

San Joaquin Kit Fox (*Vulpes macrotus mutica*)

Status

State: Threatened

Federal: Endangered

Population Trend

Global: Declining

State: Declining

Within Inventory Area: Unknown



Data Characterization

The location database for the San Joaquin kit fox (*Vulpes macrotus mutica*) within its known range in California includes 22 data records from 1975 to 1999. Of these records, none of the 7 documented within the past 10 years were of sufficient precision to be accurately located within the survey areas. Three of these 7 records are located within the ECCC HCP/NCCP inventory area. These records represent sighting within non-native grassland, grazed, and agricultural habitat. This database includes records of individual sightings and locations of occupied, vacant, and natal dens.

A moderate amount of literature is available for the San Joaquin kit fox because of its endangered status. Long-term studies have been conducted on the ecology and population dynamics of this species in core population centers at the Elk Hills and Buena Vista Naval Petroleum Reserves in Kern County and on the Carrizo Plain Natural Area in San Luis Obispo County. Numerous surveys have been conducted in the northern portion of the range, including Contra Costa County. Quantitative data are available on population size, reproductive capacity, mortality, dispersal, home-range movement patterns, and habitat characteristics and requirements. A number of models have been developed to describe the species' population dynamics. A recovery plan for the San Joaquin kit fox has been published.

Range

The San Joaquin kit fox is found only in the Central Valley area of California. Kit foxes currently inhabit suitable habitat in the San Joaquin valley and in surrounding foothills of the Coast Ranges, Sierra Nevada, and Tehachapi Mountains, from southern Kern County north to Contra Costa; Alameda and San Joaquin counties on the west; and near La Grange, Stanislaus County on the east.

Occurrences within the ECCC HCP/NCCP Inventory Area

Fifty-three occurrences of San Joaquin kit foxes have been documented within the inventory area between 1967 and 1997 (Duke et al. 1997). These records were located from the Black Diamond Mines area and Lone Tree Valley in the north to Round Valley, Los Vaqueros Reservoir, and Brushy Creek in the south (Duke et al. 1997). Fifteen of these records were documented since 1986. The greatest density of occurrences is located in the southern portion of the inventory area. There were two additional records from May 2001 and June 2002 from Vasco Caves Regional Preserve (Clark et al. 2003).

A recent survey of Contra Costa County and Alameda Counties within the known range of the San Joaquin kit fox found no evidence of recent occupancy (Clark et al. 2003). This study used a combination of ground surveys on public lands using trained dogs to find fox scat, and aircraft surveys over the entire area in search of active dens. Detection dogs have been found to be extremely effective and efficient at locating scat of San Joaquin kit fox¹. The identity of all scat found was verified with DNA testing. Despite a total of 139.4 km surveyed by the detection dog in 2002 in Contra Costa and Alameda Counties (81.0 km in Contra Costa County), no sign of San Joaquin kit fox was found. Nine dens were observed on the 4 days of aerial surveys that had the potential to be kit fox dens. Of the six dens that could be field checked, none were active; the remaining dens were on private land or in inaccessible areas. These results do not prove absence of kit fox from the inventory area (e.g., no private land was surveyed with detection dogs), but do suggest that kit fox density is low or their occurrence is periodic in the inventory area.

Biology

Habitat

San Joaquin kit foxes occur in a variety of habitats, including grasslands, scrublands, vernal pool areas, alkali meadows and playas, and an agricultural matrix of row crops, irrigated pastures, orchards, vineyards, and grazed annual grasslands (U.S. Fish and Wildlife Service 1998). They prefer habitats with loose-textured soils (Grinnell et al. 1937, Hall 1946, Egoscue 1962) that are suitable for digging, but they occur on virtually every soil type. Dens are generally located in open areas with grass or grass and scattered brush, and seldom occur in areas with thick brush. Preferred sites are relatively flat, well-drained terrain (U.S. Fish and Wildlife Service 1998, Roderick and Mathews 1999). They are seldom found in areas with shallow soils due to high water tables (McCue et al. 1981) or impenetrable bedrock or hardpan layers (O'Farrell and Gilbertson 1979, O'Farrell et al. 1980). However, kit foxes may occupy soils with a high clay content where they can modify burrow dug by other animals, such as ground squirrels (*Spermophilus beecheyi*) (Orloff et al. 1986).

¹ In tests within the southern portion of their range (where kit fox are more abundant), detection dogs were found to be 100% accurate in species identification (n = 1,298) using DNA tests for confirmation (Smith et al. In Press). Detection dogs are also 4 times more likely to find kit fox scat than trained humans.

In the northern part of its range (including San Joaquin, Alameda and Contra Costa Counties) where most habitat on the valley floor has been eliminated, kit foxes now occur primarily in foothill grasslands (Swick 1973, Hall 1983, U.S. Fish and Wildlife Service 1998), valley oak savanna, and alkali grasslands (Bell 1994). Less frequently they occur adjacent to and forage in tilled and fallow fields and irrigated row crops (Bell 1994). These foxes will den within small parcels of native habitat that is surrounded by intensively maintained agricultural lands (Knapp 1978) and adjacent to dryland farms (Jensen 1972, Orloff et al. 1986, U.S. Fish and Wildlife Service 1998).

Foraging Requirements

The diet of kit foxes varies, with season and geographic locality based on local availability of potential prey. In the northern portion of their range, kit foxes most commonly prey on California ground squirrels, cottontails (*Sylvilagus auduboni*), black-tail jackrabbits (*Lepus californicus*), pocket mice (*Perognathus* spp.), and kangaroo rats (*Dipodomys* spp.) (Hall 1983, Orloff et al. 1986, U.S. Fish and Wildlife Service 1998). Secondary prey taken opportunistically may include ground-nesting birds, reptiles, and insects (Laughrin 1970).

Reproduction

Kit foxes can, but do not necessarily, breed their first year. Sometime between February and late March, 2 to 6 pups are born per litter (Egoscue 1956, Zoellick et al. 1987a, Cypher et al. 2000). The annual reproductive success for adults can range between 20 and 100% (mean: 61%;) and 0 and 100% for juveniles (mean: 18%) (Cypher et al. 2000). Population growth rates generally vary positively with reproductive success and kit fox density is often positively related to both current and the previous year's prey availability (Cypher et al. 2000). Prey abundance is generally strongly related to the previous year's effective (October to May) precipitation.

Longevity

Kit foxes in the wild can live as long as 8 years, but such longevity is rare (U.S. Fish and Wildlife Service 1998). Annual survival rates of juvenile foxes generally range between 21 and 41% (Berry et al. 1987, Ralls and White 1995). In captivity, kit foxes can live up to 10 years (McGrew 1979). The annual natural mortality rate of adults is approximately 50% (Berry et al. 1987, Ralls and White 1995), but is closer to 70% for juveniles (Berry et al. 1987). Coyotes (*Canis latrans*) and other predators (red foxes [*Vulpes vulpes*], domestic dogs, bobcats [*Lynx rufus*] and large raptors) are the primary sources of mortality for adult and juvenile foxes (Hall 1983, Betty et al. 1987b, Ralls and White 1995, Warrick et al. 1999, White et al. 2000, Cypher et al. 2000), and vehicles are usually the secondary cause (Cypher et al. 2000).

Population Dynamics

In a long-term study of kit fox population dynamics at the Naval Petroleum Reserves in California, Cypher et al. (2000), showed that population growth rates vary positively with reproductive success, and population density is positively related to both the current and the previous year's prey availability. Prey abundance was strongly related to the previous year's effective precipitation (October to May).

White and Garrott (1999) note that 2 density-dependent mechanisms appear to regulate kit fox population patterns. The first, the rate of juvenile recruitment, is inversely related to the density of adult foxes because higher proportions of juveniles are generally killed by coyotes at higher fox densities. The mortality rates of adult foxes are apparently independent of population density. The second is that populations of kit foxes are bounded by their territorial spacing behavior, which limits recruitment at higher densities. These mechanisms, therefore, may act together to curtail population growth at high densities, whereas decreased juvenile mortality by coyotes can act independently to increase population growth at low densities.

Density-independent factors, particularly unpredictable fluctuations in precipitation that contribute to high-frequency, high-amplitude fluctuations in the abundance of kit fox prey, can also result in variations in reproductive rates that cause population crashes or eruptions (White and Garrott 1999). Unpredictable short-term fluctuations in precipitation, and in turn, prey abundance could therefore generate longer-term, aperiodic fluctuations in the density of foxes that are independent of special or persistent causes such as predation or disease.

Dispersal

The pups emerge above ground at approximately 1 month of age and some disperse after 4 to 5 months, usually between July and September. In a study of 209 dispersing juveniles, Koopman et al. (2000) found that 33% dispersed from their natal territory, significantly more males (49%) than females (24%). The percentage of male dispersal was weakly related to mean annual litter size, and the percentage of female dispersal was weakly and inversely related to annual small-mammal prey abundance. Most of the dispersing juveniles (65%) died within 10 days of leaving their natal range. However, survival tended to be higher for dispersing males than for males that remained within their natal area. There was no difference in survival for dispersing and philopatric females. Non-dispersing offspring of both sexes may remain with their parents through the following year and help raise the next litter (White and Ralls 1993), but this behavior is not always observed (Koopman et al. 2000).

Behavior

Den Use

San Joaquin kit foxes use numerous dens throughout the year. They are used for temperature regulation, shelter from inclement weather, reproduction, and escape from predators. Hall (1983) documented a family of 7 kit foxes that used 43 dens in 1 year, while 1 other individual used 70 dens (K Ralls, pers. comm. in Williams et al. 1998). Koopman et al. (1998) found that individual foxes within the Naval Petroleum Reserves use an average of 11.8 different dens each year, and den use does not differentiate between sexes. The number of dens used varied among seasons, with more dens used during the dispersal season than during the breeding or pup-rearing seasons. On average, kit foxes used an individual den 10% of the time throughout the year, but favored dens were used 32% of the time. Approximately 50% of the dens used by a kit fox in a 1-year period had not been used by that fox during the previous year. Male and female pups up to 18 months of age denned equally with either adult parent. They denned with siblings for up to 21 months of age. Radio telemetry studies of kit fox movement on the Carrizo Plain Natural Area (White and Ralls 1993) indicate that foxes use individual dens for an average of 3.5 days before moving to a different den. Den changes are believed to be primarily in response to a need to avoid coyotes, although local depletion of prey and increases in external parasites in the dens may also influence this behavior (Egoscue 1956 in Williams et al. 1998).

Movement

Kit foxes may range up to 20 miles at night (Girard 2001) during the breeding season and somewhat less (6 miles) during the pup-rearing season. Home ranges vary from less than 1 square mile up to approximately 12 square miles (Knapp 1978, Spiegel and Bradbury 1992, White and Ralls 1993). The home ranges of pairs or family groups of kit foxes generally do not overlap (White and Ralls 1993). This behavior may be an adaptation to periodic drought-induced scarcity in prey abundance.

Social Structure

Genetic and field studies of kit foxes on the Carrizo Plains Natural Area (Ralls et al. 2001) showed that foxes living in adjacent home ranges tended to be more closely related than foxes from more distant home ranges. This pattern emerged largely because females on adjacent home ranges were often closely related. Foxes that shared the same den were usually members of the same social group, but occasionally foxes from different social groups shared dens, possibly during pair formation. San Joaquin kit foxes can maintain enduring social relationships with adult offspring or siblings that have dispersed to new home ranges and found a mate.

Ecological Relationships

San Joaquin kit foxes prey upon a variety of small mammals, ground-nesting birds, and insects. They are in turn subject to predation or killing by such species as coyote, non-native red foxes, domestic dog, eagles, and large hawks (Hall

1983, Berry et al. 1987, Ralls and White 1995). White et al. (2000) determined that coyotes were responsible for 59% of kit fox deaths during a 4-year telemetry study at Camp Roberts in southern Monterey County.

Threats

Loss, fragmentation, and degradation of habitat by agricultural, urban, and industrial development continues to decrease the remaining habitat and carrying capacity of San Joaquin kit foxes throughout its range. Livestock grazing is not thought to be detrimental to kit foxes (Morrell 1975, Orloff et al. 1986), but it may affect the number of prey species available, depending on the intensity of grazing (U.S. Fish and Wildlife Service 1998). In some areas, livestock grazing may benefit kit foxes by reducing shrub cover and maintaining grassland habitat.

Continued fragmentation of habitat is a serious threat to this species. Increasing isolation of populations and social groups through habitat degradation and barriers to movement, such as aqueducts and busy highways, can limit dispersal to and habitation of existing and former lands. This isolation also favors inbreeding depression in populations, as well as making the smaller populations susceptible to extinction from stochastic environmental events such as droughts, flooding, fire, and periodic declines in prey abundance. Invasion of fragmented, occupied kit fox habitat by coyotes, red foxes, and feral dogs can contribute to increased mortality of kit foxes.

The use of pesticides to control rodents and other pests also threatens kit fox in some areas, either directly through poisoning or indirectly through reduction of prey abundance. Historically, measures such as hunting and rodenticides have been used extensively in the inventory area to control rodents and reduce conflicts with livestock. This has greatly decreased the populations of these species, reducing prey availability for their predators. In 1975, California ground squirrel, which is the main prey item for San Joaquin kit fox in Contra Costa County, was thought to have been eradicated countywide after extensive rodent eradication efforts (Bell et al. 1994; U.S. Fish and Wildlife Service 1998). California ground squirrel populations have been increasing in Contra Costa County since then; however, their abundance may still limit San Joaquin kit fox presence and abundance in the eastern portion of the County (Orloff pers. comm.).

Conservation and Management

The San Joaquin kit fox is listed as both state and federally endangered. A recovery plan for this species was completed in 1983 that outlines objectives to halt the decline of the species and increase population sizes above the 1981 level (U.S. Fish and Wildlife Service 1998). Subsequent conservation actions have included acquisition of important habitat by the U.S. Bureau of Land Management (BLM), California Department of Fish and Game (CDFG), California Energy Commission, Bureau of Reclamation, U.S. Fish and Wildlife Service (USFWS), and Nature Conservancy. Substantial long-term research has

been conducted on populations in the Naval Petroleum Reserves and in the Carrizo Natural Area in southern California. These studies have provided important information on kit fox habitat requirements, behavior, demographics, and threats.

In 1998, a recovery plan for upland species of the San Joaquin Valley was completed (U.S. Fish and Wildlife Service 1998), which included a revised recovery strategy for the San Joaquin kit fox. The goal of this recovery plan is to maintain a viable metapopulation of kit foxes on private and public lands throughout the species' range. This will include preservation of existing core and satellite populations. Areas where core populations are found include the Carrizo Plain Natural Area in San Luis Obispo County; the natural lands of western Kern County, including the Naval Petroleum Reserves, the Lokern Natural Area, and adjacent natural lands inhabited by kit foxes; and the Ciervo-Panoche Natural Area of western Fresno and eastern San Benito Counties. Camp Roberts and Fort Hunter Liggett also provide important habitat for kit foxes in the Salinas and Pajaro river watersheds. Additional lands in the San Joaquin Valley that have kit foxes or the potential to have them include refuges and other lands managed by the CDFG, California Department of Water Resources, Center for Natural Lands Management, Lemoore Naval Air Station, Bureau of Reclamation, and USFWS, as well as various private lands in these areas. While kit foxes have been documented in numerous locations in East Contra Costa County, no conservation areas were identified for this species in the 1998 recovery plan. However, the recovery plan identifies the protection of existing kit fox habitat in the northern portion of its range and protection of existing connections between habitat in Contra Costa County and habitat farther south as primary recovery actions.

Status Assessment

San Joaquin kit foxes are known to occur within the ECCC HCP/NCCP inventory area, with greater numbers occurring in the southern portion of the area. However, compared with populations in southern California, little is known about the ecology and habitat needs of kit foxes in the northern part of their range. Researchers have consistently indicated that the behavioral ecology of kit foxes in this region is poorly known and may be different from the ecology of foxes in the southern part of their range (Laughrin 1970, Swick 1973, Morrell 1975, Orloff et al. 1986, Sproul and Flett 1993, Bell 1994). The northern populations of kit foxes appear to use different prey (ground squirrels instead of kangaroo rats), and their denning habitat appears different (Orloff et al. 1986). In addition, habitat (ground cover, dominant vegetation, land use practices, rainfall, and in some cases relief) is substantially different in the north than in the south, where kit foxes are more abundant and well studied. Because of these differences, some geographic differences may exist in the demographic characteristics of these populations. However, the threats of habitat loss; degradation and fragmentation; predation by coyotes, red foxes, feral dogs, and other predators; and vehicular mortality are likely to be comparable in both regions of their range.

Modeled Species Distribution

Model Description

Assumptions

1. The following land cover types were considered core habitat for the San Joaquin kit fox:

- Annual grassland suitable for all kit fox activities including foraging, denning, shelter and movement corridors that is connected to known kit fox movement routes;
- Oak savanna contiguous with annual grassland;
- Alkali grassland within annual grassland;
- Seasonal wetland within annual grassland or oak savanna;
- Ruderal areas within annual grassland or oak savanna; and
- All wind turbine areas within annual grassland.

2. The following land cover types were considered low use habitat for San Joaquin kit fox:

- Cropland, pasture, and orchard land cover types within 1 mile of core habitat as defined above;
- Ruderal areas contiguous with low-use cropland, pasture, or orchard habitat; and
- 100-feet from suitable core habitat into oak woodlands.

3. Grassland and oak savanna patches isolated from large contiguous tracts of annual grassland by oak woodland or chaparral/scrub were considered non-habitat.

Rationale

Core Habitat: In the northern part of its range (including Contra Costa County), where most habitat on the valley floor has been eliminated, kit foxes now occur primarily in foothill grasslands (Swick 1973, Hall 1983, U.S. Fish and Wildlife Service 1998), valley oak savanna and alkali grasslands (Bell 1994). They prefer habitats with loose-textured soils (Grinnell et al 1937, Hall 1946, Egoscue 1962, Morrell 1972), suitable for digging, but occur on virtually every soil type. Dens are generally located in open areas with grass or grass and scattered brush, and seldom occur in areas with thick brush (Morrell 1972). Preferred sites are relatively flat, well-drained terrain (U.S. Fish and Wildlife Service 1998, Roderick and Mathews 1999). They are seldom found in areas with shallow soils due to high water tables (McCue et al. 1981) or impenetrable bedrock or hardpan layers (Morrell 1975, O'Farrell and Gilbertson 1979, O'Farrell et al. 1980). However, kit foxes may occupy soils with a high clay content where they can modify burrow dug by other animals such as ground squirrels (*Spermophilus beeychii*) (Orloff et al. 1986).

The geographical separation of suitable and unsuitable habitat of annual grassland and oak savanna was based on the location of large tracts of oak woodland separating large contiguous tracts of these land cover types from smaller isolated patches at higher elevations to the west. While kit foxes may occasionally use oak woodland habitat, at least along the margins adjacent to core grassland habitat (Orloff, pers. comm.), they are not likely to frequently pass through these areas due to higher predation potential from other canids (coyotes, gray foxes, red foxes) and reduced prey availability. Isolated patches of grassland and oak savanna beyond these oak woodland tracts were therefore considered not suitable habitat for this species.

Low Use Habitat: San Joaquin kit foxes also less frequently occur adjacent to and forage in tilled and fallow fields and irrigated row crops (Bell 1994, Williams et al. 1997). These foxes will den within small parcels of native habitat that is surrounded by intensively maintained agricultural lands (Knapp 1978) and adjacent to dryland farms (Jensen 1972, Orloff et al. 1986, U.S. Fish and Wildlife Service 1998). Kit foxes are known to use agricultural areas within the inventory area in these ways.

Model Results

Figure 2 shows the modeled potential habitat of the San Joaquin kit fox within the ECCC HCP/NCCP inventory area. The habitat includes approximately two-thirds of the inventory area and is primarily located within the low elevation grassland areas between the agricultural/urban areas in the east and north and the higher elevation foothill areas around Mt. Diablo to the west. The documented occurrences of San Joaquin kit foxes in this area correspond well to locations within the modeled core area habitat.

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