. For example, the population of the City of Los Banos in western Merced County grew by 34 percent between 2000 and 2006 (U.S. Census Bureau 2008). Between 2004 and 2006, growth in this area resulted in increased housing densities and in the conversion of over 200 acres of irrigated farmland and grazed lands to urban development (California Department of Conservation 2008). Growth in the area surrounding Los Banos and the nearby town of Santa Nella presents another threat to kit fox habitat in the narrow corridor of upland habitat at the western edge of the Central Valley (H.T. Harvey and Associates 2004). The City of Tracy is located further north along the western edge of the kit fox's range and has grown by 41 percent between 2000 and 2006, resulting in the loss and fragmentation of remaining kit fox habitat in the area. For example, a development proposed for the Tracy Hills would occupy all natural habitat having less than a 15 percent slope for a 2-mile portion of the remaining open habitat available as a movement corridor for kit fox. The proposed development would only preserve steeper areas for the kit fox, thereby reducing the width and viability of any available kit fox corridor. Because a movement corridor is an integral part of the Service's strategy to protect kit fox for this area, construction of the proposed development is expected to place the strategy at risk (N. Pau, Service, *in litt*. 2002). Although the project has not been built as of 2009, Service files indicate that it is once again moving forward. Additional development proposed near the Delta-Mendota Canal in this area (Pau *in litt*. 2002) would serve to isolate remaining kit fox habitat from extant dispersal habitat along the canal. For further information on core areas, satellites, and movement corridors, see Figure 1 and section III, Recovery Criteria. Further to the north the proposed development of up to 4,870 houses in Antioch, along with a new urban limit line, is expected to reduce the feasibility of acquiring lands to establish a habitat linkage for the kit fox in eastern Contra Costa County (Jones and Stokes 2006). Although these plans may have been scaled back since the onset of the recent housing slump, the proposed development is indicative of the threats to the kit fox within the northern portion of the range.

Table 2. Acreage of kit fox habitat affected by San Joaquin Valley projects reviewed under the Act (Section 10 and Section 7) by the Sacramento FWO from 1988 to 2007.[1]

Activity	Habitat Conservation Plans (Sec. 10)		Biological Opinions (Sec. 7)		Total Sec. 7 and Sec 10	
	Permanent Effects (acres)	Temporary Effects (acres)	Permanent Effects (acres)	Temporary Effects (acres)	Permanent Effects (acres)	Temporary Effects (acres)
Water storage/drainage	12,081	291	10,513	335	22,594	626
Urban, residential, and commercial development	64,643*	0	5,421	405	70,064	405
Oil/gas exploration and pipelines	2,080	53	8,970	2,231	11,050	2,284
Agricultural development	0	0	8,687	0	8,687	0
Road construction and repair	0	0	3,389	1,172	3,389	1,172
Power generation and transmission	0	0	526	1,171	526	1,171
Waste facilities	270	76	593	16	863	92
Canal O&M**	0	0	0	625	0	625
Wetlands restoration	0	0	15	13,257	15	13,257
Prison facilities	287	348	763	74	1,050	423
Fiber-optic cables	0	0	164	32	164	32
Rock mining	54	0	286	0	340	0
TOTAL	**79,415**	**768**	**39,327**	**19,318**	**118,742**	**20,087**

[1] Table includes authorized activities only and is not reflective of habitat losses in general.

* San Joaquin County Multispecies HCP authorizes the permanent impacts to 3,970 acres of valley grassland and 47,915 acres of agricultural kit fox habitat.

** O&M = operation and maintenance

In 1967, about 70,000 people lived within the City of Bakersfield, with a population of 176,400 for both the incorporated and unincorporated areas. By May of 2009, the City and metropolitan populations have grown to 333,700 and 496,300, respectively (City of Bakersfield 2009). Over the same period, the area within the city limits has grown from 20.5 to 140.5 square miles (City of Bakersfield 2009). The urban and suburban Bakersfield area has now expanded to comprise approximately 70 percent of the Metropolitan Bakersfield satellite area (S11) for the kit fox. This kit fox subpopulation has persisted in the urban environment on open lands bordering the Kern River drainage, fallow fields, vacant lots, infrastructure right-of-ways, golf courses, the CSU Bakersfield campus, and other open lands, primarily at the southwest edge of the city (Cypher and Warrick 1993; Cypher and Frost 1999; CNDDB 2008). However, between 2002 and 2004, more than 1,000 acres of non-irrigated farmland, including grazing land, and more than 2,000 acres of irrigated farmland were converted to new development on the outskirts of Bakersfield (California Department of Conservation 2004). In addition, development increased in density as infill areas were developed (California Department of Conservation 2004). Additional proposed infill projects and large residential expansion projects on the western city periphery (Wenner 2007; Shearer 2008) are expected to negatively affect this subpopulation. Some of this residential development has the potential to degrade kit fox habitat targeted for preservation by the Metro-Bakersfield HCP (City of Bakersfield and County of Kern 1994, Service 1994). While most of the proposed development is occurring within the satellite area, some is proposed within an important kit fox linkage area between the Metropolitan Bakersfield sub-populations and the Western Kern County Core Area (Cross *in litt.* 2006a; Loudermilk *in litt.* 2006a). Service biologists expect that kit fox on nearby conservation lands (Kern Water Bank and Coles Levee Ecosystem Preserve) would be adversely affected by the increased traffic and development in the area (P. Cross *in litt.* 2006b; W.E. Loudermilk, CDFG, *in litt.* 2006b).

In addition, in the Northeast Bakersfield Foothills satellite area (S10), several large scale residential developments have been in the planning stages for several years (Shearer 2008). A portion of these projects will occur on agricultural lands, but urban development and associated infrastructure development will also reduce prime kit fox habitat in these areas (Wenner 2007) and create hard barriers to movement of kit fox within and between satellite areas S10 and S11, and the Western Kern core area. The current drop in housing demand has put some housing developments on hold, at least temporarily, and has delayed others (Wenner 2007), but demonstrates the future potential for development in these satellite areas.

In the Carrizo Plains core area, north of the Carrizo Plains Natural Area, residential development has been reported in portions of California Valley (Bidlack 2007). Development pressure in this area is likely to increase to some extent with the expected construction of large solar arrays on more than 13 square miles of ranchland in the valley (DeBare 2008; Sneed 2008).

In the Salinas River Valley of San Luis Obispo County, residential development threatens open space and undeveloped grasslands (California Department of Conservation 2004; City of Paso Robles 2008, 2009) within the habitat corridor for the kit fox that connects the Camp Roberts and Fort Hunter Liggett areas with the Carrizo Plains core area. Between 1970 and 2008, the population of the City of Paso Robles quadrupled from 7,200 to 29,950 (City of Paso Robles 2009). Between 1992 and 2002 alone, over 10,000 acres of agricultural lands were converted to urban use in the County (California Department of Conservation 2002, as cited in Moonjian 2007). Such development may threaten both kit fox persistence and movement through the valley corridor. San Luis Obispo County has recently received funding to begin habitat conservation planning that may be able to protect sensitive habitat for the kit fox. Kit fox also occur on the ranchlands of the Panoche Valley floor, in San Benito County (CNDDB 2008), which comprises a portion of the Ciervo-Panoche core area. This area has remained relatively undisturbed, although in this area several ranches are for sale, including approximately 5,000 acres advertised as being suitable for multiple home sites (Schuil and Associates Diversified Real Estate 2008).

On the eastern side of the kit fox's range, uplands in eastern Merced County appear to be part of a large corridor of habitat along the eastern margin of the San Joaquin Valley that may be important to the recovery of the kit fox. Service files document that development pressure is increasing in this area in association with the new University of California, Merced campus.

In summary, loss and modification of habitat to development continues to be a threat to the kit fox throughout its range. Development along the San Joaquin Valley periphery and in adjacent valleys, such as the Salinas Valley, continues to restrict both core habitat and movement corridors for the kit fox.

Habitat Loss and Modification due to Agricultural Conversion - In the San Joaquin, Salinas, and associated valleys, and in the border foothill areas, conversion of natural habitat to intensive agriculture continues to be the primary cause of habitat loss for the San Joaquin kit fox (Cypher *et al*. 2007). As discussed above in the section on species information and status, agricultural lands do not provide suitable habitat for the kit fox for a variety of reasons, although agricultural lands may provide suboptimal foraging habitat when located near suitable habitat. Agricultural practices, such as soil cultivation, frequent irrigation, harvest, and use of chemical treatments for crops and pest control create frequent disturbance to the landscape and also limit denning opportunities and prey abundance (Cypher *et al*. 2005a), making these lands unsuitable for long-term kit fox persistence. In addition, altered prey species composition, including loss of kangaroo rats, and reduced prey diversity and abundance limit utility of agricultural lands to kit fox for foraging (Williams and Germano 1992; Clark 2001; Cypher 2006; Warrick *et al*. 2007). In comparison to natural lands, agricultural lands are used more frequently by red fox and dogs, which compete with or kill kit fox (Cypher *et al*. 2001; Clark *et al*. 2005; Cypher *et al*. 2005a). Finally, 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).

The Service does not have data on the rangewide acreage of kit fox habitat that has been converted to agriculture. Past agricultural conversion has removed most areas of the valley floor as kit fox habitat. By 1968, the Central Valley Project had expanded water deliveries to approximately 1,000,000 acres of farmland, and by 1979 less than 2 percent of the valley remained uncultivated (USDI 2005). Although conversion of natural lands to agriculture slowed on the valley floor by the mid 1980s (Service 1998), agricultural conversion continues in a number of core, satellite, and linkage areas, including areas in Kern, San Luis Obispo, Kings, Merced, and San Joaquin Counties (California Department of Conservation 2006). For example, in San Luis Obispo County, irrigated farmland and vineyard development is occurring on the floor of the Salinas River Valley and its tributaries, and in the surrounding lower foothills (California Department of Conservation 2006; WineryX Real Estate 2006; Shimmin Canyon Vineyard 2008) in kit fox habitat. In the County, the acreage in grape production increased by over 110,000 acres between 1992 and 2002 (California Department of Conservation 2002, as cited in Moonjian 2007).

In Kern County, the acreage of irrigated agricultural lands decreased by 98,000 acres between 1988 and 2004, although conversion to urban lands could have accounted for approximately 37,600 acres of that loss. Conversion of agricultural lands to grazing and other local land uses increased by 60,000 acres during that same period (California Department of Conservation 2004), but was most likely due to fallowing of croplands (California Department of Conservation 2004). Consistent with periodic fallowing, acreage for crop production appears to vary between years: between 2006 and 2007 Kern County reported a 32,079-acre increase in crop production and a decrease of 23,000 rangeland acres (Kern County 2008).

The conversion of natural lands to agriculture continues to be a threat on private lands on the western side of the San Joaquin valley floor in areas where agriculture has been extended west to the base of the foothills since the 1960s (Kelly *et al*. 2005). Large blocks of suitable habitat that support kit fox do remain in the Panoche and Pleasant Valleys in the foothills slightly to the west of the San Joaquin Valley (Cypher *et al*. 2007). However, including both these areas and the western uplands of Fresno County, there were only 5,559 acres of suitable habitat, and 20,543 acres of sub-optimal habitat remaining by 2007 (Cypher *et al*. 2007). On the western edge of the San Joaquin Valley in this area, continuing agricultural development also threatens kit fox movement, as natural habitat has narrowed to less than a mile in width, particularly where creeks intersect I-5 (Cypher 2006). On lands lying to the east of Interstate 5, there are only very scattered habitat fragments that are too small to support any kit fox families (Cypher *et al*. 2007). In recent years, the cessation of irrigation on drainage-impaired lands is facilitating conversion of other lands to permanent crops (e.g., orchards and vineyards) on the west side of the valley. In the Westlands Water District, more reliable water allocations, water freed up through land retirement, and drip irrigation systems have apparently allowed the increase in permanent crops. Between 1993 and 2004 the number of acres planted in orchards and vines in the District more than doubled to greater than 64,000 acres (Westlands Water District 2004), but the portion of this acreage converted from natural lands is not known. Conversion to permanent crops may make it somewhat easier for kit fox to move through the converted acreage, but it will also increase incentives to keep lands in agriculture (Cypher 2006).

Conversions to agriculture include known destruction of potential kit fox saltbush habitat (Krise *in litt.* 2006). During the period since construction of the Central Valley Project (CVP), the addition of agricultural customers that were not covered under State permits for CVP water has resulted in the unauthorized agricultural conversion of 45,390 acres of land, including 23,165 acres of alkali scrub habitat in western Fresno County (California State Water Resources Control Board 2000). Subsequent findings by the California State Water Resources Control Board have resulted in a requirement that the USBR provide encroachment mitigation under the State water rights permit for a portion, but not all, of the converted scrub habitat (USBR 2004). To date the USBR has protected 2,256 acres of alkali scrub habitat, with 1,231 acres of that protected within Fresno and San Benito Counties. An additional 8,140 acres of alkali scrub is being restored through the Land Retirement Demonstration Project (LRDP) at Atwell Island and Tranquility, in Tulare, Kings, and Fresno Counties (Doug Kleinsmith, USBR, *in litt*. 2009). Unauthorized conversions to agriculture have also been documented on a smaller scale. For example, in 2006, approximately 1,300 acres of saltbush scrub and sink scrub habitat along Interstate 5 north of the Kings-Kern county line were disked for agriculture (J. Vance, CDFG, *in litt.* 2006).

In Merced County, over 5,000 acres of grazing lands were converted to orchards and irrigated pasture between 2004 and 2006 (California Department of Conservation 2006). In eastern Merced County, until recently croplands (row crops, orchards, and vineyards) had been concentrated on floodplains and lower alluvial terraces of the valley. However, since the early 1990s there has been a rapid eastward expansion of orchards and vineyards into terrace lands previously used only for grazing, which has largely eliminated this native habitat between the Merced River and the Stanislaus County line (Vollmar 2002). This conversion to agriculture threatens potential kit fox linkages in remaining grassland habitat along the eastern side of the valley and may threaten the small numbers of kit fox thought to occur within eastern Merced County (CNDDB 2008).

In summary, past agricultural conversion has removed most areas of the valley floor as kit fox habitat. However, conversion of natural habitat to intensive agriculture continues to be the primary cause of habitat loss for the San Joaquin kit fox in the San Joaquin, Salinas, and associated valleys, and in adjacent foothill areas (Cypher *et al*. 2007). Agricultural lands do not appear to be suitable habitat for long-term kit fox persistence due to practices including soil cultivation, frequent irrigation, and use of agricultural chemicals and pesticides, and due to altered prey and predator communities. Loss and modification of habitat due to agricultural use continues to be a primary threat to kit fox.

Habitat loss and modification due to oil extraction and mining activities - At the time that the San Joaquin kit fox was federally listed, extraction of petroleum products (including crude oil, propane, natural gas, etc.) was not considered to be a threat to the kit fox, as most of the petroleum-producing land was still relatively undisturbed (Jensen 1972). The Service has not found information to indicate that gravel and sand mining activities were considered to be a threat to the kit fox at the time of listing.

Currently, oil extraction and gravel mining may pose both direct and indirect risks to the San Joaquin kit fox. Direct risks to kit fox from oil-field development include human disturbance, loss of habitat and den sites (Zoellick *et al*. 1987; Spiegel and Small 1996; Warrick and Cypher 1998; Cypher *et al*. 2000; P. Kelly pers. comm. 2000; BLM 2008a), entombment, entrapment in sumps or oil spills, and exposure to contaminants (Spiegel and Disney 1996; Warrick and Cypher 1999; Cypher *et al*. 2000). San Joaquin kit fox appear to tolerate human activities; they have frequently been observed around facilities and are known to use manmade structures (pipe, culverts, foundations) as dens, although with some mortality (Cypher *et al*. 2000; BLM 2008a), suggesting that the direct effects of low density oil-field development on kit fox dynamics may be minimal (Warrick and Cypher 1998).

Indirect effects of oilfield development on kit fox include changes to remaining habitat, and changes in predator and prey community composition and abundance. Oil spills may create short term disruptions of primary travel routes and foraging areas for kit fox (BLM 2008a).

Between 1976 and 1995 oil spills that occurred on 64 sites resulted in effects to an unquantified number of acres that were contaminated by chromium, arsenic, and other materials, although all sites were remediated by 1995 (Service 1995). Short-term effects of oil spills have included a 67 percent decrease in abundance of Heerman's kangaroo rats (*Dipodomys heermanni*) between spill areas and control areas (Warrick *et al.* 1997). Similarly, oil field disturbances in western Kern County have been found to result in shifts in the small mammal community from the primarily granivorous (seed-eating) species (kangaroo rats) that are a staple prey of kit fox, to species adapted to disturbed areas (murid, or old world rodents) (Spiegel *et al*. 1996). The effect of an altered prey community on the energetics of the kit fox is not currently known, but early studies suggest that such altered prey composition may result in lower kit fox density (Jensen 1972). As discussed above under habitat suitability, even a moderate level of development has been associated with changes in habitat characteristics favoring kit fox predators at the expense of kit fox (Warrick and Cypher 1998). 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).

The southwestern extent of the San Joaquin Valley harbors a high proportion of the remaining San Joaquin kit fox occurrences (Cypher *et al*. 2000; CNDDB 2008), and lands in this region that are important to the kit fox also support numerous areas of potential oilfield development. Development of these areas has continued since listing of the kit fox. By 2007, the Western Kern County Core Area included a number of high-density oil fields on private lands (e.g., Midway-Sunset, Elk Hills Oilfield [formerly the NPR-1], Cymric, and South Belridge). The Midway-Sunset Oilfield contains the highest-producing BLM lease in the United States (BLM 2008b). The 74 square-mile Elk Hills Oilfield, the seventh largest oilfield in the United States, is surrounded on three sides by oil and gas fields and agricultural lands, while on the northwest side, it is adjacent to the 30,000-acre Lokern Natural Area (also known as the Lokern Road area), an area of relatively undisturbed publicly and privately-owned habitat (Service 1995). Federal lands under the jurisdiction of the BLM, including the Buena Vista Oilfield (formerly the Naval Petroleum Reserve No. 2 [NPR-2]), an area south of Lokern Road in Kern County, and lands in the Temblor Range east of Carrizo Plain National Monument (Table 2), occupy another 59,703 acres of the core area. Subsequent to passage of the Energy Policy Act in 2005, the BLM leased an additional 2,500 acres of Federal lands in September 2006 (BLM 2008b).

In the Carrizo Plain National Monument (Carrizo Plains Natural Area core area), approximately 130,000 acres of mineral rights are privately owned (Whitney 2008a, b), including 30,000 acres of privately-held subsurface mineral rights in the center of the monument (BLM 2008c). In addition, five of the 13 "satellite areas", which have been designated as important for recovering subpopulations of the kit fox, have substantial petroleum production areas. Between 5 and 8 percent of the acreage in each of these areas (satellite areas S5, S6, S9, S10, and S11) is comprised of lands currently open to oil and gas leasing, including portions of S5 and S6 that are public lands comprising part of the mineral estate managed by BLM. In S5, most BLM lands are scattered in a checkerboard pattern of one-square-mile (640-acre) parcels or smaller. Oil and gas leases on lands under the jurisdiction of BLM in both S5 and S6 are subject to limited surface-use stipulations for the protection of threatened and endangered species (BLM 1984, 1997; J. Lowe, BLM, *in litt.* 2006, 2007).

On public lands, including the Carrizo Plains National Monument and other BLM lands, oil and gas leasing continues to pose a threat to kit fox populations. Most oil and gas leasing and development activities on public lands occur in the San Joaquin Valley on lands managed by the BLM's Bakersfield Office (BLM 2008b). Approximately 440,000 acres of Federal mineral estate holdings are located in the San Joaquin Valley (BLM 2008a). In past 10 years, oilfield development has increased in this area, with extensive new development initiated in shallow diatomite oil-bearing formations. During the period from 2001 to 2005, 10,873 wells were drilled, with 10,746 completed. During the same period, 8,844 wells were abandoned (BLM 2008a). This 10-year time period includes periods of very high, and very low, gas prices (BLM 2008a), suggesting that development will continue despite fluctuations in the oil and gas market. Additional incentive for development stems from new technology that is predicted to result in recovery of up to 3.5 billion additional barrels of undiscovered oil from existing reserves (U.S. Geological Survey 2004). The BLM lease offerings have included lands that were previously in row crops, and natural lands, including sparse saltbush scrub (BLM 2008a). Based on data collected in the past 10 years, the BLM predicts that up to 25,000 wells may be drilled on Federal, State, and private lands in the San Joaquin Valley over the next 10 years, with 1,250 – 2,500 wells on Federal Lands. Additionally, the BLM predicts that approximately 95 – 97 percent of the wells will be developed wells, and 90 – 95 percent of those will be successful, while remainder will be unsuccessful and will be plugged and abandoned after drilling (BLM 2008a). Although the actual acreage of disturbance is expected to be a small percentage of the overall leased acreage, the extent of disturbance on any one lease cannot be accurately predicted (BLM 2008a).

While BLM lands are subject to degradation by oil and gas exploration activities, the BLM Oil and Gas Programmatic Biological Opinion for Kings and Kern Counties limits modification of high quality habitat to less than 10 percent of each 640-acre section, and modification of lower quality habitat to less than 25 percent. The BLM Oil and Gas Programmatic also limits total permanent modification of kit fox habitat on BLM lands throughout Kings and Kern Counties to 1,725 acres. Several sections within NPR-2, however, had already exceeded the modification thresholds when the BLM acquired the properties (Service 2001a, 2003) and are not subject to these limitations.

Currently, the southern half of the San Joaquin Valley continues to be an area of expansion and development activity for extraction of petroleum products. Recent and continuing oil and gas leases are being offered within the range of the kit fox in Kern, Kings, Fresno, San Benito, and Monterey Counties (BLM 2008a,d, e, f, h, i, and j) where they have the potential to affect kit fox habitat and dispersal corridors. In addition, within the Carrizo National Monument, Vintage Production LLC, a subsidiary of Occidental Petroleum, recently submitted a permit request to the BLM to explore for oil on 30,000 acres of subsurface mineral holdings in the heart of the Monument's valley floor grasslands (BLM 2008c; Whitney 2008a, b). Work is projected to start in spring or summer of 2009 (BLM 2008c). Although exploration could set the stage for negotiations to purchase the oil rights (Whitney 2008a), it is also possible that exploration will result in development of oil resources in high-value kit fox habitat.

In addition to oil field development, existing and additional proposed sand and gravel mining activities are expected to affect areas in the Western Kern County Core area (e.g., the Johnny Cat mine) and in areas such as the Salinas River Watershed in northern San Luis Obispo County, where proposed linear sand/gravel mines are expected to present barriers to the movement of San Joaquin kit fox in the habitat corridor between the Carrizo Plain and Camp Roberts (Service 2006a; Service 2008).

In summary, the most robust kit fox populations now occur in the oil-producing region of the San Joaquin Valley, suggesting that kit fox can persist well with low density oil development. The cumulative and long-term effects of oil extraction activities on kit fox populations are not fully known, but studies included herein indicate that moderate to high density oil fields contribute to a decrease in carrying capacity for kit fox through outright habitat loss and through changes in characteristics of remaining habitat over time (Spiegel 1996; Warrick and Cypher 1998; Cypher *et al*. 2000). Currently, the areas in which kit fox populations are most robust are also the areas slated for expansion of oil extraction activities, including focused activities on Federal lands that are usually thought to offer protection from development. It is therefore reasonably certain that oil field development will continue to threaten the kit fox into the foreseeable future, while increased development in the arid oil lands of Kern County may present exceptional threats to critical kit fox localities.

Habitat loss, modification, and fragmentation due to construction of solar facilities – A number of large-scale solar development projects that would threaten kit fox population clusters are currently proposed for construction in kit fox habitat. Within the Carrizo Core Area, two solar firms propose to install solar panels on 13 square miles of land on the valley floor of the Carrizo Plain, San Luis Obispo County, just north of the Carrizo Plain National Monument (DeBare 2008). Although this area of the Carrizo has a fair amount of dryland farming and is less likely to be optimal kit fox habitat than land within the National Monument (B. Cypher, pers. comm. 2008), these projects will create barriers to the linkage between the Carrizo Plain Core Area, the Western Kern core area, and core and satellite areas to the north and west, thereby impeding kit fox dispersal and increasing habitat fragmentation. Within the Ciervo-Panoche core area, two large, utility-scale, solar farms that will cover approximately 11,000 acres of valley floor habitat in the Panoche and Little Panoche Valleys (essentially all flatland habitat), are being proposed. Consultation between project proponents and State and Federal wildlife agencies has not yet been completed, but preliminary maps of the proposed projects suggest that most suitable habitat in the area would be developed, leading to a significant restriction of the kit fox's range (J. Vance, CDFG, *in litt*. 2009). One 160 acre solar project is proposed for the Cuyama Valley. Although loss of currently occupied habitat may be minimal since the land is currently in row crop production, the proposed solar project would limit opportunities for future restoration. The Service expects that additional solar projects will be proposed on lands important to the kit fox at the southern extent of its range.

Habitat loss, modification, and fragmentation due to construction of infrastructure - Construction of infrastructure projects continues to result in the direct loss and indirect modification of remaining kit fox habitat throughout the range of the kit fox. Paved roads, canals, reservoirs, water banks, sound walls, and similar facilities present both permanent loss of habitat and potential barriers to kit fox movement that fragments habitat.

Linear infrastructure features that accompany development, such as roads, freeways, and canals, have the potential to disrupt or stop the movement of a variety of mammals, including kit fox and their prey (Bunn *et al*. 2007). This fragments the remaining suitable habitat into patches, where patch size affects the ability of the patch to support larger species and species that are less tolerant of human disturbance. Thus, when habitat patches are small, species such as the kit fox, which requires large home ranges (White and Ralls 1993; Koopman *et al*. 2001), may decline due to reductions in habitat quality, extreme weather events, or normal population fluctuations. Natural recovery following such declines can be difficult if community conditions have been altered (Bennett 1999, Environmental Law Institute 2003; Bunn *et al.* 2007).

Overall, the effects of roadways on kit fox movement vary depending on the location, size, and volume of vehicle use (Bjurlin and Cypher 2003; Cypher *et al*. 2005b; Bjurlin *et al*. 2005). In natural lands, backroads with little vehicle traffic generally have little effect on kit fox movement or ecology (See further discussion under Factor E). However, in urban areas such as Bakersfield, the effect of higher volume roads on kit fox dispersal is not clear, but does result in at least some mortality (Bjurlin *et al*. 2005), thereby presenting at least a partial barrier to connectivity of kit fox. Four-lane highways with median barriers generally present impermeable barriers to movement of the kit fox compared to rural roadways (Knapp 1978, as cited in Bjurlin and Cypher 2003).

Road construction in the San Joaquin Valley has resulted in the loss of kit fox habitat since listing. The Service does not have data to show the historic and current loss of kit fox habitat rangewide that is the direct result of road construction. However, rough calculations of the acreage of land lost to road development indicate that by 2003, over 7,000 acres of land had been transferred to Caltrans jurisdiction, including 3,670 acres of land in Kern County, 590 acres in Kings County, 1,065 acres in Merced County, and 2,020 acres in Fresno County (K. Hau, California Department of Transportation, pers. comm., as cited in Bjurlin and Cypher 2003).

At least one new transportation project having potentially significant unavoidable adverse impacts to wildlife, including the kit fox, is expected to be constructed the length of the San Joaquin Valley. To date, the effects of the proposed California High Speed Train have only been addressed at the programmatic level (California High Speed Rail Authority and U.S. Federal Railroad Administration 2005); however, potential routes are expected to traverse important linkage areas between satellite and core populations, resulting in additional loss of habitat in these areas (California High Speed Rail Authority and U.S. Federal Railroad Administration 2005). The proposed California High Speed Train is expected to increase fragmentation of remaining habitat by presenting both a physical and a mortality barrier to kit fox movement due to high train speeds and frequent train travel (California High Speed Rail Authority and U.S. Federal Railroad Administration 2005).

Effects such as disturbance, introduction of non-native species, and exposure to contaminants (Cypher *et al*. 2005b) may reduce suitability of habitat adjacent to roads, thereby increasing the both the loss of suitable habitat and the effect of such features as barriers to kit fox movement and connectivity (See discussion of contaminants and prey species in Factor E). To reduce habitat fragmentation and facilitate kit fox movement, crossing structures have been included in some road designs to allow movement of kit fox across roadways (Uptain *et al*. 2000; Bjurlin *et al*. 2005). To date, monitoring of crossing structures in the more northern portion of the kit fox range has failed to confirm their use by kit fox; however, failure to detect kit fox use of crossing structures may be due to low abundance of kit fox in the study area (Uptain *et al*. 2000). In contrast, in the Bakersfield area, kit fox are known to cross under an elevated section of Highway 99 using a railroad underpass (Bjurlin *et al*. 2005).

Canals also present substantial barriers to kit fox movement across the canal features. Canals are known to be hazards that can result in wildlife drownings (J. Lowe, BLM, *in litt.* 2007). Monitoring has shown that some wildlife species, including red and gray fox, will utilize flumes, pipelines, and other structures to cross canals, including the California aqueduct and the Delta Mendota canal (Johnson *et al*. 1994), potentially suggesting that kit fox may achieve some cross-canal movement, although the mortality due to drowning is not known. However, use of such structures by kit fox predators may serve to deter kit fox from using the structures when available, and the Service has no information quantifying the use of these features by kit fox.

In contrast, several canal right-of-ways have been proposed as travel corridors between northern and central occurrences of the species along either side of the canal (Clark *et al*. 2003a). The natural lands in canal right-of-ways can provide relatively abundant prey, and are utilized by kit fox (Warrick *et al*. 2007), so may serve as linkages that facilitate north-south movement of the kit fox (Warrick *et al*. 2007). However, kit fox competitors, including red fox, also utilize these corridors (Clark *et al*. 2003a) and may inhibit their successful use by kit fox (Johnson *et al*. 1994; Clark *et al*. 2005; Cypher *et al*. 2005a; Smith *et al*. 2006).

Roads and canals are present throughout the range of the kit fox. Interstate 5 and the California Aqueduct extend the length of the Valley, acting as barriers to dispersal in the western Kern County and Ciervo-Panoche core areas, and to dispersal within and between numerous satellite areas (e.g., S1, S2). In the Western Kern Core Area, the majority of the protected lands are highly fragmented into parcels of 640 acres or less, and the California Aqueduct and Interstate 5 act as barriers to kit fox dispersal between the protected lands to the east (e.g., Kern Water Bank Conservation Lands, Coles Levee ER, Tule Elk State Reserve) and the rest of the core area. The Delta-Mendota Canal extends for 117 miles along the west side of the Valley, also potentially inhibiting kit fox movement between satellite and core areas. Additional likely barriers to movement within and/or between satellite areas include State Routes 580 and 250 (Pau *in litt*. 2002), State Routes 152 and 33, Highways 101, 99 and 4, California Highways 41, 46, 58, and 198, and the East Side, Columbia, Main, Outside, and Goose Lake Canals, along with numerous local canals.

In western Kern County, the Kern Water Bank affects over 12,000 acres of potential kit fox habitat for up to 75 years through the creation of large groundwater recharge ponds (Kern Water Bank Authority 1997; Service 1997), while protecting 4,263 acres of potential kit fox habitat under the Kern Water Bank Authority HCP. The amount of land affected by water banking is expected to increase in the future. For example, currently the Semitropic Water District is proposing to develop a large groundwater bank and associated well field (Quad Knopf, in prep.) on kit fox habitat near the Semitropic Ridge Preserve and Kern NWR within Satellite Area 9.

San Luis Reservoir, Los Vaqueros Reservoir, Bethany Reservoir, and Clifton Court Forebay are impoundments that present barriers to kit fox movement in the northern portion of the kit fox range. The Los Vaqueros Reservoir was first constructed in 1999, causing permanent effects to 1,550 acres of kit fox habitat, and resulting in protection of 3,000 acres of kit fox habitat near the reservoir (McHugh 2004; USEPA 2005). Current CALFED Bay-Delta long-term plans call for enlarging the reservoir, which would inundate an additional 1,950 acres of kit fox habitat, including approximately 500 acres of the kit fox habitat conserved as compensation for the initial project (McHugh 2004). This added inundation is within a critical dispersal corridor linking kit fox in the northern extent of its range (S1) to the other kit fox populations. Construction of the project is expected to reduce the options for dispersal of kit fox in Eastern Contra Costa County.

Habitat alteration due to fires – Wildfires have the potential to alter kit fox habitat, and could either negatively or positively affect kit fox persistence. Wildfires may increase under drought conditions or with increasing human populations and habitat change. In addition, prescribed burns may be used to control shrub growth. Fires may directly endanger individual kit fox, although the magnitude of this threat is expected to be relatively low in typical kit fox habitat, which is characterized by sparse vegetation. The threat to individual fox is expected to be higher in grassland habitats or where exotic grasses, or shrub overgrowth, carry fire into native habitat. However, kit fox that must relocate their areas of foraging within their home range in response to fires become more vulnerable to predation as they relocate (M. Littlefield, Service, pers. comm. 2008).

Wildfires are known to occur within the range of the kit fox. In 1998, a major wildfire burned through the Lokern Natural Area, destroying shrublands, while smaller repeated fires also occur on the landscape, resulting in expanded areas of grassland habitat due to the failure of saltbush scrub to regenerate (Nelson 2005). Wildfires commonly occur on the western hills of Kern and Kings Counties, and into the Tumey, Ciervo, and Panoche Hills (L. Saslaw, BLM, pers. comm. 2007). The BLM uses prescribed fire on 400 to 2,000 acres every 3 to 5 years in the Carrizo Plain (Saslaw pers. comm. 2007). Military Reserves, such as Fort Hunter-Liggett, also use prescribed fire to control vegetation so that military operations do not ignite wildfires (Clark pers. comm. 2008).

To date, monitoring of kit fox at the Lokern and at NPRC indicates that kit fox populations may benefit from fires over the long run (Warrick and Cypher 1998; Nelson *et al.* 2007). Kit fox appear to prefer open habitats for denning and resting (Zoellick *et al*. 1989, as cited in Warrick and Cypher 1998). Open areas also benefit the kit fox because they are used less often by large predators such as coyotes and bobcats (Warrick and Cypher 1998). However, abundance and diversity of rodent prey species may be lower in burned than unburned areas (Nelson 2005; Cypher *in litt.* 2007; Nelson *et al.* 2007), depending on fire-return intervals. Capture rates have been positively associated with burning at the NPRC (Warrick and Cypher 1998), suggesting that burns do not pose a substantial threat to kit fox, and may in fact be beneficial.

Habitat alteration due to changes in vegetation structure from growth of non-native vegetation, and altered grazing regimes – During the period when the kit fox was listed, arid areas with sparse vegetation were noted to be suitable for kit fox because of their open structure (Laughrin 1970; Morrell 1975). Laughrin (1970) suggested that overgrazing on annual grasslands likely increased the suitability of grassland habitat for kit fox and their rodent prey, presumably by increasing open areas and reducing vegetation build-up. Laughrin (1970) further noted that in areas of the eastern San Joaquin that were not grazed, grass was two to three feet tall and rather dense, with little evidence of rodent activity. However, changes in vegetation structure, and in grazing levels, were not noted as threats at that time.

In the period since the kit fox was listed, grazing practices that result in either overgrazed areas or in relatively high vegetative structure have been proposed as potential threats to kit fox by either reducing their prey base or increasing their vulnerability to predation. Kit fox are more vulnerable to coyotes in dense vegetation (Warrick and Cypher 1998; Nelson 2005; Nelson *et al.* 2007). Arid grassland habitat, with low vegetative structure, common patches of bare ground, and abundant kangaroo rats, is recognized as optimal habitat for the kit fox (Cypher 2006). In contrast, lands that develop dense stands of vegetation higher than approximately 18 inches are expected to result in increased predation risk for the kit fox (Cypher *et al.* 2007). Non-native grasses have become the dominant herbaceous component in many California habitats (See review in Germano *et al*. 2001). In such grasslands, reduction or cessation of grazing has been demonstrated to result in conditions unsuitable for the kit fox under some conditions (e.g., where precipitation and soil conditions allow dense vegetative growth). In addition to non-native grasslands, often parcels of vacant or retired lands harbor dense growths of weedy species (e.g., *Brassica nigra* and *Sisymbrium irio* [mustards], *Bassia hyssopifolia* [five-hook bassia], and *Atriplex argentea* [silverscale], etc.) (Uptain *et al*. 2005; Cypher 2006) that render habitat unsuitable for kit fox. Weed control has been identified as a major challenge for restoration of retired lands (USDI 2007a) and grazing is thought to be key to preventing dense vegetation growth on retired and protected lands (Germano *et al*. 2001; Cypher *et al*. 2007).

Altered vegetative structure also can affect the availability of the kit fox's prey base, particularly for kangaroo rat species. Grazing effects on kangaroo rats appear to be mixed, and the Service expects that grazing may either negatively or positively affect kangaroo rats, depending on the particular site conditions, grazing level, annual weather regime, and the particular species involved (Goldingjay *et al*. 1997). While kangaroo rats depend on open areas for burrow construction, they also consume seeds, and research on grazing effects suggests potential benefits to kangaroo rats of a mix of ungrazed and grazed habitats (Williams 1985). Most species appear to prefer open, grazed areas, although giant kangaroo rats apparently cope with dense grass cover by clipping grasses near the ground to create open areas surrounding their burrow systems (Williams and Germano 1992; Williams 1992, as cited in Goldingjay *et al*. 1997, Germano *et al*. 2001). In the San Joaquin Valley, kangaroo rats have declined where dense vegetation has developed with the elimination of grazing (see discussions in Goldingjay *et al*. 1997 and Germano *et al*. 2001).

Habitat Conservation

San Joaquin kit fox have been documented to occur on both public and private lands; however, because the kit fox are highly mobile, the land ownership/management is recorded as "unknown" for over 60 percent of CNDDB occurrence records (CNDDB 2008). In western Kern County and in the Ciervo-Panoche area, failure to determine ownership of parcels where kit fox have been documented may be due in part to the highly fragmented pattern of land-ownership where public and private lands alternate in a one-mile square checkerboard pattern over large areas. For those records where land ownership is known, the largest portion of occurrences (13 percent) is recorded either wholly or partially from private lands. Kit fox have also been recorded on the following State and Federal lands: California Department of Water Resources (5 percent), California Departments of Transportation, California Department of Parks and Recreation and CDFG (1 percent each), and other State lands (less than 1 percent); and U.S. Department of Defense (8 percent), BLM (3 percent), USBR (3.5 percent), Fish and Wildlife Service (1 percent), and Department of Energy (less than 1 percent). Less than one percent of the records are from lands held by the Nature Conservancy; and city, county, and regional lands account for under 2 percent of the records (CNDDB 2008). These numbers are not exact, as numerous occurrences list multiple landowners. The size of recorded occurrences varies substantially, and some of the large occurrences occur on land that is primarily, or substantially, under the jurisdiction of the BLM at the former NPR-2 and at the Carrizo Plains.

Strategies to protect and recover the San Joaquin kit fox rely primarily on preservation of existing natural kit fox habitat, but efforts also include protection and restoration of suboptimal or altered habitat. Between 1987 and 2007, approximately 152,809 acres of kit fox habitat have been identified for protection as compensation for project activities under section 7 consultations (Service unpublished data), or under Habitat Conservation Plans, although the actual acreage under protection to date has not been determined. The Recovery Plan (Service 1998) provided direction for the identification of core and satellite recovery areas that would serve as focal regions for protection of kit fox habitat. The location of these areas was based on known kit fox occurrences and the existence of available habitat, including land in large public holdings. Since completion of the Recovery Plan, land acquisition efforts have focused on protection of habitat in these areas and in areas (linkages) that that allow movement between subpopulation areas. Further information on development of core and satellite areas is provided under the heading, *Refinement of core and satellite areas listed in the recovery criteria* on page 66 and in Appendix 2. See Figure 1 for core area, satellite area, and linkage locations. Larger parcels protected for the kit fox within core and satellite areas, including compensation lands set aside under sections 7 and 10, are included in Table 3a (Appendix 3). State and Federal lands that may provide either primary or dispersal habitat for the kit fox within core and satellite areas, but that have broad multiple use mandates, are included in Table 3b (Appendix 3).

The most substantial kit fox populations remain in the natural arid lands of the southern San Joaquin Valley, including portions of Kern, San Luis Obispo, and Santa Barbara Counties. In western Kern County, protected lands include the 7,800-acre Elk Hills Conservation Area located in disjunct parcels of the Elk Hills Oil and Gas Field (formerly NPR-1) (Live Oak Associates, Inc. 2004; B. Dixon, Occidental of Elk Hills, pers. comm. 2009); and the Buena Vista Hills Oilfield (formerly the NPR-2 lands) that now receives some protection under the jurisdiction of the Bureau of Land Management. The BLM is currently revising the Caliente Resource Management Plan, which covers 600,000 acres of land, including the Buena Vista Hills Oilfield and Atwell Island LRDP lands, to address increased oil and gas activity on public lands and management. The management plan is proposed for completion in 2011 (BLM. 2008g). In a number of cases, protected lands are pieced together as opportunities arise for purchase or protection.

In western Kern County, the Lokern Natural Area is a 44,000-acre expanse of privately and publicly-owned natural arid lands located on both sides of the California Aqueduct, in which alternating sections of land are owned by Chevron. The Lokern Natural Area has a network of small disjunct parcels of protected lands within its boundaries. The area provides habitat for the kit fox and other listed species. Owners with protected parcels in the Lokern Natural Area include BLM; CDFG; Pacific Plains and Exploration; Occidental of Elk Hills, Inc.; and Chevron. Here protected lands include the 4,000-acre CNLM Lokern Preserve, which consists of 82 disjunct parcels that are spread out over 40,000 acres along both sides of the California Aqueduct (CNLM 2008; G. Warrick, CNLM, pers. comm. 2008, 2009) and CDFG's Lokern Ecological Reserve. The Kern NWR includes 2,600 acres of habitat that are suitable for the kit fox (Williams *in litt*. 2007). Five miles away, the 3,709-acre Semitropic Ridge Preserve, consisting of 49 parcels managed by the Center for Natural Lands Management (CNLM), is contiguous with CDFG's 6,770-acre Northern Semitropic Ecological Reserve, which protects shadescale scrub and alkali sink habitat and associated uplands (California Fish and Game Commission [CFGC 2007]; CNLM 2008; G. Warrick, CNLM pers. comm. 2009).

In eastern San Luis Obispo and Santa Barbara Counties, the Carrizo Plain National Monument (formerly the Carrizo Plain Natural Area) contains over 200,000 acres of natural habitat, much of which is valley floor habitat suitable for the kit fox. The Monument is jointly managed by the BLM, CDFG and the Nature Conservancy (TNC) (California Resources Agency 2008). Although core portions of the Monument, such as the Elkhorn Plain and southern extents of the Carrizo Plain, provide optimum habitat for the kit fox (L. Saslaw, BLM, pers. comm. 2008, 2009), as discussed above, 130,000 acres within the Monument are open to potential oil and gas development. Approximately 15,000 acres in the northern portion of the Monument (around and north of Soda Lake) have not been grazed for a number of years, providing marginally suitable habitat for the kit fox in dry years and habitat that is likely not suitable in wet years when vegetation growth is greater. In recent years grazing has been discontinued on an additional 10,000 acres within the northern portion of the monument to improve habitat for elk and antelope, which require a higher vegetation structure than is appropriate for the kit fox or kangaroo rats (L. Saslaw, BLM, pers. comm. 2009). The northern portion of the monument is considered to be less suitable habitat for the kit fox and other alkali scrub species, such as kangaroo rats; however, potentially these areas might be more suitable with management (e.g., burning or grazing) to reduce vegetation from recent levels (Saslaw pers. comm. 2009).

In some areas, resident kit fox groupings appear to have declined or disappeared from lands that have been protected from development. In Monterey and San Benito Counties, in the Salinas and Pajaro River valleys (S13) and adjacent foothills to the northwest of the Carrizo core area, the Camp Roberts and Fort Hunter Liggett Military Reserves have protected kit fox habitat from residential development and agricultural conversion, although the resident subpopulations on both Reserves appear to be extirpated at this time (Moore *in litt*. 2008; Moonjian 2007; Service 2007a). In southwestern Tulare County (S7), the Pixley NWR itself includes disjunct parcels that contain a total of more than 5,000 acres that are suitable habitat for the kit fox, although the kit fox is not known to occur on the National Wildlife Refuge currently. In this area, several dairies might interfere with movement of animals between parcels, but there is interest in protecting linkages to provide large, contiguous habitat, should a subpopulation of kit fox re-establish on the refuge (Williams *in litt*. 2007).

The Ciervo-Panoche core area includes over 52,000 acres of BLM holdings that offer some protection to the kit fox, although most BLM holdings in the core area are not suitable for kit fox due to their rugged character and shallow soils. Most suitable kit fox habitat in the core area occurs on private lands in the valley floors (EG&G 1981). Approximately 21,000 additional acres of potential kit fox habitat could be set aside for conservation by 2010 as California court-ordered outstanding mitigation for the unpermitted loss of alkali scrub habitat in areas that received water through the CVP (California State Water Resources Control Board 2000). Potentially, most mitigation would occur in the Westlands Water District, including lands in western Fresno County; however, currently mitigation lands in several counties are being used to meet the court order (Kleinsmith *in litt*. 2009). The Service expects that most lands would require restoration to be optimal kit fox habitat and is concerned that no requirements stipulate that lands be purchased in locations that would benefit the kit fox.

Habitat Conservation Plans - Protective measures for the San Joaquin kit fox are currently included in 21 different completed Habitat Conservation Plans (HCP) authorized under section 10 of the Endangered Species Act. Although most HCPs completed to date cover relatively small areas, three regional-scale HCPs have been completed to guide planning in areas with extant kit fox. The Metropolitan Bakersfield HCP (MBHCP) (City of Bakersfield and County of Kern 1994, Service 1994) covers development activities in an area of 408 square miles around Bakersfield, California, and provides for compensation of impacts to natural lands at a ratio of 3 acres of replacement habitat for every acre that is impacted, while compensation for impacts to agricultural lands is one acre of replacement habitat for every acre impacts.

The San Joaquin County Multi-Species HCP (County of San Joaquin 2000; Service 2001b) authorizes permanent impacts to 3,970 acres of valley grassland habitat and 47,915 acres of agricultural lands within San Joaquin County for residential, commercial, and industrial development activities. Within the County, 208,686 acres of valley grassland and agricultural habitat are considered to be potential kit fox habitat. Impacted lands are compensated at a ratio of 3:1 for natural lands and 1:1 for agricultural lands. Service files indicate that the San Joaquin County Multiple Species HCP provides compensation for loss of kit fox habitat, but that there is no requirement that the replacement habitat be occupied by a specific species. As of December 31, 2006, the take of 85 acres of valley grassland habitat and 12,456 acres of agricultural habitat in San Joaquin County has been permitted through the HCP (SJCOG, Inc. 2006).

The East Contra Costa County HCP was completed in 2006 and authorized impacts to 4,576 acres of kit fox habitat while directing that an estimated 17,164 to 20,465 acres of suitable habitat be preserved to benefit kit fox. The Service expects that the protected lands will form a network of preserves and movement routes that will protect a critical linkage for kit fox between the northern edge of the subspecies range and the Contra Costa-Alameda County line. In 2006 – 2007, $14 million in Federal conservation grants were provided to purchase habitat that will contribute to the Natural Community Conservation Plan's (NCCP) requirement to conserve natural communities. This will contribute to protection of kit fox habitat through acquisition of part of the largest contiguous annual grassland habitat in eastern Contra Costa County for protection through the HCP/NCCP (Service 2007b).

Considerations in habitat protection - Although preserves and conservation banks have been set aside for the protection of the kit fox habitats, some protected lands may not contain all elements needed for flourishing kit fox populations. Large expanses of ranchlands, such as the Simon-Newman and the Connolly ranches, have been set aside and portions of these ranches may provide sufficient area and appropriate conditions to either support kit fox or provide dispersal habitat. In other cases, parcels that have been protected to date are likely to be too small or disjunct to support reproductive kit fox. For example, because the Lokern Preserve is comprised of over 80 small protected parcels that are scattered in alternate sections between sections belonging to Chevron (Warrick pers. comm. 2008), they currently do not provide sufficient habitat unless additional acreage is protected. Although Chevron has initiated an HCP process to protect a portion of these lands, it has not yet been completed. Some lands may not provide the appropriate habitat conditions to sustain resident kit fox populations. For example, lands east of the California Aqueduct in some areas have heavier soils and higher water tables, suggesting that they may be areas less suited to abundant kit fox populations (Cypher *et al*. 2000). The abundance of preferred prey species, especially kangaroo rats, appears to be a factor in the home range size that kit fox need (Cypher *et al*. 2000; California Air National Guard 2008), suggesting that the condition and identity of prey resources on protected lands will be an important factor in kit fox recovery.

Conservation of potential kit fox habitat under Federal and State land retirement programs - As a result of the large-scale irrigation efforts in the western San Joaquin Valley, approximately 1,750,000 acres of agricultural lands with shallow groundwater tables have become impaired due to accumulated concentrations of naturally-occurring toxic elements, including selenium and boron. With the passage of the Central Valley Project Improvement Act (CVPIA) in 1992, Federal and State acquisition programs enabled owners to stop farming, or “retire” their privately owned, drainage-impaired agricultural lands as a strategy to reduce drainage problems and address selenium accumulations (Service 1998; USDI 2005). Retirement of impaired farmlands was expected to have potentially large conservation benefits to kit fox and the suite of species (including kit fox prey species) that historically occupied areas of the valley floor. The 1998 Recovery Plan proposed to use strategic retirement of irrigated farmland as a cost-effective and expedient recovery strategy to increase habitat for the San Joaquin kit fox where there was not a contaminant issue (Service 1998, pgs. 134, 306). Lands targeted for retirement lie primarily within the San Luis Unit of the Central Valley Project (CVP) along the west side of the San Joaquin Valley where kit fox populations were historically abundant (Kelly *et al*. 2005). The Service expected that land retirement would include the permanent cessation of agriculture on these lands, conferring a conservation benefit to the kit fox.

Land retirement has the potential to include large areas within the western valley. Within the San Luis Unit alone, approximately 379,000 acres of agricultural land have been identified as contributing to poor water quality and of these lands, nearly 200,000 acres have been proposed for land retirement (USBR 2007). To date, more than 100,000 acres of agricultural land have been retired within the San Luis Unit; many acres have been acquired through fee acquisition by the Westlands Water District (Wichelns and Cone 2006; USBR 2007). The USBR plans to retire 75,000 acres in the San Joaquin Valley by 2040 (USDI 2007b) and to retire an additional 15,000 acres under the Land Retirement Demonstration Project (LRDP) by 2014 (USDI 2005; USDI 2007b). In addition, the Department of Interior has acquired 9,306 acres, and has removed 8,596 acres from irrigated agriculture (USDI 2007b). A portion of the lands proposed for retirement are expected to be used for drainage reclamation; between 1,275 and 3,300 acres of existing irrigated cropland will be converted to treatment facilities and evaporation basins, while 12,500 acres of either existing or fallowed cropland will be converted to reuse areas in which crops will be irrigated with selenium-contaminated agricultural drainwater (Service 2006b) in order to reduce selenium loads in the agricultural run-off. These areas would not be available for kit fox habitat, and might threaten individual kit fox with selenium toxicity, as described below under Factor E.

Protection or acquisition of drainage-impaired lands to provide linkages and eventual habitat on the valley floor has been an important goal of kit fox recovery efforts. However, use of this process to provide habitat that supports the kit fox is proving to be more elusive than originally conceived. It is likely to require active restoration activities, and to be a lengthy process. Habitat conditions on most retired agricultural lands are suboptimal for kit fox. Retired areas have frequently been leveled, and are difficult to restore with the native plant community (Cypher pers. comm. 2008). Many parcels are characterized by dense growths of weedy plant species (Cypher 2006; Service 2006b) that kit fox are known to avoid (Smith *et al*. 2005). Retired lands also tend to be characterized by saturated soils as a function of their poor drainage, making them unsuitable for kit fox denning (Cypher 2006; Service 2006b). For example, lands to the east of Santa Nella are known to have a high water table, and do not constitute good habitat for kit fox (C. Johnson, Caltrans, *in litt*. 2002). Retired lands also may lack sufficient prey to sustain kit fox, and may lack burrowing animals needed to facilitate den construction (Cypher 2006). These factors require careful evaluation of parcels for conservation purposes.

Retired lands may potentially be restored to provide suitable habitat for native San Joaquin Valley species, including the kit fox. However, since completion of the Recovery Plan, restoration efforts on retired lands and oil-field lands have shown limited success, and have been time-consuming and financially costly (Hinshaw *et al*. 1999; Uptain *et al*. 2005). For example, land restoration activities are continuing on lands acquired under the LRDP. The LRDP was first implemented in 1999 at Tranquillity, Fresno County, and at Atwell Island in the Tulare Lake Basin, Kern County. To date some elements of restoration have been achieved on 4,981 acres. Five years of monitoring have shown that the shallow water table is declining and selenium levels have shown a decreasing trend. Recent restoration activities have focused on weed control, which is considered the major challenge in successful upland habitat restoration. However, restoration attempts have shown that complete restoration to the natural upland habitats found in the San Joaquin Valley can take many years to achieve (USDI 2007b), and that no one strategy will be successful in every soil type or year.

When prey species establish on restored lands, the prey community may be typical of disturbed, ruderal habitats rather than native habitats (Uptain *et al*. 2005). Ruderal habitats are those where the natural vegetative cover has been disturbed by humans. Re-establishment of native prey species is delayed, although native prey species are beginning to return to some lands (Cypher pers. comm. 2008). Parcel size, habitat conditions, and distance from existing prey and kit fox occurrences are thought to be factors that affect lag times between land retirement and potential re-colonization of lands by the kit fox (Cypher 2006; Service 2006b). For example, in the study of habitat restoration on retirement lands at Tranquillity, no kit fox were ever observed during spotlighting surveys in the 5 years of the study (Uptain *et al.* 2005). These considerations have led biologists to conclude that most retired lands within the San Luis Unit probably do not currently support kit fox populations (Cypher 2006).

Experience since completion of the Recovery Plan indicates that achievement of recovery objectives will require actions beyond the current mandates of the Land Retirement Program, which ends the irrigation of program lands by use of CVP water, but does not require that retired lands be restored to native habitat. In fact, lands not used as re-use areas or evaporation ponds may be grazed, fallowed, or dry-farmed (Service 2006b). In 2003, approximately 16,000 acres of retired lands were being irrigated with groundwater or other purchased water (USBR 2006), thereby allowing irrigated agriculture to continue. Kit fox biologists have suggested that up to 78,000 acres of retired farmlands could be made available as moderately suitable, or suboptimal, habitat for kit fox within the Westlands Water District. They have suggested that with suitable planning and active management, these lands might have value for recovery by increasing connectivity between remaining habitat on the west side of the valley and natural, protected lands to the east (Cypher 2006). However, the actual value of the lands for foraging and dispersal would depend on land management regimes, crops, and prevalence of disking (Service 2006b), which discourages colonization of retired lands by burrowing rodents, such as kangaroo rats. In their current condition, retirement lands have limited value for kit fox due to their existing vegetative structure and absence of prey, and consequently, kit fox do not appear to be utilizing these lands. In conclusion, there may be too many uncertainties with implementation to count on land retirement as a core part of the recovery strategy at this time (Cypher pers. comm. 2008).

Factor A Summary - In summary, the loss, modification, and fragmentation of natural kit fox habitat continue to be the primary threats to the San Joaquin kit fox. Most of the optimal habitat on the valley floor has been converted to agriculture. Although the rate of agricultural conversion on the valley floor has slowed in recent years, urban and agricultural conversion activities have continued to extend up to and into the lower foothill slopes where corridors of residual habitat had remained. In many areas, remaining natural lands have become fragmented, inhibiting movement of kit fox between remnant parcels and delaying or preventing re-colonization of retired and restored habitat. Some isolated parcels, including protected lands, have lost the vegetative structure or prey species important to persistence of kit fox populations, resulting in loss of resident kit fox subpopulations. Restoration of the kit fox’s natural habitat has proved difficult, and lands, such as retired lands that were thought to be valuable for kit fox recovery, do not necessarily provide adequate conditions for kit fox. In the Western Kern County and the Carrizo Plain core areas, where kit fox remain relatively abundant, threats due to oil and gas leasing continue. The Service and its public and private partners have made great progress in acquiring lands for conservation of the kit fox. Currently, land ownership or management for 60 percent of CNDDB occurrences is unknown. However, 13 percent of occurrences are recorded from private lands, while another roughly 24 percent of occurrences are recorded from various Federal, State, regional, county, and city holdings that are subject to varying management goals and objectives. Lastly, the kit fox are mobile predators that require large home ranges, and appropriate vegetative, prey, and predator conditions to persist. Despite conservation efforts since listing, kit fox subpopulations appear to be declining.

FACTOR B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

At the time that the kit fox was listed, it was considered to be particularly vulnerable to night hunting by "varmint calling" sportsmen, and indiscriminant killing was considered to be a significant mortality factor for populations of the kit fox (Laughrin 1970, Morrell 1972). The California Fish and Game Commission declared the kit fox a protected furbearer in 1965; however, indiscriminant and illegal shooting of kit fox was noted in 1972 (Morrell 1972). The State subsequently closed portions of Kern, San Luis Obispo, Fresno, Kings, and Monterey Counties to all night hunting and furbearer trapping to protect the kit fox (Morrell 1975).

Overutilization for any purpose is not known to be a threat at this time, although kit fox mortality due to shooting is known to occur at least occasionally (Cypher *et al*. 2000; Nelson *et al*. 2007), and most areas within the range of the kit fox are currently open to night hunting (CFGC 2008). The potential for accidental shooting of kit fox will be discussed under Factor E.

FACTOR C: Disease or Predation

At the time of listing the San Joaquin kit fox, several biologists noted that the range of the kit fox was likely limited to the San Joaquin Valley floor and lower foothills, in part by competition with the gray fox (Laughrin 1970; Jensen 1972). However, neither predation nor disease was considered to be a potential threat to the species at that time. Currently, kit fox are exposed to a number of wildlife diseases with the potential to threaten the kit fox. Predation by large carnivores, in particular by coyotes and introduced red fox, has become a major source of kit fox mortality in the time since listing and is currently considered a threat to the species.

Disease - Wildlife diseases (rabies, canine parvovirus, canine distemper virus, etc.) could cause substantial mortality or contribute to reduced fertility in female kit fox (White *et al.* 2000; Miller *et al.* 2000). Diseases may threaten long-term viability of small populations of wildlife (Thorne and Williams 1988), but, as discussed above under species biology and life history, they do not appear to be a primary mortality factor for kit fox populations (McCue and O'Farrell 1988; Standley and McCue 1992). Although 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), past studies have not observed clinical indications of these diseases (McCue and O'Farrell 1988) nor found evidence that disease was an important mortality factor where it was studied (Cypher *et al*. 1998, 2000). To date the Service has no information to indicate that any diseases, with the potential exception of rabies (Standley and McCue 1997; White *et al*. 2000), have been identified as major sources of kit fox mortality.

Disease and predation may have both contributed to the catastrophic decline in the isolated population of San Joaquin kit fox at Camp Roberts, in San Luis Obispo County. Surveys conducted between 1986 and 1991 at Camp Roberts indicated that kit fox were distributed throughout approximately 25,000 acres of the installation except for the steeper, wooded slopes and chaparral areas in the southwest portions of the Camp (Moore *in litt*. 2008). Kit fox captures decreased from 103 in 1988 to 20 in 1991, and further to only 3 in 1997 (White *et al*. 2000). During this same period, generally captures of striped skunks (*Mephitis mephitis*) also decreased, but the proportion of skunks that were found to be rabid increased. This correlation led biologists to propose that rabies was a factor in the kit fox decline (White *et al*. 2000). However, insufficient data prevented determination of the specific cause, or causes, of the decline. Other potential causes included limited recruitment of young and the presence of relatively high numbers of other predators and competitors, including the red fox and the coyote (White *et al*. 2000). A telemetry study between 1988 and 1991 indicated that coyotes were responsible for 59 percent of known kit fox mortality, while the relative abundances of kit fox and coyotes were negatively correlated. In addition, opportunistic observations of red fox at Camp Roberts increased five-fold between 1993 and 2000. Red fox were found to have displaced kit fox from several dens. Between 1997 and 2000, no kit fox were sighted or captured in the developed areas of the camp (White *et al*. 2000), and only one kit fox has been detected at Camp Roberts since 2000 (in 2003) (Moonjian 2007; Moore *in litt*. 2008).

Predation - Wildlife research and monitoring activities completed since listing have illustrated the role that predation has played in mortality rates for the kit fox. Away from urban areas, large predators are the primary cause of kit fox mortality. Most predator-related deaths are attributable to coyotes and bobcats, with mortality also caused by red fox (Cypher *et al*. 2001; Cypher *et al*. 2005a). In addition to mortality caused by wild canids, kit fox have also been killed by badgers, golden eagles, and free-ranging dogs (Briden *et al*. 1992; Standley *et al.* 1992; Ralls and White 1995; Spiegel and Disney 1996; Cypher *et al*. 2000; Clark 2001; Clark *et al.* 2005).

Canid predators do not always consume their prey, so kit fox mortality may in fact be due to interference competition (Cypher and Spencer 1998; Cypher *et al*. 2000; Nelson *et al*. 2007) rather than a strict definition of predation. Interference competition occurs when individuals of one species behave in a manner that suppresses individuals of another species, effectively reducing the second species' use of shared resources. Interference competition may arise as a strategy when shared resources are scarce (Gotelli 1995). In the non-urban environment, coyotes compete with kit fox for resources (Cypher and Spencer 1998). Coyotes may attempt to lessen resource competition with kit fox by killing them (Cypher and Spencer 1998). However, for the purposes of this discussion we will collectively refer to predation and interference competition as "predation". In some studies, coyotes have consumed the majority of kit fox that they killed (Ralls and White 1995). In addition to direct mortality, coyotes and red fox also negatively affect kit fox by competing for prey resources, and by competing with kit fox for habitat and/or denning resources. Increased presence of wild and domestic canids that pose an increasing threat to kit fox may be due to human-associated changes in the natural environment (Cypher *et al*. 2001; Cypher *et al*. 2005a).

Coyote predation - As discussed in the section on species biology and life history, predation by coyotes and other large carnivores has become a major source of kit fox mortality (Ralls and White 1996; Cypher *et al*. 2000; Nelson *et al*. 2007). Mortality due to interactions with predators, primarily coyotes, has ranged between 57 percent and 89 percent in the southern San Joaquin Valley (Standley *et al.* 1992; Ralls and White 1995; Spiegel and Disney 1996; Cypher *et al*. 2000). Coyote-related injuries accounted for 50-87 percent of the kit fox mortality at Camp

Roberts, Carrizo Plain Natural Area, Lokern Natural Area, and NPRC (Cypher and Scrivner 1992; Standley *et al*. 1992; Ralls and White 1995; Spiegel *et al*. 1996; Cypher and Spencer 1998). Nelson *et al*. (2007) found that probable and known predation accounted for 76 percent of total kit fox mortality in the Lokern Natural Area. Briden *et al*. (1992) found that larger carnivores accounted for 45.5 percent of observed kit fox mortality in western Merced County. During surveys in eastern Merced County, the coyote was the most abundant carnivore reported, and appeared to be common and widespread within the area (Orloff 2002).

Land conversion and associated human activities have led to changes in the distribution and abundance of coyotes. During the past few decades, coyote abundance has increased in many areas potentially due to favorable landscape changes, and reduced control efforts (Orloff *et al*. 1986; Cypher and Scrivner 1992; White and Ralls 1993; White *et al*. 1995). Coyotes apparently will feed on cattle carcasses and other human-derived prey items that could subsidize coyote abundance even when drought conditions reduce natural prey. The subsidy may therefore maintain coyotes at artificially high levels and compound predation effects when kit fox are stressed by reductions in availability of their preferred prey (Cypher and Spencer 1998). The diets and habitats selected by coyotes and kit fox often overlap (Cypher and Spencer 1998; Cypher *et al*. 2001), and coyotes may displace kit fox from scrublands into grassland habitats, with diet overlap occurring at an increased mortality cost for the kit fox (Nelson *et al*. 2007). In the Lokern Natural Area in the Southern San Joaquin Valley, coyotes generally used shrublands in preferences to grasslands and left the grasslands to kit fox. However, along the California Aqueduct where there was more vegetative structure and prey was more abundant, coyotes utilized grasslands that were also used by kit fox (Nelson 2005).

Coyotes occur in most areas within the kit fox range. Survival rates of adult kit fox decrease significantly as the mortality caused by coyotes increases (Cypher and Spencer 1998; White and Garrott 1997). 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; Cypher *et al*. 2000). In fact, declines in kit fox abundance have been associated with high coyote predation rates combined with poor reproduction in kit fox due to drought-associated reductions in prey availability (Cypher and Scrivner 1992; White and Ralls 1993). To reduce predation on kit fox, a program to reduce coyote abundance at the NPRC was conducted from 1985 to 1990. Despite evidence that coyotes were both preying on kit fox and competing with them for resources (Cypher and Spencer 1998), reduction in coyote abundance did not correlate with an increase in kit fox, and coyotes continued to be the primary cause of kit fox mortality. The program did not result in increased kit fox abundance (Cypher and Scrivner 1992).

Coyotes apparently threaten kit fox on lands that are protected to provide natural habitat. In recent years coyotes have increased in density at some conservation lands that have been protected for the kit fox and other listed upland species (see Service 1997; Contra Costa Water District 2009). In several areas of the San Joaquin Valley, high coyote densities are thought to be excluding kit fox from valley floor grassland habitat that otherwise is thought to be suitable for the kit fox (B. Moffitt, California Department of Parks and Recreation, pers. comm. 2009; D. York and D. Clendenen, The Wildlands Conservancy, pers. comm. 2009). Coyotes also appear to be the only wild canids encountered at the San Luis NWR Complex in recent years, even though approximately 30 artificial dens have been installed for the kit fox (K. Forrest, San Luis

NWR, *in litt*. 2009). Coyote densities are also noted to be high at other protected sites (D. Olstein, TNC, pers. comm. 2009; S. Brueggemann, CDFG, pers. comm. 2009). The density of coyotes in these areas has not been quantified, nor compared to densities found in the NPRC in the early 1990s, and effects of coyote-kit fox interactions could vary substantially depending on the particular prey available and other habitat conditions. The apparent effect of coyote density upon kit fox presence, however, may also be due to some other factor that may favor the coyote while disadvantaging the kit fox.

Predation by non-native red fox and other canids – Non-native red fox are known to kill kit fox, displace kit fox from dens, and compete with them for habitat and prey resources (Ralls and White 1995; Clark *et al*. 2005). Nonnative red fox are close to kit fox both morphologically and taxonomically, which could result in more intense competitive interactions (Clark 2001), including predation. Kit fox escape mechanisms, such as den use, may not be effective against red fox because the similar size of the two species allows red fox to enter and use kit fox dens (Clark *et al*. 2005). Red fox are more fecund than kit fox, commonly having six to seven pups compared to two to six pups for kit fox (Egoscue 1962; Morrell 1972; Zoellick *et al.* 1987). Red fox also live longer than kit fox, with a life span of 8 years compared to an average of 2 years in kit fox (Jurek 1992). In the Lost Hills area of the San Joaquin Valley, sympatric red fox and kit fox have been found to favor like habitat types (Clark *et al*. 2005). However, spatial segregation between the two species has been detected, suggesting that kit fox may avoid or be excluded from red fox-inhabited areas (Clark 2001; Clark *et al*. 2005). Such avoidance would limit the resources available to kit fox, and possibly result in decreased kit fox abundance and distribution.

Land-use changes have contributed to the expansion of non-native red fox into areas inhabited by kit fox. Non-native red fox were first introduced to several areas of California in the 1870s. By the 1970s, however, introduced and escaped red fox had expanded their range and had established breeding populations in many areas inhabited by kit fox (Lewis *et al*. 1993). As early as 1993, red fox appeared to be displacing kit fox in the northwestern part of the kit fox range (Lewis *et al*. 1993). At Camp Roberts, red fox have usurped several dens used by kit fox during previous years (California Army National Guard, Camp Roberts Environmental Office, unpublished data). Opportunistic observations of red fox in the temporary living quarters area of Camp Roberts have increased 5-fold since 1993, and no kit fox have been sighted or captured in this area since October 1997 (Moore *in litt*. 2008).

Red fox are associated with surface water sources, and their colonization of new areas is thought to be facilitated by the development of water sources such as canals, reservoirs, and stock ponds (Orloff 2002). The potential for predation by both red fox and dogs is thought to be higher near agricultural lands due to the association of red fox and dogs with agriculture (Cypher *et al*. 2005a). Agricultural lands also lack escape cover (dens) for kit fox thereby increasing their risk of predation (Cypher et al. 2005a). Non-native red fox have been documented from northern, central, and southern portions of the kit fox's range, and are thought to be increasing (Smith *et al*. 2006). Red fox have been relatively common in western Merced County, and have also been detected in Alameda and San Joaquin counties (Orloff 2002; Smith *et al*. 2006).

Recent surveys suggest that red fox have expanded into eastern Merced County where they are now thought to also be fairly common (Orloff 2002). Use of eastern Merced County by the coyote, red fox, and gray fox is attributed to the increased presence of canals and agricultural infrastructure in this area. Canal right-of-ways especially are used by kit fox (Warrick *et al*. 2007); however, these areas may also be utilized by other fox. For example, within the northern range for the kit fox, the only fox scat identified along the Delta Mendota canal were those of red fox, which is common and may be increasing in the area (Clark *et al*. 2002; Johnson *in litt*. 2002; Clark *et al*. 2003a). The canal levees have been considered to serve as a travel corridor linking northern and southern populations of the kit fox (Clark *et al*. 2003a, b), but use of levees by red fox could reduce successful dispersal of kit fox along these corridors. In addition, the increase in presence of red fox may reduce suitability of remaining natural kit fox habitat, especially in the northern and central portions of the kit fox range (Clark *et al*. 2003a, b; Smith *et al*. 2006). Red fox are also known to occur in lands that have been conserved for kit fox habitat (Smith *et al*. 2006).

Although red fox have not been known from the Carrizo Plains National Monument and Lokern Natural Area (Smith *et al*. 2005), red fox were found to be responsible for two kit fox deaths in the Carrizo Plain Natural Area, an area where most kit fox mortality was caused by coyotes (Ralls and White 1995). Biologists here suggested that red fox might pose a greater threat to kit fox than coyotes in some areas (Ralls and White 1995). In the Bakersfield area, red fox have been observed using dens formerly occupied by kit fox and displacement of kit fox by red fox may be occurring, but the effect on kit fox is not clear (Cypher *in litt*. 2009).

Although the threat that red fox pose to kit fox range-wide may be ameliorated by factors such as the red fox's relatively poor adaptation to arid lands, the spread of non-native red fox through the San Joaquin Valley is considered to constitute a potentially significant threat to the kit fox (Cypher *et al*. 2001; Clark *et al*. 2005). The importance of preserving large blocks of natural habitat for the kit fox (Jurek 1992; Cypher *et al*. 2001) is highlighted by these factors.

The predation threat posed by domestic canids is though to be small, but has not been quantified. However, dogs are common in the exurban environment and often accompany recreationists to protected and open space areas where they may chase wild canids, including the kit fox, or otherwise alter their behavior (Lenth *et al*. 2008). Domestic dogs also reduce the area that is utilized by rodent prey species (Lenth *et al*. 2008). However, the effect that domestic dogs have on kit fox populations has not been quantified to date.

Summary - In summary, predation of kit fox by large canid predators including the coyote and non-native red fox, appears to be a major and increasing threat to the viability of kit fox populations. In most areas of the kit fox's range, coyotes are the primary cause of kit fox mortality, and survival rates of kit fox decrease significantly as coyote-caused mortality increases (White and Garrott 1997; Cypher and Spencer 1998). Canid predators have increased both in distribution and abundance with the increased land conversion, presence of water sources, and related human activities in the San Joaquin Valley (Orloff *et al*. 1986; Cypher and Scrivner 1992; White and Ralls 1993; White *et al*. 1995). As noted above, abundant coyote populations currently appear to be excluding kit fox from some protected kit fox habitat. In contrast, disease does not appear to be an important threat to the kit fox at this time. Although kit fox are apparently exposed to a variety of pathogens, to date the Service has no information to indicate that any diseases, with the potential exception of rabies (Standley and McCue 1997;

White *et al*. 2000; Cypher, *in litt*. 2009), have been identified as major sources of kit fox mortality.

FACTOR D: Inadequacy of Existing Regulatory Mechanisms

The San Joaquin kit fox was listed as endangered under the Endangered Species Preservation Act in 1967, and subsequently listed as a threatened species by the State of California in 1971. At the time of Federal listing, many of the current environmental laws did not yet exist. In 1972, continued concerns about the significant effects of illegal shooting of kit fox led the California Fish and Game Commission to close portions of Kern, San Luis Obispo, Fresno, Kings, and Monterey Counties to all night-hunting and furbearer trapping. In 1975 the area closed to night-hunting was enlarged to include the majority of the southwest portion of the kit fox's range (Morrell 1975). Currently night-hunting is only prohibited east of Highway 101 in Monterey and San Benito Counties (CFGC 2008).

There are several State and Federal laws and regulations that are pertinent to federally listed species, each of which may contribute in varying degrees to the conservation of federally listed and non-listed species. These laws, most of which have been enacted in the past 30 to 40 years, have greatly reduced or eliminated the threat of wholesale habitat destruction, although the extent to which they prevent the conversion of natural lands to agriculture is less clear.

State Protections in California

The State's authority to conserve rare wildlife and plants is comprised of four major pieces of legislation: the California Endangered Species Act, the Native Plant Protection Act, the California Environmental Quality Act, and the Natural Community Conservation Planning Act.

California Endangered Species Act (CESA): The CESA (California Fish and Game Code, section 2050 *et seq*.) prohibits the unauthorized take of State-listed threatened or endangered species. The CESA requires State agencies to consult with the CDFG on activities that may affect a State-listed species and to mitigate for any adverse impacts to the species or its habitat. Pursuant to CESA, it is unlawful to import or export, take, possess, purchase, or sell any species or part or product of any species listed as endangered or threatened. The State may authorize permits for scientific, educational, or management purposes, and to allow take that is incidental to otherwise lawful activities. On June 27, 1971, the San Joaquin kit fox was listed as threatened under CESA. CESA allows for take incidental to otherwise lawful development projects. "Take" under CESA is defined in Section 86 of the Fish and Game Code as "hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill", but unlike the Act, CESA does not include the actions "harm" or "harass" in the definition of "take". Therefore, CESA does not protect kit fox from significant habitat modification or degradation to the extent of the protection afforded by the Act (50 CFR [Code of Federal Regulations] Section 17.3).

California Environmental Quality Act (CEQA): The CEQA requires review of any project that is undertaken, funded, or permitted by the State or a local governmental agency. If significant effects are identified, the lead agency has the option of requiring mitigation through changes in the project or to decide that overriding considerations make mitigation infeasible (CEQA section

21002). Through this process, the public is able to review proposed project plans and influence the process through public comment. Typically, project proponents propose conservation measures to offset or minimize adverse effects to listed species. However, CEQA does not guarantee that such conservation measures will be implemented. Protection of listed species through CEQA is, therefore, dependent upon the discretion of the lead agency involved.

Natural Community Conservation Planning Act: The Natural Community Conservation Program is a cooperative effort to protect regional habitats and species. The program helps identify and provide for area wide protection of plants, animals, and their habitats while allowing compatible and appropriate economic activity. Many Natural Community Conservation Plans (NCCPs) are developed in conjunction with Habitat Conservation Plans (HCPs) prepared pursuant to the Federal Endangered Species Act.

Federal Protections

Endangered Species Act of 1973, as amended through P.L. 108-136 (Act): The Act is the primary Federal law providing protection for this species. The Service's responsibilities include administering the Act, including sections 7, 9, and 10 that address take. Since listing, the Service has analyzed the potential effects of Federal projects under section 7(a)(2), which requires Federal agencies to consult with the Service prior to authorizing, funding, or carrying out activities that may affect listed species. A jeopardy determination is made for a project that is reasonably expected, either directly or indirectly, to appreciably reduce the likelihood of both the survival and recovery of a listed species in the wild by reducing its reproduction, numbers, or distribution (50 CFR 402.02). A non-jeopardy opinion may include reasonable and prudent measures that minimize the amount or extent of incidental take of listed species associated with a project.

Section 9 prohibits the taking of any federally listed endangered or threatened species. Section 3(19) defines "take" to mean "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct". Service regulations (50 CFR 17.3) define "harm" to include significant habitat modification or degradation which actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering. Harassment is defined by the Service as an intentional or negligent action that creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering. The Act provides for civil and criminal penalties for the unlawful taking of listed species. Incidental take refers to the taking of listed species that results from, but is not the purpose of, carrying out an otherwise lawful activity by a Federal agency or applicant (50 CFR 402.02). For projects without a Federal nexus that would likely result in incidental take of listed species, the Service may issue incidental take permits to non-Federal applicants pursuant to section 10(a)(1)(B). To qualify for an incidental take permit, applicants must develop, fund, and implement a Service-approved Habitat Conservation Plan (HCP) that details measures to minimize and mitigate the project's adverse impacts to listed species. Regional HCPs in some areas now provide an additional layer of regulatory protection for covered species, and many of these HCPs are coordinated with California's related Natural Community Conservation Planning program.

National Environmental Policy Act (NEPA): The NEPA (42 U.S.C. 4371 *et seq*.) provides some protection for listed species that may be affected by activities undertaken, authorized, or funded by Federal agencies. Prior to implementation of such projects with a Federal nexus, NEPA requires the agency to analyze the project for potential impacts to the human environment, including natural resources. In cases where that analysis reveals significant environmental effects, the Federal agency must propose mitigation alternatives that would offset those effects (40 CFR 1502.16). These mitigations usually provide some protection for listed species. However, NEPA does not require that adverse impacts be mitigated, only that impacts be assessed and the analysis disclosed to the public.

Sikes Act: The Sikes Act (16 U.S.C. 670) authorizes the Secretary of Defense to develop cooperative plans with the Secretaries of Agriculture and the Interior for natural resources on public lands. The Sikes Act Improvement Act of 1997 requires Department of Defense installations to prepare Integrated Natural Resource Management Plans (INRMPs) that provide for the conservation and rehabilitation of natural resources on military lands consistent with the use of military installations to ensure the readiness of the Armed Forces. INRMPs incorporate, to the maximum extent practicable, ecosystem management principles and provide the landscape necessary to sustain military land uses. While INRMPs are not technically regulatory mechanisms because their implementation is subject to funding availability, they can be an added conservation tool in promoting the recovery of endangered and threatened species on military lands.

Federal Land Policy and Management Act of 1976 (FLPMA): The Bureau of Land Management is required to incorporate Federal, State, and local input into their management decisions through Federal law. The FLPMA (Public Law 94-579, 43 U.S.C. 1701) was written "to establish public land policy; to establish guidelines for its administration; to provide for the management, protection, development and enhancement of the public lands; and for other purposes." Section 102(f) of the FLPMA states that "the Secretary [of the Interior] shall allow an opportunity for public involvement and by regulation shall establish procedures … to give Federal, State, and local governments and the public, adequate notice and opportunity to comment upon and participate in the formulation of plans and programs relating to the management of the public lands." Therefore, through management plans, the Bureau of Land Management is responsible for including input from Federal, State, and local governments and the public. Additionally, Section 102(c) of the FLPMA states that the Secretary shall "give priority to the designation and protection of areas of critical environmental concern" in the development of plans for public lands. Although the Bureau of Land Management has a multiple-use mandate under the FLPMA which allows for grazing, mining, and off-road vehicle use, the Bureau of Land Management also has the ability under the FLPMA to establish and implement special management areas such as Areas of Critical Environmental Concern, wilderness, research areas, etc., that can reduce or eliminate actions that adversely affect species of concern (including listed species). The Carrizo Plains National Monument is under the jurisdiction of the BLM. Management of special status species is directed through Chapter 6840 of the Bureau of Land Management Manual. The manual was last revised in January of 2001, and provides for management to conserve not only federally-listed, but also state-listed species. A draft revision, dated April 22, 2008, would, among other changes, remove the automatic conservation of state-listed species, so would not automatically provide protection for the kit fox, were it to be delisted under the Act (BLM 2008k); however, the revision has not yet been finalized (Amy Fesnock, BLM, *in litt*. 2008).

*The Lacey Act***:** The Lacey Act (P.L. 97-79), as amended in 16 U.S.C. 3371, makes unlawful the import, export, or transport of any wild animals whether alive or dead taken in violation of any United States or Indian tribal law, treaty, or regulation, as well as the trade of any of these items acquired through violations of foreign law. The Lacey Act further makes unlawful the selling, receiving, acquisition or purchasing of any wild animal, alive or dead. The designation of "wild animal" includes parts, products, eggs, or offspring.

National Wildlife Refuge System Improvement Act of 1997: This act establishes the protection of biodiversity as the primary purpose of the National Wildlife Refuge system. This has lead to various management actions to benefit the federally listed species.

In summary, the Endangered Species Act is the primary Federal law that provides protection for this species. The California Endangered Species Act provides protection against take of the species, but the definition of take is more limited than that provided under the Act and does not protect the kit fox from significant modification of habitat. Other Federal and State regulatory mechanisms provide discretionary protections for the species based on current management direction, but do not guarantee protection for the species absent its status under the Act. Therefore, we continue to believe other laws and regulations have limited ability to protect the species in absence of the Endangered Species Act.

FACTOR E: Other Natural or Manmade Factors Affecting Its Continued Existence

During the period when the subspecies was listed, reports by State and Federal staff included rodent-control programs (especially the use of compound 1080), agricultural pesticides, and vehicle-caused mortality as potential threats to the kit fox, although the threat posed by vehicle-caused mortality was deemed to be uncertain (Laughrin 1970; Morrell 1972, 1975). Additionally, mortality of kit fox due to shooting and varmint calling was a major factor in the progression of state protections afforded the species before it was federally listed (Morrell 1972, 1975). Morrell (1972) considered indiscriminant and illegal shooting of kit fox to be the most significant mortality factor affecting kit fox in the Buena Vista Valley of Kern County.

Currently rodenticide use, use of agricultural pesticides, and vehicle-caused mortality continue to be considered to be threats to the species. Although compound 1080 is no longer in use, rodent-control measures now utilize newer formulations of rodenticides that threaten the kit fox. There is some evidence that illegal shooting of kit fox still occurs, although the population-level effects are not known. Since the time of listing we have identified human-caused changes in prey availability; selenium accumulations; off-road vehicle use; effects associated with small population size, such as inbreeding depression, genetic drift, and stochastic extinction; climate change; and research-related activities to also pose threats to kit fox.

Rodenticides and pesticides – At the time of listing, early generation poisons, such as compound 1080 and strychnine, were used as pesticides for predator and rodent control and were considered a threat to kit fox. Currently, kit fox may encounter a variety of pesticides in localities throughout their range. Pesticides, and specifically rodenticides, pose a threat to kit fox through direct or secondary poisoning. For example, kit fox may be killed if they ingest rodenticide in a bait application, or if they consume rodents that have consumed bait (Orloff *et al.* 1986; Berry *et al.* 1992; Huffman and Murphy 1992; Standley *et al.* 1992; CDFG 1999; Hosea 2000; L. Briden, CDFG, *in litt.* 2006). Kit fox may also be threatened by loss of prey if rodent prey populations decline due to rodent control programs, or if availability of insect prey is substantially reduced by insecticide treatments, especially if insect prey declines occur when overall prey resources are limited. Pesticide effects on prey are covered under the heading, *Prey availability*. There also is the potential that availability of den sites may be impacted by rodent control programs, as kit fox can depend on ground squirrels to create potential burrows in areas with hardpan soil layers (Orloff *et al*. 1986; Orloff 2002).

The range of the San Joaquin kit fox overlaps with agricultural areas on about 10 million acres in 14 counties, mostly in the San Joaquin Valley (California Department of Pesticide Regulation 2007). Although kit fox have been excluded from large portions of agricultural lands, kit fox currently utilize agricultural lands that border natural lands. In 1997, the California Department of Pesticide Regulation listed approximately 400 pesticides for which at least one use occurred within a mile of kit fox habitat, warranting further evaluation of potential effects to the kit fox (Marovich and Kishaba 1997). Pesticides used within close proximity to kit fox habitat include the following: Malathion, aldicarb, carbaryl, chlorpyrifos, lindane, parathion, and the anticoagulant rodenticides; brodifacoum, chlorophacinone and diphacinone (Marovich and Kishaba 1997).

Documented poisoning of kit fox due to use of baiting for pests extends back to 1925 when seven kit fox were found to have died from strychnine-poisoned baits put out to control coyotes (Grinnell *et al*. 1937, as cited in Service 1998). At the time of listing, CDFG was concerned about the effect of rodent control programs on kit fox populations (Morrell 1972), but after the kit fox was listed, various agencies took action to reduce the risk of rodenticide-poisoning to kit fox (Service 1993). In 1972, the Federal government initiated control of rodenticides and predator-control chemicals with an Executive Order banning the use of Compound 1080 on Federal lands (Service 1998). Above-ground application of strychnine within the geographic range of the San Joaquin kit fox was prohibited in 1988 (Service 1992b), although it may be used in bait boxes or placed directly in pocket gopher burrows (Heintz 2000). Because of the potential effects of rodent and predator-control activities on kit fox populations, zinc phosphide, a compound known to be minimally toxic to kit fox, became the only chemical authorized for use by the U.S. Department of Agriculture to accomplish control of animal damage within the occupied range of the kit fox (Service 1992b; USDA 2007). Zinc phosphide is considered a restricted use material and may only be legally applied by state-certified pesticide applicators (University of California 2009). Based on a 2007 concurrence letter from the Service, qualified individuals (certified applicators, biologists, Federal and State employees, county and UC extension agents) who have been trained to distinguish between dens and burrows of target and non-target species may also use sodium nitrate gas cartridges to kill coyotes inside active dens where the qualified personnel have positively observed coyotes (by sight or sound) at the time of, or immediately prior to treatment (USDA 2007; Service 2007c; C. Coolahan, APHIS, pers. comm. 2009).

In the intervening period since use of these original compounds became more restricted, two new generations of rodenticides have been developed. Currently both first and second-generation anticoagulant rodenticides may be used as rodent control agents within the range of the kit fox, although the appropriate use of individual anticoagulants differs depending on the terms of their registration. First-generation anticoagulant rodenticides (FGARs) include warfarin, chlorophacinone, and diphacinone, while brodifacoum, bromadiolone, difethialone, and difenacoum are considered second-generation anticoagulant rodenticides (SGARs). Both FGARs and SGARs interfere with blood clotting, leading to death from hemorrhaging. First-generation anticoagulant rodenticides require several days of consecutive feedings to deliver a lethal dose to the target species, while SGARs can deliver a lethal dose in only one night of feeding. However, with either type of anticoagulant, death does not occur until 5 to 7 days after the feeding (USEPA 2008), providing opportunities for secondary poisoning of diurnal predators and scavengers (Cox and Smith 1992).

Rodenticide active ingredients are known to pose significant risks to non-target wildlife through both primary and secondary exposure. Risks to non-target wildlife have been determined from multiple lines of evidence, including acute toxicity, persistence of compounds in body tissues of primary consumers (i.e., animals eating the treated bait), information from studies in which poisoned prey were fed to predators or scavengers in various amounts, data from field trials and operational control programs, and incidents of wildlife mortality, including the San Joaquin kit fox (USEPA 2008). Secondary exposure to SGARs is particularly problematic due to the high toxicity of the compounds and their long persistence in body tissues. For example, brodifacoum, a common SGAR, is persistent in tissue, bioaccumulates, and appears to impair reproduction (Mount and Feldman 1983; Chen and Deng 1986; Hedgal and Colvin 1988; Alterio 1996; Howald *et al.* 1999; Alterio and Moller 2000; Eason *et al.* 2001; Eason *et al.* 2002; Munday and Thompson 2003). In addition, because these compounds are designed to be toxic after a single night's feeding, but death does not occur for 5 to 7 days, rodents may accumulate (and carcasses may contain) residues that may be many times the lethal dose. Finally, because compounds persist for extended periods in body tissues, predators and scavengers may sustain adverse or lethal effects from additive exposures through feedings that may be separated by days or weeks (Jackson and Kaukeinen 1972; Padgett *et al.* 1998; Stone *et al*. 1999; Eason *et al.* 2001; Munday and Thompson 2003; USEPA 2008). Exposed individuals are known to become progressively weaker and lethargic due to blood loss prior to death. Even in cases where the proximate cause of death has been identified as automobile strike, predation, or disease, toxicologists and pathologists have attained sufficient toxicological evidence to conclude that rodenticide-induced blood loss increased animal vulnerability to the proximate cause of death (USEPA 2008).

Rodenticides are used in urban, suburban, and rural areas to control a variety of rodents, including house mice, voles, pocket gophers, ground squirrels, and Norway rats (USEPA 2008), animals that may comprise prey for the kit fox to varying degrees, depending on the prey community available in each locality. Both FGARs and SGARS are registered for use in and around buildings, transport vehicles, in alleys, and inside sewers, although difethialone and bromadiolone are not labeled for outdoor use in "non-urban" areas (B. Erickson, USEPA, *in litt*. 2006). Diphacinone and chlorophacinone area also registered for agricultural and field uses, including use in crop land, orchards and rangelands, in irrigation ditches, and on ditch banks, river banks, railroad tracks, fence lines, garbage dumps, and landfills (B. Erickson *in litt*. 2006;

USEPA 2008). Chlorophacinone is used on rangelands to control rodents, including the Belding's ground squirrel (*Spermophilus beldingi*), California ground squirrel, pocket gopher (*Thomomys spp*.), deer mouse (*Peromyscus spp*.), and house mouse, and may be used for spot baiting for rodents in alfalfa (Ramey *et al*. 2007). Currently, approximately 10 million pounds of anticoagulants are sold in California each year (O'Neill 2004), of which approximately 75 percent (by weight) is diphacinone (Timm *et al*. 2004).

Rodenticide use is known to occur in a variety of counties within the range of the kit fox, including Fresno, Merced, Kern, San Luis Obispo, and Monterey Counties (D.F. Williams *in litt.* 1989, as cited in Service 1998; Berry *et al*. 1992; R. Hosea, CDFG, *in litt.*1999; Hosea 2000; Briden *in litt*. 2006). For example, rodenticides were utilized at Camp Roberts in the past to reduce rodent populations (Berry *et al*. 1992). Between 1991 and 1998, rodenticide poisoning on adjacent private lands was determined to be a factor in the deaths of two, and possibly four kit fox (Berry *et al*. 1992; Standley *et al*. 1992). Limited use of the rodenticide, chlorophacinone, continued at Camp Roberts until 2003, when its use was discontinued. Currently zinc phosphide is the only rodenticide approved for use at Camp Roberts (M. Moore, Camp Roberts, pers. comm. 2008). Rodenticide use on private rangelands adjacent to Fort Hunter Liggett has also been implicated in decreased rodent presence in the area (M. Littlefield, Service, pers. comm. 2007). Rodenticides have been used on USBR property to kill rodents threatening adjoining agricultural fields (Service 2000a).

Predatory mammals (particularly the kit fox) from the urban-suburban environment surrounding Bakersfield experience high levels of exposure to anticoagulant rodenticides (L. R. Broderick, CDFG, *in litt*. 2007). In 1987, a necropsy of a kit fox carcass found on a nursery in Bakersfield indicated chlorophacinone poisoning from bait spread at the site (E. Littrell, CDFG, *in litt*. 1987). Since then, ongoing toxicology studies of the carcasses of kit fox and other wild canids collected in the Bakersfield area show that the animals had elevated levels of anticoagulants in their livers (CDFG 1999; Hosea *in litt.* 1999; Hosea 2000; S. McMillin, CDFG, *in litt*. 2008). Between 1999 and the current time, 39 out of 51 kit fox livers sampled have contained residues of anticoagulant rodenticides: particularly brodifacoum, but also bromadiolone, pival, and chlorophacinone. Use of these rodenticides by the untrained public is thought to be the likely source of exposure for these animals (Broderick *in litt*. 2007). The carcasses of kit fox and other wild canids have also been collected from conserved lands in the Lokern Natural Area, which is remote high-quality desert habitat, has little agriculture, and is relatively undeveloped. Kit fox carcasses from the Lokern Natural Area do not contain anticoagulant residues, indicating that animals in the Lokern Natural Area do not experience exposure to these compounds. The other canids have shown the same pattern with exposure to rodenticides at Bakersfield and lack of exposure in the Lokern (McMillin *et al*. In review; McMillin *in litt*. 2008).

In March of 1993, the Service (1993) concluded a biological opinion on the effects of 16 vertebrate control agents on both threatened and endangered species, including the San Joaquin kit fox and the giant, Tipton, and Fresno kangaroo rats. The Service determined that most rodenticides were likely to jeopardize the continued existence of the San Joaquin kit fox, and one or more federally-listed prey species if used without restrictions (Service 1993). To avoid jeopardizing these species, the Service provided measures that would allow use of specific rodenticides within the range of these species under certain circumstances, as approved by the

Service (Service 1993). For example, chlorophacinone could be used in agricultural areas that were one or more miles from kit fox habitat, as mapped by the California Environmental Protection Agency in consultation with the Service, or in areas where Service-approved surveys indicated that kit fox were not present within a mile of the use location (Service 1993). In contrast, use of brodifacoum was not expected to jeopardize the kit fox's existence because of its restricted area of recommended use (around urban and agricultural buildings). Although kit fox occurrences around buildings at military bases, in urban/suburban Bakersfield, and in Kern County oil fields were noted, the Service concluded that use of the rodenticide would not jeopardize the kit fox due to the fact that many kit fox habitats are far removed from areas of rodenticide use, and prescribed only that brodifacoum be placed in tamper proof containers, and not be accessible to wildlife within the range of the kit fox (Service 1993). The biological opinion, in effect, allowed for local adjustments to the rule based on detailed State-Federal coordination on preventive measures; however, to date measures are provided on a voluntary basis.

Due to ongoing concerns about exposure of non-target species to rodenticides, the EPA re-evaluated 10 rodenticides in 2007, and considered classifying all products containing brodifacoum, bromadiolone, and difethialone as restricted use products (USEPA 2008). However, the EPA stopped short of classifying these ingredients as restricted-use products, relying instead on sales and distribution limits on SGARs (brodifacoum, bromadiolone, difethialone, and difenacoum) that are intended to prevent general consumers from purchasing these compounds as residential use products (USEPA 2008). New requirements will go into effect in 2011 (USEPA 2008). The effectiveness of these new regulations is not clear at this time. Kit fox may be exposed to products used legally or illegally, or even to products whose use has been discontinued (McMillin *et al*. In review).

To date, the Service is not aware of any specific research that has been conducted to quantify the effects of rodent control activities on kit fox populations. However, given the potential for secondary exposure of kit fox in agricultural areas, on rangelands, and along infrastructure projects, such as canals, that are utilized as foraging and denning habitat by kit fox, the Service expects that effects of rodenticide exposure could have substantial population level effects where exposure is present, especially where kit fox populations are small and where they rely on target species, such as ground squirrels and murid rodents, for prey.

Selenium and other contaminants - Selenium toxicity may pose a threat to the kit fox in some areas on the western side of the San Joaquin Valley where Federal water is delivered to the San Luis Unit and where local conditions result in elevated concentrations of selenium in soil and surface water, or in near-surface groundwater. In these areas, naturally occurring selenium has been concentrated in surface waters due to drainage from agricultural areas. These localities can include retired or fallowed seleniferous farm land, open ditches that convey subsurface drainwater, and drainwater reuse projects (Beckon and Maurer 2008). As discussed under Factor A, approximately 3,300 acres of evaporation ponds and approximately 19,000 acres of "reuse areas" may be used in the treatment of selenium-contaminated agricultural drainwater (Service 2006b; USBR 2007). Selenium has the potential to bio-accumulate in aquatic organisms, such as zooplankton and benthic invertebrates, and may then biomagnify as it reaches top level predators, including birds, mammals, and fish (USBR 2006). Although evaporation ponds are not expected to attract kit fox when managed as proposed, all reuse areas might potentially be available to kit fox for foraging (USBR 2006). Cover-cropping systems proposed for reuse areas include crops, such as grain crops and pasture lands, that may support substantial prey resources although some areas may be grazed, which would reduce prey abundance (USBR 2006). The selenium applied to these reuse areas via agricultural drainwater can enter the food chain through uptake by plants and soil invertebrates where it may be bio-accumulated by the seed- and invertebrate-eating organisms that comprise typical kit fox prey (Chesemore *et al*. 1990, as cited in Service 2006b). Studies of kit fox in the vicinity of Kesterson Reservoir indicate that kit fox are likely to forage in reuse areas and around evaporation ponds where selenium levels in prey are higher than levels known to negatively affect canids (Beckon and Maurer 2008). Foraging or scavenging by kit fox in such areas may expose the kit fox to elevated levels of selenium, potentially resulting in significant effects (USBR 2006; Beckon and Maurer 2008). Although no toxicity tests for selenium have been performed on kit fox, other canids (dogs) have been shown to suffer adverse effects from selenium toxicity, including reduced appetite, subnormal growth, poorly developed ovaries and testes, and even death, depending on the amount of dietary exposure (Rhian and Moxon 1943, as cited in Beckon and Maurer 2008). The magnitude of this threat to kit fox is not clear, and is expected to be dependant on the vegetative crop grown, prey abundance on site, and use of the areas by kit fox. The Service expects that, depending on extent of bioaccumulation at reuse sites and the level of foraging by kit fox, individual kit fox could suffer toxicosis effects ranging from reduced appetite and subnormal growth to adverse histopathological effects and mortality (Service 2006b). Given effects to development of reproductive organs (Rhian and Moxon 1943, as cited in Beckon and Maurer 2008), kit fox reproduction in these areas could be negatively affected.

Prey availability - Kit fox have been strongly linked ecologically to kangaroo rats, with kit fox densities and population stability highest in areas with abundant kangaroo rats (Speigel *et al*. 1996; Cypher *et al*. 2000; Cypher 2006; see also Bean and White 2000). Abundance of prey species, particularly abundance of kangaroo rats, has been linked with successful recruitment of young kit fox and increases in kit fox population numbers (Morell 1972; Orloff *et al.* 1986; White and Ralls 1993; Cypher *et al*. 2000; Bidlack 2007; Saslaw pers. comm. 2008). Conversely, prey scarcity has been a primary factor contributing to decreased reproductive success during droughts (White and Ralls 1993), or to extirpation of kit fox in specific localities (Williams *in litt*. 2007). Early studies suggested that kangaroo rats were a preferred food for the kit fox throughout the range (Laughrin 1970), and that kit fox densities were lower in areas like those near Bakersfield where plant associations changed and abundant ground squirrels replaced kangaroo rats (Jensen 1972). Current studies have shown that kit fox subsist primarily on ground squirrels in some portions of their range, including areas around Bakersfield, and in valleys within the inner Coast Range (Balestreri 1981; Orloff *et al.* 1986; Cypher and Warrick 1993), while they may subsist on a variety of native and nonnative species in disturbed areas or areas near to agriculture, and often also rely upon insect prey during portions of the year (Spiegel *et al*. 1996; Cypher and Brown 2006).

Concurrent with the decline in kit fox, the kangaroo rat species and subspecies native to the range of the kit fox have also declined. Three taxa are currently State and federally-listed as endangered (giant kangaroo rat [*D. ingens*], Tipton kangaroo rat [*D. n. nitratoides*], and Fresno kangaroo rat [*D. n. exilis*]), although habitat loss also threaten other subspecies within the San

Joaquin and associated valleys (Williams and Germano 1992). These small mammals are believed to have declined due to loss of habitat to agriculture (Williams and Germano 1992), increases in thick cover of exotic plant species and the related thatch build-up (Germano *et al*. 2001; Saslaw pers. comm. 2008), and use of rodenticides and pesticides for pest control in rangelands and agricultural crops (Orloff *et al*. 1986; Bell *et al*. 1994). By 1979, the giant kangaroo rat occupied only about 1.6 percent of its historic geographic range, while the Tipton kangaroo rate occupied only 3.7 percent of its historic range by 1985 and the Fresno kangaroo rats was only known from several small, isolated, natural parcels west of Fresno (see review in Williams and Germano 1992). Since 1994, kangaroo rats and other small native mammals have declined precipitously in the southern San Joaquin Valley (Single *et al*. 1996, as cited in Germano *et al*. 2001). Loss of habitat and changes in vegetation have been covered elsewhere in this document in relation to direct effects to kit fox and will not be covered again here, but also negatively affect presence of kangaroo rats (Williams and Germano 1992; Germano *et al*. 2001; Saslaw pers. comm. 2008), which appear to be critical to kit fox recovery. Effects of grazing on kangaroo rat populations due to changes in habitat conditions are covered under Factor A. However, livestock may affect individual kangaroo rats by damaging burrows (Germano *et al*. 2001), and potentially killing individuals. The Service expects these effects to comprise a threat primarily where livestock are concentrated in areas of kangaroo rat precincts (e.g., by watering and feeding stations, or by penning). While livestock grazing may damage individual precincts, cessation of grazing may also lead to larger-scale declines in kangaroo-rat populations during wet years due to negative effects related to dense growth of vegetation (Germano *et al*. 2001).

The reduction and elimination of prey species by pesticide use is a threat to kit fox. As discussed above, rodenticides are utilized specifically to reduce or eliminate rodents in rangelands, agriculture, and developed areas. In addition to loss of target species, rodenticide use is known to poison non-target rodent prey, such as kangaroo rats, and deer mice, etc. (Salmon *et al*. 2007). Past rodent eradication programs are thought to have eliminated the prey base for kit fox in areas such as Contra Costa County, severely reducing kit fox abundance in the area (Orloff *et al*. 1986; Bell *et al*. 1994). In recent years, use of rodenticides by individual landowners has continued to result in low densities of kit fox prey species on at least a local level (Orloff 2002; Briden *in litt*. 2006). The population consequences of this use have not been quantified, but could be substantial in areas where rodenticides are commonly used.

In addition to rodents, insects can be important prey for the San Joaquin kit fox (Hawbecker 1943; Scrivner *et al.* 1987; Archon 1992), especially during periods of low prey availability. In the northern portion of the kit fox' range, insects, especially grasshoppers and crickets, currently provide the primary prey for kit fox during the summer months, particularly July and August (Briden *et al.* 1992; Archon 1992). Insecticides that target grasshoppers and crickets (*Orthoptera* spp.) (Scrivner *et al.* 1987) may suppress kit fox populations, reduce juvenile survivorship, or inhibit successful dispersal.

Organophosphate insecticides are used to control insect pests, and have been used since the 1980s in almond orchards, but may also be used on alfalfa, and on other stone fruits to control pests. Malathion, a broad-spectrum organophosphate insecticide, has been used to control the beet leaf-hopper (*Circulifer tenellus*) in rangeland habitat, fallow fields, oil fields, and cultivated areas on both public (BLM) and private lands in the San Joaquin Valley, and in adjacent valleys and foothills (Service 1997; BLM 2002; California Department of Food and Agriculture [CDFA] 2008a, b). The beet leaf-hopper is a vector for curly top virus, which negatively affects crops. In the western and southern portions of the San Joaquin Valley, aerial spraying may occur during winter, spring, or fall control periods, and may include treatment of approximately 80,000 acres in years with low beet leaf-hopper populations, although annual treatment is not required in all areas (CDFA 2008a, b). Increases in beet leaf-hopper populations appear to be correlated with drought-mediated reductions in rangeland vegetation. In drought periods, increased beet leaf-hopper populations may require treatment of up to 200,000 acres of agricultural and natural lands, and also require treatment of the Salinas and Cuyama Valleys (CDFA 2008a, b). Treatment usually results in a target population decline of over 90 percent (CDFA 2008b); however, loss of insects important to the kit fox has not been quantified. Although the project is potentially immense in scale, the actual areas treated on an annual basis appear to be more restricted, but do include kit fox habitat in core, satellite, and linkage areas in the western and southern portions of the valley (CDFA 2008a). Within the range of the federally-endangered blunt nosed leopard lizard (*Gambelia silas*), whose range occurs within the range of the San Joaquin kit fox, measures implemented to minimize effects of curly top virus treatments on the lizard's insect prey base require that insecticide treatments be applied in alternating swaths covering no more than 50 percent of the treatment area (Service 2000b). These measures are expected to also reduce potential effects to kit fox within the area. Depending on the baseline prey conditions and the magnitude of prey loss, lowered prey levels have the potential to contribute directly or indirectly to starvation of individual animals, but the actual risk of occurrence has not been tested.

In general, lowered prey abundance is expected to require kit fox to expend more effort and cover more territory while foraging, which increases their exposure to predation. Effects of prey reductions on kit fox populations would be hard to quantify, but have the potential to have observable population-level effects.

Inbreeding Depression, Genetic Drift and Stochastic Extinction - Small populations may be subject to inbreeding depression and genetic drift, and also to chance extinction from stochastic environmental and demographic incidents (Gilpin and Soulé 1986; Goodman 1987; Shaffer 1987). Demographic research has suggested that kit fox may be susceptible to inbreeding depression and that they are threatened by local extirpation due to stochastic events (Otten and Cypher 1998). San Joaquin kit fox population abundance has been found to fluctuate widely on an inter-annual basis (Harris 1987; Cypher *et al*. 2000; Warrick and Harris 2001; Bidlack 2007). Large fluctuations can occur over relatively short time periods; with the annual finite rate of increase (a measure of the rate of growth of a population) positively correlated with adult reproductive success. Even at the NPRC, kit fox populations exhibit high environmentally-mediated inter-annual fluctuations in abundance, and are potentially vulnerable to extinction. Deterministic models indicate that under poor environmental conditions, such as extended droughts, extirpation here could occur in as little as 3 or 4 years (Cypher *et al*. 2000). Kit fox groups in smaller patches of habitat are thought to be extremely vulnerable to local extinctions due to catastrophic or environmental events (Cypher *in litt*. 2007). Although status is unknown for kit fox in many of the satellite areas (CNDDB 2008), it appears that at least several of these small and isolated resident subpopulations have recently "winked out" (become locally extinct), including subpopulations at the Fort Hunter Liggett military reserve, and at San Luis and Pixley

National Wildlife Refuges (Williams *in litt*. 2007; Cypher *in litt*. 2007; Service 2007a; Cypher pers. comm. 2008). In addition, at Camp Roberts military reserve, resident kit fox are no longer detected, while the last sighting of a kit fox was in 2003 (Moonjian 2007; Moore pers. comm. 2008).

Vehicle strikes – Vehicle strikes are a consistent, but small source of kit fox mortality on natural lands (Cypher *et al*. 2000; see table summarizing study results in Bjurlin and Cypher 2003), with vehicle strikes accounting for 9 percent of mortality at the NPRC (Cypher *et al*. 2000). In natural lands, kit fox are sometimes killed by vehicle strikes (M. Stockton, Bitter Creek NWR, pers. comm. 2006; Williams *in litt.* 2007), but impacts of roads on kit fox ecology are generally thought to be low (Cypher *et al*. 2005a, b) although mortality due to vehicle strikes may significantly affect small populations (Williams *in litt*. 2007). Although vehicle strikes may not have population-level effects in natural lands where traffic volume is low, vehicle strikes appear to be a more substantial source of mortality in human-altered landscapes, including urban environments (Bjurlin *et al*. 2005; Cypher *et al*. 2003, as cited in Cypher and Brown 2006; Briden *in litt*. 2006). In urban settings such as Bakersfield, vehicle strikes can be the largest source of kit fox mortality and may impact urban kit fox populations (Bjurlin *et al*. 2005).

Accidental Shooting – In the past, State regulations, such as restrictions on night hunting and spotlighting, were promulgated to reduce the potential for intentional and incidental shooting of kit fox (Morrell 1975). Although threats have been reduced, it appears that kit fox are still subject to accidental and illegal shooting throughout most of their range. Kit fox may potentially be mistaken for other wild canids, especially coyotes, but naïve hunters could also potentially mistake kit fox for gray fox or red fox. Kit fox superficially resemble juvenile coyotes (Clark *et al*. 2007a), suggesting that kit fox may be particularly vulnerable to misidentification at particular times of the year. Both the coyote and the gray fox are nongame species that may be taken in any number. While the coyote may be taken all year, hunting gray fox is restricted to a season that runs from November 24 through February (California Fish and Game Commission 2008). Within the range of the kit fox, a closure on night hunting is in effect in those portions of Monterey and San Benito Counties lying east of Highway 101, but legal in the rest of the range (CFGC 2008). Coyote hunting by people using predator calls, and by sheepherders, has been reported in lands surrounding the former NPR-1 (J.R. Bennett, USDA, pers. comm., as cited in Warrick and Cypher 1998).

Documented kit fox mortality due to shooting occurs occasionally on both public and private lands, including protected lands (Briden *et al*. 1992; Standley *et al*. 1992; Warrick and Cypher 1998). In addition, kit fox harassment in association with hunting has been reported (J. Vance, CDFG, pers. comm. 2007). Hunting is allowed at Fort Hunter Liggett, on most BLM lands, at a variety of Ecological Reserves managed by the Department of Fish and Game (USDOD 2008; CDFG 2008), and at one or more conservation banks (see Service 1997 files). However, at one unit of CDFG's Carrizo Plains Ecological Reserve hunting of coyotes and ground squirrels has been prohibited to prevent incidental take of the kit fox (CDFG 2008). In total, the Service does not have information to suggest that illegal shooting of kit fox is a threat to kit fox subpopulations where animals are abundant, but loss of individual kit fox due to shooting could represent significant stochastic events where extant kit fox are rare, where only several family groups exist, or where recruitment and successful dispersal are key to continuation of small population groupings.

Off-Road Vehicle Use - Use of off-road vehicles (ORVs) poses an unquantified threat to the San Joaquin kit fox, primarily through the potential for off-road travel to disturb soil, reduce or destroy herbaceous vegetation, and to destroy burrow systems of prey species, such as the kangaroo-rat, and damage kit fox dens. Off-road travel also increases access to areas that are otherwise remote and little used. Off-road travel is expected to increase impacts to animals on large expanses of natural lands including both publicly and privately held lands (see Hammitt and Cole 1998). The southern San Joaquin Valley is experiencing increased demand for dispersed recreation and ORV use on public and private lands, including oil field holdings (Dixon pers. comm. 2009; Saslaw pers. comm. 2009). Near Taft, the BLM has experienced a spike in ORV use on 30,000 acres of holdings (Shepard 2007) that are within the range of the kit fox. ORV use is occurring in the Temblor Hills, California Aqueduct, and Chico Martinez areas where most use has been on existing roads, but where cross-country travel that creates new disturbance is also occurring (Shepard 2007; BLM 2008a). On public and oil company lands in western Kern County, increasing off-road vehicle use has resulted in a substantial increase in new, unauthorized roads and trails (Saslaw pers. comm. 2009). In addition, the recent, rapid increase in off-road use has expanded to privately-held conservation lands where ORV use has caused varying amounts of damage to good quality kit fox habitat (Dixon pers. comm. 2009). Land managers are working together to contain off-road vehicle use. Efforts include coordinated construction of fencing to preclude ORV use in conserved lands in the Lokern Natural Area and several other areas (Dixon pers. comm. 2009; Saslaw pers. comm. 2009). Some private lands, such as the 74 square-mile Occidental Elk Hills Oilfield holdings, are completely fenced and are regularly patrolled, thereby limiting damage from illegal ORV trespass (Dixon pers. comm. 2009). Efforts to contain and eliminate illegal off-road use in these areas and in protected areas is expected to increase ORV pressure on less-protected areas, such as unfenced lands in the Buena Vista Hills area (Dixon pers. comm. 2009). Kit fox present within the Carrizo Plains National Monument are protected from ORV use, as the core area of the Monument has been closed to off-road vehicle travel (Saslaw pers. comm. 2009), although areas peripheral to the monument may be accessible to increased use.

In summary, the increase in off-road vehicle use in this area appears to be an increasing threat to the kit fox in otherwise suitable habitat. Although effects to habitat have not been quantified in large portions of the western Kern County area (Dixon pers. comm. 2009; Saslaw pers. comm. 2009), in specific areas the recent increased use has substantially degraded soil and vegetation conditions on lands targeted for conservation.

Climate change - Climate researchers list three clear, observable connections between climate and terrestrial ecosystems, such as those inhabited by the kit fox: seasonal timing of life-cycle events (phenology), responses of plant growth, and biogeographic distributions of plant and animal species (Field *et al*. 2007).

Current climate change predictions for terrestrial areas in the northern hemisphere indicate warmer air temperatures, more intense precipitation events, and increased summer continental drying (Field *et al*. 1999; Cayan *et al*. 2005; Cayan *et al*. 2006; IPCC 2007). Although predictions of future climatic conditions for smaller sub-regions in California remain uncertain (Christensen et al. 2007; Field *et a*l. 2007; Moser *et al*. 2009), daily minimum and maximum temperatures have begun to change (Moser *et al*. 2009), and interannual precipitation variability has already begun to increase (Kelly and Goulden 2008; Loarie *et al*. 2008). Across the mid-latitudes of the northern hemisphere, spring plant green-up has advanced by almost two weeks and animals in many areas are responding to such changes by breeding earlier and shifting their ranges (see review in Field *et al*. 2007). The Service expects that kit fox populations are also subject to these commonly observed patterns.

Interannual precipitation variability increased in both Central and Southern California regions, beginning in the early to mid-1970s (McLaughlin *et al*. 2002; Kelly and Goulden 2008). As climate change models predict increased precipitation variability in the future (McLaughlin *et al*. 2002), the Service expects these weather events to continue to increase. Population extirpations have been linked to the amplified population fluctuations that are due to these increases in variability of precipitation (McLaughlin *et al*. 2002).

Kit fox subpopulations are threatened by both droughts and high rainfall events (Cypher *in litt.* 2007; Williams *in litt.* 2007; Williams *et al*. 1993, Rathbun 1998, Germano and Williams 2005, all cited in BLM 2008a). Kit fox subpopulations, including the relatively large subpopulations at the NPRC and Carrizo Plains areas, demonstrate large fluctuations in abundance in response to weather-mediated prey levels, which increases the potential for these groups to be extirpated (Cypher *et al*. 2000; Bean and White 2000; Bidlack 2007). Weather conditions usually vary over larger landscape scales, leading to the general expectation that drought-mediated decreases in kit fox abundance, or local extirpation of some groups, should not affect persistence of the species as long as healthy core kit fox populations are not limited to one portion of the range. However, the loss and fragmentation of habitat documented herein has reduced the likelihood that lost sites will be re-colonized (Williams *in litt*. 2007; Cypher 2006; Cypher *et a*l. 2007), which is expected to result in a cumulative loss of small groupings over time (Clark *et al*. 2007b). Because increased drying and droughts, and substantial precipitation events are expected to negatively affect the native prey species upon which the kit fox depends, the Service expects climate change to pose a substantial threat to the species by further exacerbating interannual fluctuations in kit fox reproductive success and abundance.

Climate changes are also linked to recent and predicted changes in the distribution of California plant species (Kelly and Goulden 2008; Loarie *et al*. 2008). As discussed in this review, kit fox and their prey resources depend on seed sources and on particular vegetation structures to persist. Changes in the distribution of individual plants species could increase or decrease distributions of key species (Kelly and Goulden 2008; Loarie *et al*. 2008), and are expected to affect kit fox. However, the magnitude and direction of effect are not known at this time.

Research-related activities – A limited amount of mortality has been documented to occur due to research activities (Cypher *et al*. 2000). During monitoring of 542 radio-collared kit fox at the NPRC between 1980 and 1991, seven suffered minor injuries, while one suffered a lethal injury when its front paw became trapped in the collar (Cypher 1997). Newly collared adults lost body mass compared to uncollared adults, consistent with collaring effects observed in other species (Cypher 1997), but the long-term effects of this difference have not been determined. In general, these research-related effects on kit fox appear to have few population-level consequences, but could potentially be important to dynamics of a small subpopulation.

Factor E Summary - In summary, the kit fox is subject to a variety of threats beyond those related to habitat loss, disease, and predation. Some threats, such as the use of compound 1080 and varmint calling, are no longer considered to threaten kit fox. However, newer formulations of rodenticides and pesticides subject kit fox and other non-target wildlife to direct and secondary poisoning, have been linked to kit fox mortality (Orloff *et al.* 1986; Berry *et al.* 1992; Huffman and Murphy 1992; Standley *et al.* 1992; CDFG 1999; Hosea 2000; L. Briden, CDFG, *in litt.* 2006), and are used widely within the range of the kit fox (D.F. Williams *in litt.* 1989, as cited in Service 1998; Berry *et al*. 1992; R. Hosea, CDFG, *in litt.*1999; Hosea 2000; Briden *in litt*. 2006). Although no research to date has quantified the effect of rodenticides on kit fox populations, the Service expects that rodenticide exposure could have substantial population-level effects, especially where population are small and where kit fox rely on rodent species targeted by rodenticides. New regulations on the use of rodenticides will go into effect in 2011 (USEPA 2008); however, the effectiveness of the new regulations in preventing kit fox exposure in not currently known. Rodenticides and pesticides may also negatively effect kit fox populations through their reduction of both rodent and insect prey resources for the kit fox. In addition, selenium toxicity may threaten kit fox in some areas on the western side of the San Joaquin Valley where elevated concentrations of selenium are present at the ground surface. Toxicity effects range from reduced appetite and subnormal growth to mortality (Service 2006b).

Additional threats include loss of individuals to mortality from accidental shooting, vehicle strikes, off-road vehicle use, and research-related activities. Where populations are small, such events could have population-level effects and could increase the threat of stochastic extinction. Where populations are small inbreeding depression, genetic drift, and stochastic extinction are recognized threats. Finally, climate change is considered to threaten kit fox populations through the increased variability in precipitation and severe weather events, which are expected to reduce prey availability when such events occur and may also affect vegetation and seed resource availability.

III. RECOVERY CRITERIA

Recovery plans provide guidance to the Service, States, and other partners and interested parties on ways to minimize threats to listed species, and on criteria that may be used to determine when recovery goals are achieved. There are many paths to accomplishing the recovery of a species and recovery may be achieved without fully meeting all recovery plan criteria. For example, one or more criteria may have been exceeded while other criteria may not have been accomplished. In that instance, we may determine that, over all, the threats have been minimized sufficiently, and the species is robust enough, to downlist or delist the species. In other cases, new recovery approaches and/or opportunities unknown at the time the recovery plan was finalized may be more appropriate ways to achieve recovery. Likewise, new information may change the extent to which criteria need to be met for recognizing recovery of the species. Overall, recovery is a dynamic process requiring adaptive management, and assessing a species' degree of recovery is likewise an adaptive process that may, or may not, fully follow the guidance provided in a recovery plan. In this 5-year review, we focus our evaluation of species status on progress that has been made in eliminating or reducing the threats discussed in the five-factor analysis since the species was listed (or since the most recent 5-year review). In that context, discussion of the progress in fulfilling recovery criteria is utilized to indicate the extent to which threat factors have been reduced or eliminated.

The *Recovery Plan for Upland Species of the San Joaquin Valley, California* (1998) is the approved final recovery plan that provides recovery criteria for the kit fox. The recovery criteria are not explicitly threats based, but primarily address Factor A through their emphasis on protection of habitat in areas where core and satellite populations are identified. The criteria address the recovery strategy of establishing a viable complex, or viable metapopulation, of kit fox populations on private and public lands throughout the kit fox's geographic range. Recovery criteria are listed separately as criteria for downlisting and for delisting the kit fox. See Appendix 2 for the recovery criteria as they appear in Tables 4 and 5 of the Recovery Plan.

Downlisting criteria - These criteria provide for reclassification of the kit fox to threatened status when the following criteria are met:

1. Secure and protect specified recovery areas from incompatible uses:
    a. The three core populations; Carrizo Natural Area, western Kern County, and Ciervo-Panoche Area.
    b. And three satellite areas.
2. Management plans that include survival of the kit fox as an objective are approved and implemented for all protected areas identified as important to continued survival of the kit fox.
3. Population monitoring in the specified recovery areas shows:
    a. Stable or increasing populations in the three core areas through one precipitation cycle*.
    b. Population interchange between one or more core populations and the three satellite populations.

Delisting Criteria – These criteria provide for delisting of the kit fox. The Recovery Plan states that delisting criteria include meeting all of the downlisting criteria. It also specifies a protection level for the kit fox that provides an extinction probability of 5 percent for 300 years for the entire population of the San Joaquin kit fox (Service 1998, pg 188).

1. In addition to the satellite areas protected under downlisting criteria, secure and protect from incompatible uses several additional satellite populations (number dependent on the results of research) encompassing as much as possible of the environmental and geographic variation of the historic geographic range.
2. Management plans that include survival of the kit fox as an objective are approved and implemented for all protected areas identified as important to continued survival of the kit fox.

3. Population monitoring in the specified recovery areas shows stable or increasing populations in the three core areas and three or more of the satellite areas during one precipitation cycle[*].

The recovery criteria for delisting the kit fox include site-specific objectives for habitat protection in each of the identified core and satellite areas (Service 1998, page 188). In the Carrizo Plains Natural Area (including BLM, CDFG, TNC, and private lands) in San Luis Obispo County, the protection level was set at 100 percent of existing potential habitat. In western Kern County (including BLM, CDFG, Kern County Water Agency, California Department of Water Resources, US Department of Energy, CNLM, and private lands) the protection level was set at 90 percent of the existing potential habitat, and at the Ciervo-Panoche Natural Area (including BLM, CDFG, and private lands) in Fresno and San Benito Counties, the protection level was set at 90 percent of the existing potential habitat. For the nine or more proposed satellite populations, the protection level was set at 80 percent of the existing potential habitat. The term "potential habitat" is not defined in the Recovery Plan; however, the Service expects that to achieve recovery, habitat must include components, such as appropriate physical conditions, vegetative structure and community structure needed by the kit fox.

See Appendix 2 for the satellite areas listed in the Recovery Plan. The actual number of additional satellite populations to be protected was deferred in the plan, and was to be based on pending or future research outcomes. However, the additional sites were to encompass as much as possible of the environmental and geographic variation of the kit fox's historic geographic range. Since the Recovery Plan was written, the core and satellite areas have been refined as described below. A table comparing the satellite areas included in the Recovery Plan with currently delineated satellite areas is included in Appendix 2.

Refinement of core and satellite areas listed in the recovery criteria - The Recovery Plan included core and satellite areas that were selected based on known public lands and known occurrence clusters of the kit fox (Service 1998). Two core areas, the Carrizo Plain Natural area and Western Kern County held large aggregations of public lands, and the largest known extant populations of kit fox. Based on preliminary metapopulation viability analyses, the Ciervo-Panoche area was selected as the third core area to provide increased recovery probabilities. The Ciervo-Panoche area also consisted of large public land holdings and was known to periodically have had substantial numbers of kit fox (Service 1998). Selection of the suggested satellite areas was based primarily on the location of remaining natural lands and the location of known kit fox

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[*] A precipitation cycle is defined as "a period when annual rainfall includes average to 35 percent above average through greater than 35 percent below-average and back to average or greater. The direction of change (average to above or below average) is unimportant in this criterion." A stable population is one in which population size remains statistically the same during the average phase of a precipitation cycle (anticipated to be about 20 years). Increasing population size means that the population has increased over the previous or baseline year, measured during the specified portion of a precipitation cycle. Range-wide population monitoring programs would have to be established for all listed species in the Recovery Plan to measure progress in meeting recovery criteria (Service 1998, pg 179).

occurrences (Cypher pers. comm. 2008). Although the Recovery Plan provided general descriptions of populations, it did not provide either maps or explicit descriptions of most core and satellite area boundaries (S. Phillips, ESRP, *in litt*. 2007). The Carrizo Plains Natural Area was comprised of BLM, TNC, CDFG, and private lands, with a defined boundary. The geographic delineation of the other areas was not precise. However, the glossary provided some additional description of two core areas and one satellite area, as follows. Western Kern County was described to consist of Elk Hills, Buena Vista Valley, Buena Vista Hills, Lokern Natural Area, and the adjacent natural lands. The Ciervo-Panoche Natural Area was defined as the natural lands along the western edge of the Valley and in the contiguous foothills and coastal range, from the Panoche Hills and Valley, in Fresno and San Benito Counties, south to Anticline Ridge near Coalinga, in Fresno County. The Salinas-Pajaro Region was described as the areas of the Salinas River and Pajaro River watersheds with habitat for kit fox. At the time the Recovery Plan was written, 83 percent of the 253,628-acre Carrizo Plains Natural Area was in either public ownership or owned by The Nature Conservancy; however, location of kit fox habitat within the Natural Area was not quantified. Figures 3 and 4 in the Recovery Plan show locations of agricultural, natural, and urban lands; and locations of public land, respectively (Service 1998, pgs. 11 and 21). To date, neither the habitat that was existing potential habitat for the kit fox in 1998, nor the habitat currently present have been mapped or quantified.

Since completion of the Recovery Plan, the recovery team has used ongoing research to define working revisions of core and satellite area and linkages, as envisioned in the 1998 Recovery Plan. The current core and satellite areas are listed in Table 1, and are compared with the core and satellite areas listed in the Recovery Plan in Appendix 2. The current areas are based, in part, on models used to optimize reserve design for the kit fox (Haight *et al*. 2002; Haight *et al*. 2004; Phillips *in litt*. 2007). Figure 1 depicts the current core, satellite, and linkage areas in and bordering the San Joaquin Valley. The Salinas-Pajaro corridor extends between Camp Roberts and the Carrizo Plain (C. Kofron, USFWS Ventura Office, *in litt*. 2008) but specific satellite and linkage areas have not yet been delineated in the portion of this corridor that extends outside of the San Joaquin Valley and the Carrizo Plain Natural Area (Kofron *in litt*. 2008). San Luis Obispo County has recently received funding to initiate an HCP/NCCP process that will lead to identification of lands to be protected for the kit fox (Kofron *in litt*. 2008).

Achievement of downlisting criteria - The first downlisting criterion, to secure and protect the three core populations and three satellite populations from incompatible uses, has not yet been achieved. Since completion of the Recovery Plan, land ownership conditions in Western Kern County, particularly at the NPRC, have changed, resulting in ongoing habitat conservation planning negotiations to protect habitat for the kit fox. A number of lands have been secured within this core area, including lands protected by the Center for Natural Lands Management; Occidental of Elk Hills, Inc.; Pacific Plains and Exploration; CDFG; Kern Water Bank; and Aera Energy LLC, but sufficient protected status for this core area has not yet been achieved. The Carrizo Plains core area is comprised almost entirely of either public or protected lands; however, private inholdings remain in important kit fox habitat within the National Monument. In addition, subsurface mineral rights are privately owned, potentially allowing for oil exploration and development within the Monument (Whitney 2008a, 2008b; BLM 2008c). Therefore the Carrizo Natural Area core area is not yet protected from incompatible uses. The Ciervo-Panoche core area, where solar energy farms are proposed in important valley habitat, is largely in private ownership. Service files indicate that, although lands have been protected in many of the satellite areas though use of HCPs, conservation banks, etc., no satellite areas are sufficiently secured from incompatible uses.

This recovery criterion is up to date. The criterion is expected to reduce or eliminate threats by protecting land from development and irrigated agriculture, major threats to the kit fox. It is critical to conserve the existing native kit fox habitat remaining, especially given the current threats to these remaining areas. However, research reviewed in this document indicates that persistence of substantial kit fox populations appears to be correlated with suitable vegetative structure and an adequate native prey base. Some natural lands may be either suboptimal or marginal kit fox habitat due to loss of native prey species or changes in vegetative structure. Also, although kit fox were once thought to be able to re-occupy farmlands, it now appears that kit fox venture into the margins of agricultural fields to forage, but do not occupy farmlands. Two elements of the Recovery Plan recovery strategy draw on use of retired lands and farmland in achieving recovery of the San Joaquin kit fox (Service 1998, pg. 178). These strategy elements should be used carefully to assure that protected lands provide the conditions needed to sustain or produce a net increase in kit fox. As such, this criterion would be strengthened by including a provision for restoration of habitat to conditions that meet kit fox needs for those cases where suboptimal or marginal lands are used to meet the recovery criterion.

The second recovery criterion requires that all protected lands identified as important to the kit fox's continued survival have management plans that include survival of the kit fox as a management objective. It has not yet been achieved. For example, in Western Kern County, planning groups in the Elk Hills Conservation Area and at the 44,000-acre Lokern Natural Area are working to finalize a draft management plan that will consider kit fox survival and recovery. Participants include Federal and State agencies, land preservation non-profits, and privately-held oil companies, but currently an estimated completion date is lacking. Only the Center for Natural Lands Management and the Pacific Plains and Exploration preserves have management plans that meet the recovery criteria. The BLM's management plan covering BLM lands within the Lokern Natural Area does not provide secure protection for the kit fox, as lands are managed for multiple uses. Chevron USA, Inc. (Chevron), the largest landowner in the Lokern Natural Area, does not yet have a finalized management plan for kit fox. Within the Carrizo Plains core area, the Carrizo Plains National Monument is in the process of revising their management guidelines. When completed, it is expected to include survival of the kit fox as a management objective (BLM 2008l).

This criterion is up to date. Kit fox persistence on protected lands will depend on the implementation of management actions that are designed to achieve kit fox survival. The criterion will help to reduce or eliminate threats to the kit fox in that managing for kit fox survival will require managing to reduce the threats that affect kit fox.

The third criterion stipulates that kit fox populations in the specified recovery areas show that the three core areas have stable or increasing populations through one precipitation cycle and that there is population interchange between one or more core populations and the three satellite populations. This criterion reduces the potential for populations loss due to small population size or stochastic loss, but also measures recovery directly through tracking kit fox survival and abundance. Although the Recovery Plan was completed only 10 years ago, monitoring of kit fox abundance at the NPRC indicates that kit fox populations often undergo significant changes in abundance on an inter-annual basis, dependant on annual precipitation patterns, and may not meet the criteria that populations be stable or increasing over the requisite time period. Population studies of this species began after interannual variability in precipitation increased substantially in the 1970s, so the historic pattern of kit fox population stability is not clear. If future monitoring that is completed at a rangewide scale may meet this criterion, as kit fox that re-establish in protected habitat in more northerly regions may experience different annual precipitation regimes than those at the southern extreme of the range. The extent of population interchange between one or more core populations and the three satellite populations has also not yet been determined.

This criterion is up to date. It is important in that kit fox are cryptic, mobile, upper-level predators that have been substantially reduced in range and that are subject to a variety of interacting threats. Due to these factors, achievement of criteria one and two may not guarantee kit fox recovery; monitoring population numbers is necessary to gauge effectiveness of these criteria. One drawback of this criterion is that in satellite areas such as Fort Hunter Liggett or Camp Roberts, where kit fox have declined precipitously in the last ten years, the Service is not able to determine whether stable or increasing population numbers over a precipitation cycle would bring animal numbers back up to the abundance reported in the early 1990s. A provision that ties this measure to baseline numbers from the 1990s would strengthen the criterion.

IV. SYNTHESIS

The San Joaquin kit fox was listed as endangered in 1967, primarily due to the extensive loss of its native San Joaquin Valley habitat to agricultural development and the observed disappearance of the kit fox from large portions of its historic range. During the period when the kit fox was listed, kit fox were reported from new areas of the San Joaquin Valley and its adjacent valleys, increasing the number of counties in which the kit fox was documented. In the years since the kit fox was listed, loss of natural habitat to agricultural development has continued on the floor of the San Joaquin Valley and in the associated valleys of the Coast Range. Agricultural and urban development now threaten remaining foraging and dispersal habitat along the east and west sides of the valley. Additional threats to kit fox populations have been identified since listing, including competitive exclusion by coyotes and red fox, which may be occurring over portions of the range. Pesticide and anticoagulant rodenticide use pose an unquantified, but potentially significant threat to kit fox populations, both through direct mortality and through loss of prey species. Kangaroo rats, preferred prey for the kit fox, have declined throughout much of the kit fox's range, and several of these species are also federally-endangered.

Agricultural development of kit fox habitat remains the largest threat to the kit fox. Although kit fox were once thought able to inhabit established agricultural fields, subsequent research has shown that kit fox are unable to maintain long-term occupancy in these areas, although they forage into fields at night. Research has also shown that agricultural crops do not generally sustain the prey species and numbers needed to sustain subpopulations of kit fox. Consistent with research, kit fox appear to be excluded from most of the San Joaquin Valley floor. Lands along the periphery of the valley have been increasingly converted to agriculture or developed, leading to loss of additional kit fox habitat and increasing the barriers to movement of kit fox between areas of suitable habitat. Thus, during the time since listing, kit fox distribution has become more fragmented and kit fox subpopulations and family groupings, including subpopulations at Fort Hunter Liggett and Pixley National Wildlife Refuge, appear to become locally extinct in areas of extant natural, and protected, habitat. Habitat fragmentation appears to preclude the recolonization of these areas. Therefore kit fox currently appear to be rare throughout much of their former range.

Kit fox subpopulations in the Western Kern County and Carrizo Plains core areas appear to be most robust, but even these populations have been shown to fluctuate greatly in abundance on an inter-annual basis, depending on climatic conditions. Population modeling using long-term monitoring data has indicated that these subpopulations are at risk of extirpation in as little as 3 or 4 years under poor conditions, such as the poor environmental conditions that reduce prey populations. In these core areas new development, including expanded oil and gas development and the construction of solar farms, threaten new areas of suitable habitat for the kit fox, which may further strain these source populations.

Since listing, kit fox have been increasingly threatened by introduced red fox, which have expanded their range southward from the San Francisco Bay Area. High coyote densities also threaten kit fox where they apparently exclude them from what appears to be otherwise suitable open and protected lands.

The Service and cooperating public, non-profit, and private stakeholders are working to conserve habitat that will adequately sustain the kit fox through the establishment of preserves, conservation banks, and conservation easements. Habitat Conservation Plans have been completed to protect kit fox habitat, while additional HCPs are currently in development, but are not yet complete. However, because the kit fox is a wide-ranging predator, providing habitat conditions that will sustain kit fox populations is complex and also involves maintaining needed prey components that often requires additional restoration activities. Currently, many protected holdings are too small and are too disjunct to support a kit fox family. Also, to date the recovery potential of the Land Retirement Program has not been realized as it was envisioned in the 1998 Recovery Plan, which has limited recovery potential for the species.

Based on the continued loss of kit fox habitat to agricultural and urban development, the continued threats from pesticide exposure, competitive exclusion by other canids, the highly fluctuating population dynamic of most kit fox populations, and the isolation and loss of small subpopulations due to stochastic events and habitat fragmentation, and due to threats identified since listing, such as off-road vehicle use and loss of prey, the kit fox continues to meet the definition of endangered. Although substantial progress has been made in protecting habitat, it is not yet likely that all protected habitat parcels contain the requisite contiguous acreage, vegetative structure, and prey base to adequately sustain kit fox.

V. RESULTS

Recommended Listing Action:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist (indicate reason for delisting according to 50 CFR 424.11):
    ____ *Extinction*
    ____ *Recovery*
    ____ *Original data for classification in error*
__X__ No Change

VI. RECOMMENDATIONS FOR ACTIONS OVER THE NEXT 5 YEARS

1. The 1998 Recovery Plan identified core and satellite areas where subpopulations of kit fox occur. However, baseline mapping and quantification of the extant habitat remaining in each core and satellite area at the time of Recovery Planning has not yet been completed. Mapping efforts that quantify the acreage of suitable/native habitat and altered or degraded habitat in core, satellite, and linkage areas at 1) the time of the 1998 Recovery Plan, and 2) the current time, will assist the Service and other conservation entities in prioritizing conservation strategies and in determining progress in meeting recovery goals for protection of core and satellite areas. The locations, acreage, and quality (or characteristics) of protected habitat could also be compiled and mapped.

2. Studies that assist in determining the population-level effects of contaminants, including first and second generation anticoagulant rodenticides, on kit fox or surrogate species are needed. Studies that test correlations between rodenticide use and kit fox population parameters, measure sublethal effects on behavior, or quantify rodenticide/pesticide effects on availability of prey in relation to the energetic needs of the kit fox would provide information useful to recovery actions.

3. Focus land acquisitions on the establishment of large blocks of land (at least 10,000 acres in size) on the San Joaquin Valley floor and western fringes. Such large parcels are critical to supporting sustainable populations of kit fox for long-term conservation, and should be linked with protected broad dispersal corridors. These acquisitions are most

likely to aid kit fox recovery if they build on existing protected lands to achieve larger expanses of protected land, if acquired lands possess the vegetative structure and native prey base that are associated with thriving kit fox populations, and if acquired lands are not isolated from extant populations of either the kit fox or its prey species. Large holdings of native habitat are also expected to be less suitable for coyotes and red fox that are responsible for high levels of kit fox mortality. Lands no longer suitable for agriculture, such as those targeted for land retirement, may be restored and conserved through fee title acquisition, conservation easement acquisition, or conservation banking arrangements from willing sellers or participants. However, on suboptimal habitat, conservation planning should recognize the lag times inherent in restoration of the ecological community needed to support the kit fox. Linkages will be most effective in contributing to kit fox recovery where they link to habitat that retains the characteristics needed to sustain resident populations.

4. A rangewide census of kit fox should be conducted using a methodology that assures statistically significant data collected for all areas. Collaboration with U.S. Geological Service on methods that utilize occupancy models may be a promising approach, but needs additional consideration. Some biologists have suggested that more northerly satellite areas and/or linkages have become population sinks for the kit fox and this possibility merits further study to determine what factors contribute to population status in these areas, and how these factors may be altered to promote range-wide recovery. The amount of gene flow between subpopulations of the kit fox should be confirmed using appropriate methods, adequate sample size, and inclusion of subpopulations of interest, including isolated groupings in the valley center and subpopulations occurring along the west side of the valley.

5. Consultations on the location of solar facilities may wish to consider lands that are drainage impaired and that may not constitute suitable habitat for the kit fox due to level of groundwater present, condition of site vegetation, presence and density of preferred prey species, and isolation from other suitable habitat. These lands may be a potential alternative to development of solar facilities in areas north of the Carrizo Plain and Panoche Valley.

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Appendix 1

Regional abundance information - Specific kit fox populations were the subject of various research and monitoring efforts between the 1983 and 1998 recovery plans. The kit fox of the NPRC Areas 1 and 2 (Elk Hills and Buena Vista Hills oilfields) and the City of Bakersfield, Kern County (Cypher *et al*. 2000, B.L. Cypher pers. comm., as cited in Service 1998), Carrizo Plain Natural Area, San Luis Obispo County (White and Ralls 1993, Ralls and White 1995), Ciervo-Panoche Natural Area, Fresno and San Benito Counties (Endangered Species Recovery Program, as cited in Service 1998), Fort Hunter Liggett, Monterey County (V. Getz, Jones and Stokes, pers. comm., as cited in Service 1998), and Camp Roberts, Monterey and San Luis Obispo Counties (W. Berry pers. comm., as cited in Service 1998) have all been the focus of research, survey, and/or monitoring projects. 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, and in the Carrizo Plain Natural Area, San Luis Obispo County. 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 – 1983 (Harris 1987), and that fluctuated between 46 and 363 adults from 1983 to 1995 (Warrick and Harris 2001).

Intensive studies of San Joaquin kit fox population baselines and dynamics were conducted on the NPRC as a result of the Service's biological opinion that proposed oil production activities on NPR-1 might jeopardize the continued existence of the kit fox (Service 1995). The intensive studies were to be performed over a defined number of years and they were discontinued subsequent to the 1995 biological opinion, although annual spotlight and scent station monitoring of kit fox has continued (Service 1995; Quad Knopf, Inc. 2008; B. Dixon, Occidental Petroleum, pers. comm. 2009). Cypher *et al*. (2000) used the annual abundance data to model potential population dynamics for the NPRC kit fox. 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. Dennis and Otten (2000) used the same data to model effects of drought on the NPRC population and determined that the population may not be viable in the long term.

Surveys within the Carrizo Plains National Monument (CPNM) have suggested that kit fox abundance there exhibits large variations over time (Bidlack 2007) and that distribution of kit fox within the CPNM has changed substantially over time (Bidlack 2007), and may have become more fragmented (Bean and White 2000). Bean and White (2000) provided an estimated population size of between 251 and 610 individuals within the CPNM although they cautioned that the estimate was not precise, and that the study did not accurately represent the breeding population size because surveys were conducted slightly before the period of juvenile dispersal and its associated high juvenile mortality (Bean and White 2000). They also reported that the population in the northern portion of the Carrizo Plain had become drastically reduced by 2000 possibly due to invasion by dense stands of *Lactuca spp*. (lettuce) and abandonment of extensive kangaroo rat colonies. However, Bidlack (2007) reported that by 2005, she sighted most kit fox along the northern portion of one spotlighting route, while fewer animals were seen in on the southern portion and associated presence with return of kangaroo rat precincts to the north. Management interpretation currently is that changes in vegetative structure and thatch build-up, and hence occupation by kangaroo rats, are likely weather-related cyclic processes on the Carrizo landscape (Saslaw pers. comm. 2008). In total, studies and long-term monitoring here indicate that kit fox abundance is quite variable on an inter-annual basis, and that kit fox here may be vulnerable to extinction over time (Bidlack 2007).

In the central and northern portions of the range there has been no continuous monitoring of kit fox populations; however, individual studies provide information on kit fox occurrence over time. Kit fox were recorded in the late 1980s in the areas near the San Luis Reservoir, Merced County (Briden *et al*. 1992), at the North Grasslands and Kesterson National Wildlife Refuge areas on the Valley floor, Merced County (Paveglio and Clifton 1988; Parris *in litt*. 2007), and in areas of eastern Alameda County, northern Santa Clara County, and western San Joaquin County, and southern Contra Costa County, including the Los Vaqueros watershed, Contra Costa County, in the 1980s and early 1990s (Orloff *et al*. 1986; Getz pers. comm., as cited in Service 1998). At the San Luis NWR, a high of 22 kit fox were observed 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). In addition, surveys using trained dogs indicate that kit fox occasionally occur in suitable habitat between known populations of kit fox (see Schwartz *et al*. 2005). Although 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), individual kit fox have been observed periodically (CNDDB 2008; Mueller *in litt.* 2008).

Since documented, the Camp Roberts and Panoche populations have apparently been relatively small and isolated. The kit fox was first detected in 1960 at the California National Guard Training Site at Camp Roberts in the Salinas River Valley foothills west of the San Joaquin Valley (Balestreri 1981, as cited in White *et al*. 2000), increased in population numbers over the next 20 years, and then began a catastrophic decline in the late 1980s (White *et al*. 2000; Schwartz *et al*. 2005). Since 2002 only two observations of single kit fox, likely migrants, have occurred in the Camp Roberts area (M. Moore *in litt*. 2008), and the most recent data indicate that the resident group has been extirpated (J. Eliason, pers. comm., as cited in Schwartz *et al*. 2005; M. Moore *in litt.* 2008). Likewise, kit fox have disappeared from the Fort Hunter Liggett Military Reservation further north in the Salinas-Pajaro area (Service 2007a; Clark pers. comm. 2008). In contrast, the Panoche subpopulation occurs in a relatively isolated, small valley slightly west of the San Joaquin Valley (Schwartz *et al*. 2005). Habitat loss and fragmentation of populations now make recolonization of areas in the northern and central portions of the range difficult, even when climatic conditions support high productivity and survival of kit fox (Smith *et al*. 2006).

As noted above, San Joaquin kit fox population abundance has been found to fluctuate widely on an inter-annual basis (Harris 1987; Cypher *et al*. 2000; Warrick and Harris 2001, Bidlack 2007). Large fluctuations can occur over relatively short time periods; with the annual finite rate of increase (a measure of the rate of growth of a population) positively correlated with adult reproductive success. For example, at the NPRC, the estimated annual finite growth rate varied from 0.37 in 1995 to 2.22 in 1993 (Cypher *et al*. 2000). Kit fox in non-urban areas experience dramatic annual variation in prey availability, associated with annual variation in precipitation

(Cypher *et al*. 2000; Ralls and Eberhardt 1997). Although some studies have failed to detect a correlation between precipitation levels and annual population abundance of kit fox (Otten and Cypher 1998; Warrick and Harris 2001; Bidlack 2007), other work has shown a correlation with local precipitation using a one or two-year lag time (Cypher *et al*. 2000; Dennis and Otten 2000). Additionally, precipitation patterns over the previous three years may have a cumulative effect on kit fox population trends, with population changes apparently mediated through changes in prey abundance. Both drought conditions and unusually high precipitation levels have been shown to reduce abundance of some prey species (e.g., kangaroo rats) (Cypher *et al*. 2000). At the NPRC, Cypher *et al*. (2000) completed a population projection using the demographic data that they collected, and determined that the study population was vulnerable to extinction within a 10-year time period under several different demographic scenarios, including mean conditions, but was likely to experience sustained population growth under only the most favorable demographic conditions (in this case the population could triple in as little as five years [Cypher *et al*. 2000]).

In contrast with other study populations, the urban Bakersfield population does not appear to be subject to the marked population fluctuations characteristic of other populations (B. Cypher, unpublished data, as cited in Cypher and Frost 1999). Population stability in the Bakersfield population is thought to be due to the relatively-high abundance of California ground squirrels, and to the availability of human-derived food sources that may buffer the kit fox subpopulation from declines in prey availability (Cypher and Warrick 1993; Cypher and Frost 1999).

Survey and Monitoring Methods – Information on kit fox abundance has been gathered by conducting monitoring and population surveys using a variety of methods, including the use of scent-stations with track plates, spotlight surveys, mark-recapture analyses, and scat-detection dog surveys (Ralls and Eberhardt 1997; White *et al*. 2000; Warrick and Harris 2001; Clark *et al*. 2002; Clark *et al*. 2003a, b; Smith *et al*. 2003; Bremner-Harrison *et al*. 2006; Smith *et al*. 2006). Due to small sample sizes and lack of replication, early spotlight surveys provided limited information that could be used to adequately detect changes in kit fox populations (Ralls and Eberhardt 1997; Warrick and Harris 2001). More recent work has indicated that scent-track survey techniques and spotlight surveys are imprecise and are likely only capable of detecting large changes in kit fox populations (White *et al*. 2000; Warrick and Harris 2001). Spiegel and Bowen (In Preparation) found that spotlight surveys were only marginally effective in detecting kit fox, even under optimal conditions. Factors that reduce the precision of spotlight surveys include limits on search distance from the survey vehicle, effects of varying topography on detectibility of kit fox, misidentification of canid species, and availability of road locations (Harris 1987; Bean and White 2000). Spotlight surveys also are not considered optimal for mapping distribution (Smith *et al*. 2005). However, in some cases revision of survey transect placement and methods have been suggested to improve precision of the method (Bean and White 2000).

Mark-recapture methods are generally considered to provide relatively precise measures of populations when sampling is adequate, but can be labor intensive, costly, result in injury to animals, and suffer from low capture success where abundance is low (Finley *et al*. 2005; Smith *et al*. 2005). The use of scat-detection dogs to locate scat of kit fox, followed by DNA analysis of scat material, represents a newer means of determining kit fox distribution and is reported to show promise for indexing population abundance. These methods allow non-intrusive assessment of kit fox presence, and allow discrimination between the scat of kit fox and other fox species (Smith *et al*. 2003, Smith *et al*. 2005). As with other methods, surveys that rely on roadways may be biased to the extent that animal occurrence along roads is representative of animal occurrence on the larger landscape (Bean and White 2000). In areas with known kit fox populations, kit fox have been demonstrated to leave scat on unpaved roadways (Smith *et al*. 2005); however, comparison to use of areas away from roads has not been examined. Smith *et al*. (2006) have the most recent known survey of the kit fox's relative abundance within the southern, central, and northern portions of the kit fox's range. Survey transects utilized scat detection dogs along transects of unpaved roads and in vegetation, primarily on public lands This recent work concludes 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). Several authors conclude that kit fox populations appear to be persistent over the long term in the main core areas (Schwartz *et al*. 2005; Bidlack 2007); however, these conclusions could be biased by the insensitivity of survey methods used and by assumptions that do not account for dispersal between core areas. In summary, the above studies indicate that surveys may not accurately track abundance, depending on the method used.

Denning behavior and dispersal - Biologists have also studied denning behavior and dispersal of the kit fox. Kit fox form pair-mates throughout the year, and the pair-mates continue to associate throughout the year, not just during breeding and pup raising. Pair-bond duration is therefore generally for more than a year; pair-mates that survive to the next breeding season generally remain together (Ralls *et al*. 2007). Loss of pairs-mates to mortality accounted for dissolution of most pair bonds – due to high mortality rates few pairs would be expected to last more than 3 breeding seasons. Kit fox in natural habitats generally suffer from high mortality rates due to interference competition from coyote; death of a pair mate due to predation was the primary reason for pair dissolution (Ralls *et al*. 2007. Ralls *et al*. (2007) conclude that kit fox exhibit a perennial monogamous social system with generally life-long pair bonds. Both parents care for the young. The social system is determined to increase fitness by enhancing survival and reproductive success in these non-migratory, territory-holding animals. Remaining on a well-known territory with familiar dens locations has been shown to decrease predation risk (Cypher and Spencer 1998; McGee *et al*. 2006; but see Koopman *et al*. 2000).

Kit fox appear to disperse readily. Successful dispersal appears to be a key factor for the recovery and survival of kit fox, in large part because kit fox populations are becoming more fragmented and are thought to be approaching a metapopulation structure (Koopman *et al*. 2000) wherein local subpopulations occupy patches of suitable habitat and use the intervening habitat only for movement from one patch to another (Burgman *et al*. 1993). Successful dispersal among subpopulations is often thought to maintain genetic diversity, and to rescue declining populations and prevent extinction (see discussions in Hanski 1999). However, dispersal does have associated costs that may negatively affect species survival in fragmented landscapes (Hanski 1999). For the kit fox, animals traveling to unfamiliar areas are more vulnerable to predation, and dispersing juveniles have been shown to suffer high mortality when traveling outside their natal territory, (Koopman *et al*. 2000). At the NPRC, Koopman *et al*. (2000) found that, overall, 33 percent of juveniles dispersed from their natal territory. While over 65 percent of dispersing kit fox died within 10 days of dispersing, dispersal was not found to have negative consequences on overall survival. Average dispersal was 4.8 miles (range 1.1 to 20 miles). The authors, however, pointed out that their study was conducted within a large area having little urban or agricultural development, and stressed the need for studies of dispersal in natural habitat areas that are fragmented by development. Briden *et al*. (1992) have documented dispersal distances of 1.2 to 12 miles, although four long-distance dispersal events (between 25 and 50 miles) were documented between Camp Roberts and either Fort Hunter Liggett Military Reserve (1) or locations to the southeast as far away as the Carrizo Plains (3) (California Air National Guard 2008).

Appendix 2

Recovery Criteria for the San Joaquin kit fox: Tables 4 and 5 of the Recovery Plan. A crosswalk table provides a comparison of the current core and satellite areas and the core and satellite areas described in Table 5 of the Recovery Plan.

A.

Table 4. **Generalized Recovery criteria for San Joaquin kit fox. Though not explicitly stated, delisting criteria included meeting all of the downlisting criteria.**

Species	Recovery Step	Secure and protect specified recovery areas for incompatible uses	Management Plan approved and implemented for recovery areas that include survival of the species as an objective	Population monitoring in specified recovery areas shows:
San Joaquin kit fox	**Downlist to threatened**	The three core populations, Carrizo Natural Area, western Kern County, and Ciervo-Panoche Area; three satellite populations	For all protected areas identified as important to continued survival	Stable or increasing populations in the three core areas through one precipitation cycle; population interchange between one or more core populations and the three satellite populations
	Delist	Several additional satellite populations (number depending on results of research) encompassing as much as possible of the environmental and geographic variation of the historic geographic range;	For all protected areas identified as important to continued survival	Stable or increasing populations in the three core areas and three or more of the satellite areas during one precipitation cycle

B.

Table 5. Site-Specific Protection Requirements to Meet Delisting Criteria for the San Joaquin Kit Fox. Protection levels apply to any lands specified in the ownership column.

Species	Site Name	County	Ownership	Protection Level
San Joaquin kit fox[1]	Ciervo-Panoche Natural Area western Kern County	Fresno, San Benito, Kern	USBLM/CDFG/private USBLM/CDFG/Kern County Water Agency/California Department of Water Resources/U.S. Department of Energy/Center for Natural Lands Management/private	90 percent of existing potential habitat
	Carrizo Plain Natural Area	San Luis Obispo	USBLM/CDFG/The Nature Conservancy/private	100 percent of existing potential habitat
	Greater than or equal to 9 satellite populations:			80 percent of existing potential habitat
	northern range and Valley edges	Alameda, Contra Costa, San Joaquin, Stanislaus		
	northern Valley floor	Merced, Madera		
	central Valley floor	Fresno		
	west-central Valley edge	Fresno, Kings	various public and private	
	southeast Valley floor	Tulare, Kern		
	Kettleman Hills	Fresno, Kings, Kern		
	southwestern Valley floor	Kern		
	Salinas-Pajaro Rivers watershed	Monterey, San Benito, San Luis Obispo		
	upper Cuyama Valley	Santa Barbara, San Luis Obispo		

[1] protection level: extinction probability of 5 percent for 300 years for entire population of the San Joaquin kit fox.

C. "Crosswalk" table comparing revised core and satellite areas for the San Joaquin kit fox with the core and satellite areas listed in Recovery Plan Table 5. Current core and satellite areas are delineated in Figure 1.

Current Core or Satellite Name	**County**		**Recovery Plan Core or Satellite Area**	**County**
Ciervo-Panoche (C-P)	Fresno, San Benito		Ciervo-Panoche Natural Area	Fresno, San Benito
western Kern County (WK)	Kern		western Kern County	Kern
Carrizo Plain (C)	San Luis Obispo, Kern		Carrizo Plain Natural Area	San Luis Obispo
S1 (Alameda, Contra Costa, San Joaquin)	Alameda, Contra Costa, San Joaquin		Northern range and Valley edges	Alameda, Contra Costa, San Joaquin, Stanislaus
S2 (Western Merced and Stanislaus Counties)	Stanislaus, Merced			
S3 (Central Merced County)	Stanislaus, Merced		Northern Valley Floor[1]	Merced, Madera
S4 (Western Madera County)	Madera, Fresno		Central Valley floor[1]	Fresno
S5 (Southwestern Fresno County)	Fresno		West-central Valley edge	Fresno, Kings
S6 (Southwestern Kings County)	Fresno, Kings		Kettleman Hills	Fresno, Kings, Kern
S7 (Southwestern Tulare County)	Kings, Tulare			
S8 (Tulare County Foothills)	Tulare		Southeast Valley floor[1]	Tulare, Kern
S9 (Northwestern Kern County)	Kern		Southwestern Valley floor[1]	Kern
S10 (Northeast Bakersfield Foothills	Kern			
S11 (Metropolitan Bakersfield)[2]	Kern			
S12 (Cuyama Valley)	Santa Barbara, San Luis Obispo		Upper Cuyama Valley	Santa Barbara, San Luis Obispo
S13 (Salinas-Pajaro)	Monterey, San Benito		Salinas-Pajaro Rivers watershed	Monterey, San Benito, San Luis Obispo

[1] Portions of these satellite areas are also captured in the currently designated linkages that extend between satellite and core areas. See Figure 1 to see linkages.

[2] This satellite area was determined to be an important center for the San Joaquin kit fox based on research that culminated after the Recovery Plan was completed.

Appendix 3

Table 3a. Summary of larger protected* land holdings that provide habitat for the kit fox and associated upland species.

Core or Satellite Area	**A.** Protected site	Ownership	Total acres	Primary threats within the core or satellite are. Protected* lands may be subject to some listed threats	Information source
Carrizo Plain (C)	Carrizo Plain National Monument (inc. ACEC and ER)[1,6]	BLM, TNC, and CDFG	181,620	Potential oil and gas development of surface and subsurface mineral rights, predation-competition, vehicle strikes, largescale solar development, change in vegetative structure.	BLM 2008l; Saslaw pers. comm. 2009; GIN 2009
Western Kern (WK)	Lokern [2,6]	CNLM	3,870	Oil and gas exploration, unauthorized off-road vehicle use, predation-competition, overgrazing, pesticides, vehicle strikes, unauthorized hunting and target practice, urban and residential development, agricultural development	Cypher *in litt*. 2007; Warrick pers. comm. 2009
	Elk Hills Conservation Area (HCP) [2,6]	Oxy	7,800		Service 1995 files; Dixon pers. comm. 2009
	Lokern (HCP)	PXP	312		Service files
	Lokern ER	CDFG	2,118[10]		M. Selmon, CDFG, pers. comm. 2009; M. Selmon, CDFG, *in litt*. 2009; E. Tennant, CDFG, *in litt*. 2009
	Elk Hills Unit	CDFG	516[10]		
	Kern Water Bank Conservation Lands (HCP) [5]	KWB	2,112		Service 1997 files; C. Harding, KWB Authority, *in litt*. 2009
	Coles Levee ER (HCP) [3,4,6]	Aera Energy	5,318[8]		Service files
Ciervo-Panoche (C-P)	Panoche Hills ER [6]	CDFG	580	Predation-competition, oil and gas development, residential and agricultural development, pesticides, vehicle strikes, diseases.	GIN 2009

Appendix 3

Table 3a. Summary of larger protected* land holdings that provide habitat for the kit fox and associated upland species.

Core or Satellite Area	Protected site	Ownership	Total acres	Primary threats within the core or satellite are. Protected* lands may be subject to some listed threats	Information source
S1	Los Vaqueros Reservoir lands	CCWD	4,150	Urban-residential-agricultural development, predation-competition, pesticides, vehicle strikes, barriers to dispersal, reservoir expansion, illegal hunting, increased recreation use	CCWD 2009
	San Joaquin County Multiple Species HCP	San Joaquin County	3,975		S. Mayo, SJCOG, pers. comm. 2009
	East Bay Regional Parks Preserves	EBRP	926[12]		B. Olsen, EBRP, pers. comm. 2009
	Byron Conservation Bank	CDFG	139		G. Van Klompenburg, CDFG, pers. comm. 2009
	Byron Airport Conservation Easement (CE)	CDFG	821		
	Connelly Ranch CE	CDFG	637		
	Crites Ranch CE	CDFG	450		
	Corral Hollow ER	CDFG	99		
	East Contra Costa County HCP	East Contra Costa Conservancy (ECCC)	191		A. Fateman, ECCC, pers. comm. 2009
	Haera Conservation Bank	Wildlands, Inc.	299		Service files

Appendix 3

Table 3a. Summary of larger protected* land holdings that provide habitat for the kit fox and associated upland species.

<table>
<tr><th>Core or Satellite Area</th><th>Protected site</th><th>Ownership</th><th>Total acres</th><th>Primary threats within the core or satellite are. Protected* lands may be subject to some listed threats</th><th>Information source</th></tr>
<tr><td rowspan="5">S2</td><td>Jaspar-Sears mitigation parcel</td><td>CDFG</td><td>272</td><td rowspan="5">Urban-residential-agricultural development, predation-competition, pesticides, vehicle strikes, barriers to dispersal, illegal hunting, increased recreation use</td><td rowspan="2">Van Klompenburg pers. comm. 2009</td></tr>
<tr><td>Salt Creek</td><td>CDFG</td><td>398</td></tr>
<tr><td>Agua Fria Multi-species Conservation Bank</td><td>R. Campion</td><td>137</td><td>Service files</td></tr>
<tr><td>Simon-Newman Ranch CE</td><td>TNC</td><td>~13,000[11]</td><td>D. Olstein, TNC, in litt. 2009</td></tr>
<tr><td>Romero Ranch CE</td><td>TNC</td><td>~9,400[11]</td><td>Olstein in litt. 2009</td></tr>
<tr><td>S3</td><td>San Luis National Wildlife Refuge</td><td>Service</td><td>16,700</td><td>Urban-residential-agricultural development, predation-competition, pesticides, vehicle strikes, barriers to dispersal, illegal hunting, flooding</td><td>K. Forrest, San Luis NWR, in litt. 2007; D. Woolington, San Luis NWR, pers. comm. 2009</td></tr>
<tr><td rowspan="2">S4</td><td>Kerman ER [6]</td><td>CDFG</td><td>1,760</td><td rowspan="2">Urban-residential-agricultural development, predation-competition, pesticides, vehicle strikes, barriers to dispersal, illegal hunting</td><td>GIN 2009</td></tr>
<tr><td>Alkali Sink ER [6]</td><td>CDFG</td><td>945</td><td>GIN 2009</td></tr>
<tr><td rowspan="2">S5</td><td>Kreyenhagen Hills Conservation Bank</td><td>Wildlands, Inc</td><td>1,295</td><td rowspan="3">Oil and gas development, urban-residential-agricultural development, predation-competition, pesticides, vehicle strikes, barriers to dispersal, illegal hunting</td><td>R. Moss, Wildlands, in litt. 2007</td></tr>
<tr><td>Pleasant Valley ER</td><td>CDFG</td><td>1,283</td><td>GIN 2009</td></tr>
<tr><td>S6</td><td></td><td></td><td></td><td>Service files</td></tr>
</table>

Appendix 3
Table 3a. Summary of larger protected* land holdings that provide habitat for the kit fox and associated upland species.

Core or Satellite Area	Protected site	Ownership	Total acres	Primary threats within the core or satellite are. Protected* lands may be subject to some listed threats	Information source
S7	Allensworth ER	CDFG	5,226[7,10]	Urban-residential-agricultural development, predation-competition, pesticides, vehicle strikes, barriers to dispersal, illegal hunting	Selmon *in litt*. 2009; Tennant *in litt.* 2009
	Allensworth Conservation Bank	Wildlands, Inc.	514		Service files
	Pixley NWR	Service	5,410		Service files
	Atwell Island	BLM	7,000		Service files
S8				Urban-residential-agricultural development, predation-competition, pesticides, vehicle strikes, diseases	Service files
S9	Semitrpohic Ridge Preserve [2,6]	CNLM	3,709	Oil and gas development, urban-residential-agricultural development, predation-competition, pesticides, vehicle strikes, illegal hunting	CNLM 2008
	Northern Semitrophic ER [2,6]	CDFG	9,269[10]		Tennant *in litt*. 2009,
	Kern NWR	Service	2,609		Williams *in litt*. 2007
S10	Metro Bakersfield HCP: Hart Park ER	CDFG	134[10]	Oil and gas development, urban-residential-agricultural development, predation-competition, pesticides, vehicle strikes, diseases	Selmon *in litt*. 2009; Tennant *in litt.* 2009
S11				Oil and gas development, urban-residential-agricultural development, predation-competition, pesticides, vehicle strikes, diseases	Service files

Appendix 3

Table 3a. Summary of larger protected* land holdings that provide habitat for the kit fox and associated upland species.

Core or Satellite Area	Protected site	Ownership	Total acres	Primary threats within the core or satellite are. Protected* lands may be subject to some listed threats	Information source
S12	Carrizo Plain NM (inc. ACEC and ER) [1,6]	BLM, CDFG, TNC	16,625	Oil and gas development, urban-residential-agricultural development, predation-competition, pesticides, vehicle strikes, diseases	BLM 2008l; Saslaw pers. comm. 2009; GIN 2009; Service GIS files
S13	Palo Prieto Conservation Bank	CDFG	5,000	Oil and gas development, urban-residential-agricultural development, predation-competition, pesticides, vehicle strikes, diseases	B. Stafford, CDFG, *in litt*. 2007, 2009b
Multi-unit	California Aqueduct Right-of-way (HCP)[6,9]	CDWR	3,474: long linear parcel 150-200 feet wide and miles long	Oil and gas development, urban-residential-agricultural development, predation-competition, pesticides, vehicle strikes, diseases	Service files
Linkages	Deadman Creek Conservation Bank	Wildlands, Inc.	684[7]	Oil and gas development, urban-residential-agricultural development, predation-competition, pesticides, vehicle strikes, diseases	Service files
	Drayer Ranch Conservation Bank	San Joaquin Valley Conservancy	254[7]		Service files
	Great Valley Conservation Bank	Wildlands, Inc.	1, 067[7]		Service files
	Sand Creek Conservation Bank	Wildlands, Inc.	498[7]		Service files
	Vierra-Sandy Mush Road Conservation Bank	CNLM	333[7]		Service files

Appendix 3

Table 3a. Summary of larger protected* land holdings that provide habitat for the kit fox and associated upland species.

Core or Satellite Area	**B.** Protected site	Ownership	Total acres	Primary threats within the core or satellite are. Protected* lands may be subject to some listed threats	Information source
Other	Buttonwillow ER[6]	CDFG	1,366[10]	N/A	Selmon *in litt.* 2009; Tennant *in litt.* 2009

BLM = Bureau of Land Management; CDFG = California Department of Fish and Game; CDPR = California Department of Parks and Recreation; EBRP = East Bay Regional Parks; NM = National Monument; ER = Ecological Reserve; CNLM = Center for Natural Lands Management; WA = Wildlife Area; TNC = The Nature Conservancy: Oxy = Occidental of Elk Hills, Inc.; PXP = Plains Exploration and Production Company; KWB = Kern Water Bank; CCWD = Contra Costa Water District; SJCOG = San Joaquin County Council of Governments; ECCC = East Contra Costa County Conservancy; CDWR = California Department of Water Resources

* Protected lands: Lands under conservation easement, conservation banks, reserves, or preserves with the objective of protecting kit fox habitat in perpetuity.

[1] All or part of the area not managed specifically for SJKF. For example, portions of the Carrizo Plain NM are comprised of rugged terrain not suitable for the kit fox. Also, approximately 20 percent of the Carrizo Plain National Monument is not grazed, or is managed for ungulate species, providing a higher vegetative structure that may make lands marginally suitable or unsuitable for kit fox in at least some years. Within the CPNM approximately 150,000 acres are considered potentially suitable habitat for the kit fox.

[2] Total acres comprised of disjunct parcels of varying acreages. For example, on CNLM's Lokern Preserve, 82 disjunct parcels (maximum size 640 acres) contribute to the total acreage given. Other sites are comprised of 2 or more disjunct parcels. Parcels may be located next to either unprotected lands or lands protected by other entities.

[3] Acreage given is the acreage acquired and protected to date, not the eventual total prescribed by the HCP.

[4] The Coles Levee HCP has changed hands, and the management status of the HCP is currently uncertain.

[5] Retired lands or other non-native habitat, restoration may be in progress.

[6] Kit fox are currently documented to occur on, or directly adjacent to this site. Occurrences may consist of residence, foraging, or dispersal use.

[7] Multispecies bank, including vernal pool species, amount of kit fox habitat is estimated to be a portion of the total presented here.

[8] Acreage given includes lands where oil and gas development may occur.

[9] The right of way is managed as habitat for endangered species, but is not protected by a Conservation Easement.

[10] Acreages estimated via ArcMap data, not as recorded on deeds. Allensworth includes lands set aside under the Metropolitan Bakersfield HCP.

[11] Estimated portion of conservation easements that are most suitable topographically for kit fox. Not managed specifically for kit fox.

[12] Total acreage currently under conservation easements to provide grassland habitat for the San Joaquin kit fox. Approximately 3,600 additional acres of grassland habitat has been secured under the East Contra Costa County HCP, and conservation easements are expected to be completed in 2010. Some of the acreage is already included in calculations of EBRP acreage. Conservation easements in progress include Souza parcels 1 and 2 at Vasco Caves Preserve, Vaqueros Farms, Fox Ridge, and Byron vernal pool holdings

Appendix 3

Table 3b. Public lands* within core and satellite areas. Acreage includes habitat that may serve as primary or dispersal habitat for the kit fox, although suitability of habitat for kit fox varies within acreage provided here. Such lands are not generally subject to large-scale urban, residential, or agricultural development.

Core or Satellite Area	Public Area	Ownership	Total acres	Information source
Carrizo Plain (C)	Bitter Creek NWR and ACEC	Service, BLM	11,279	M. Stockton, Bitter Creek NWR, pers. Comm. 2009; BLM Caliente RMP
Western Kern (WK)	NPR-2, Lokern ACEC	BLM		Service GIS files
	Tule Elk State Reserve	CDPR[4]		B. Moffitt, CDPR, pers. comm. 2009
Ciervo-Panoche (C-P)	Ciervo-Panoche[5]	BLM	97,832	Service GIS files
	Little Panoche Reservoir WA[6]	CDFG	828	B. Cook, CDFG, pers. comm. 2009
S1	Black Diamond Mine, Brushy Peak, Contra Loma, Round Valley, and Vasco Caves Regional Preserves	EBRP	9,950.32[7]	Service GIS files
S2	San Luis Reservoir Recreation Area	USBR (CDPR mgr)	53,500	J. Karlton, CDPR, pers. comm. 2009
	O'Neill Forebay Wildlife Area[3]	CDFG	700	B. Cook, CDFG, pers. comm. 2009
S3	Great Valley Grasslands State Park[3]	CDPR		J. Karlton, CDPR, pers. comm. 2009
S4	Mendota WA[1,2]	CDFG	300	S. Brueggemann, CDFG, pers. comm. 2009

Appendix 3

Table 3b. Public lands* within core and satellite areas. Acreage includes habitat that may serve as primary or dispersal habitat for the kit fox, although suitability of habitat for kit fox varies within acreage provided here. Such lands are not generally subject to large-scale urban, residential, or agricultural development.

Core or Satellite Area	Public Area	Ownership	Total acres	Information source
S5	Panoche-Coalinga	BLM	22,313	Service GIS files
S6	Kettleman Hills	BLM	11,675	Service GIS files
S7	Pixley NWR	Service	5,410[1]	Service files
		BLM	1,068	Service GIS files
S8				
S9		BLM	1,355	Service GIS files
S10		BLM	1,952	Service GIS files
S11		BLM	1	Service GIS files
S12		BLM	16,625	Service GIS files
S13	Big Sandy Wildlife Area	CDFG	850	T. Palmisano, CDFG, pers. comm. 2009; B. Stafford, CDFG, pers. comm. 2009
	Camp Roberts and Fort Hunter Liggett	Camp Roberts and Fort Hunter Liggett	67,000	Service files
Linkages		BLM	14,105	Service GIS files

BLM = Bureau of Land Management; ACEC = Area of Critical Environmental Concern; NWR = National Wildlife Refuge; RMP = Resource Management Plan; NPR-2 = Naval Petroleum Reserve No. 2; GIS = Geographic Information Systems; CDFG = California Department of Fish and Game; CDPR = California Department of Parks and Recreation; EBRP = East Bay Regional Parks; WA = Wildlife Area; USBR = U.S. Bureau of Reclamation

* Public lands that do not have a conservation easement or other agreement for protecting kit fox habitat in perpetuity. Federal lands, however, are subject to limitations on kit fox habitat modification through section 7 of the Federal Endangered Species Act.

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[1]Wetland areas excluded from acreages
[2]Mendota WMA is 12,400 acres in size; however much of it is water or floodplain and not suitable for kit fox habitat. Approximately 300 acres are unmanaged alkali sink-scrub habitat. The rest is managed for wetlands and waterfowl.
[3]Most of the area is managed for the benefit of wetland species and is not suitable for kit fox habitat.
[4]Kit fox are not currently found at this site.
[5]Includes lands with ACEC designation that may provide management to protect and prevent irreparable damage to kit fox habitat. For example. the Kettleman Hills portion of the Ciervo/Coalinga ACEC was closed to OHV travel in 2007 to protect habitat for endangered species, including the kit fox. ACEC lands are open to oil and gas, and geothermal development subject to limitations to protect species.
[6]Kit fox are currently documented to occur on, or directly adjacent to this site. Occurrences may be either residence, foraging, or dispersal use.
[7]Approximate acreage of East Bay Regional Parks within Satellite area 1 boundaries. Includes a portion of acreage listed in Table 3a as being under conservation easement. Total acreage in 5 disjunct regional preserves and parks. Not all acreage is grassland habitat. The East Bay Regional Parks multiple-use mission includes management for native wildlife, including the kit fox.

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW

San Joaquin kit fox (*Vulpes macrotis mutica*)

Current Classification: Endangered

Recommendation Resulting from the 5-Year Review:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
__X__ No change needed

Review Conducted By Sacramento Fish and Wildlife Office Staff

FIELD OFFICE APPROVAL FOR REGION 8:

Lead Field Supervisor, U.S. Fish and Wildlife Service

Approve ______________________ Date 2.16.10

Field Supervisor, Cooperating Field Office, Fish and Wildlife Service

Concur ______________________ Date 2/12/10