SUITABILITY OF POTENTIAL REINTRODUCTION SITES FOR SAN JOAQUIN KIT FOXES

PREPARED FOR CENTRAL VALLEY PROJECT CONSERVATION PROGRAM

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EXECUTIVE SUMMARY

San Joaquin kit fox (*Vulpes macrotis mutica*) populations have been significantly reduced throughout their historic range in central California, primarily due to profound habitat loss and degradation. As a result, San Joaquin kit foxes are listed as Federally Endangered and California Threatened. Increasing the numbers of both individuals and populations through reintroductions to vacant habitat is one potential recovery strategy. Kit foxes have been extirpated from several locations in the San Joaquin Valley but habitat is still present. Furthermore, large areas of farmland have been "retired" in recent years and could serve as habitat for this species. However, reintroductions of wildlife species should not be attempted without first conducting a comprehensive evaluation of potential reintroduction sites to ensure that they can support a viable population of the species.

We identified 5 potential reintroduction sites for San Joaquin kit foxes. These sites were the Allensworth Ecological Reserve (AER), Pixley National Wildlife Refuge (PNWR), Kern National Wildlife Refuge (KNWR), Wind Wolves Preserve (WWP), and retired agricultural lands in western Fresno County (retired lands). We then conducted a thorough review of available information to determine whether any of the sites was sufficiently suitable to attempt a reintroduction of kit foxes. Our specific objectives were to (1) examine biological variables to assess the potential for successful reintroduction and population establishment at a given site, (2) examine non-biological variables to assess potential anthropogenic impediments to a successful reintroduction, and (3) develop recommendations for possible reintroduction of kit foxes to any of the sites assessed.

For all 5 sites, we identified significant issues that might inhibit the successful reintroduction and establishment of a kit fox population. Only 1 site, the WWP, has a sufficient quantity of habitat within its borders to support a kit fox population of 10 or more breeding pairs. Also, the habitat at all but the WWP site is significantly fragmented. There is sufficient habitat within 10 km of all sites, but much of this again is highly fragmented with poor connectivity. Den availability likely is low at all sites, and food availability, especially kangaroo rats (*Dipodomys spp.*), also may be low. Potential competitors are present at all sites. All of the sites except the retired lands are owned and managed by conservation-oriented organizations, offer protections for kit foxes, and have goals and land uses compatible with kit foxes. Threats from incompatible land uses are relatively low on KNWR and WWP. At least some beneficial habitat management, usually cattle grazing, is present on all sites, although at AER this mostly occurs as an unauthorized trespass activity. Connectivity to other kit fox habitat is low at AER, PNWR, and the retired lands.

Based on our evaluation of biological and administrative attributes at each site, reintroduction of kit foxes is not recommended to any of the sites at this time. With the current attributes, we estimate that the probability of a successful reintroduction effort is unacceptably low. However, the issue of reintroduction can be revisited if conditions improve markedly on any of the sites. To that end, we recommend further habitat acquisitions to increase habitat patch size and create movement corridors, along with the implementation of beneficial habitat management (e.g., grazing) and enhancements (e.g., artificial dens).

INTRODUCTION

San Joaquin kit fox (*Vulpes macrotis mutica*) populations have been significantly reduced throughout their historic range in central California, primarily due to profound habitat loss and degradation. Much of the habitat within their former range was displaced by agricultural, industrial, and urban development, facilitated by the completion of the Central Valley Project and the California Water Project in the early 1970's (U.S. Fish and Wildlife Service 1998).

As a result of this decline, San Joaquin kit foxes are listed as Federally Endangered and California Threatened. Kit foxes currently persist in a meta-population of 3 core populations and several satellite populations of varying size (U.S. Fish and Wildlife 1998). Such population fragmentation increases vulnerability to demographic and stochastic events, thereby increasing the risk of extinction. Thus, it is desirable to increase the numbers of both individuals and populations. Increasing the number of individuals within existing populations might be achieved by mitigating current sources of mortality (e.g., predation by coyotes [*Canis latrans*] and bobcats [*Lynx rufus*]) or enhancing habitat suitability (e.g., vegetation management). Both strategies have their challenges and also could be cost-prohibitive as they both would require indefinite application. Increasing the number of populations also has its challenges, but no further efforts would be necessary once populations were established and self-sustaining.

In recent years, large areas of agricultural lands in the western San Joaquin Valley have been "retired" (Cypher et al. 2007, Ritter and Lair 2007). With the cessation of agricultural activities, some of these lands could be actively restored to habitat, or could revert on their own through natural succession. Thus, they could be available for use by kit foxes, if appropriately managed. Also, kit foxes occasionally are extirpated from smaller patches of fragmented habitat due to annual variations in environmental conditions (e.g., drought, prey availability) or demographic stochasticity (i.e., random changes in survival and reproductive rates). In both situations (retired lands and extirpations), recolonization of these areas by kit foxes may be inhibited by distance from existing populations or a lack of suitable dispersal corridors. In such situations, reintroduction is a potential strategy for re-establishing fox populations in these vacant habitats.

Reintroductions of wildlife species should not be attempted without first conducting a comprehensive assessment of the suitability of potential reintroduction sites (Kleiman 1989, Chivers 1991, Kleiman 1994, IUCN 1995, Kleiman 1996). Such assessments significantly increase the probability of successful population establishment, and are particularly important if the species to be reintroduced is rare. Variables to be assessed on a given site include biological factors such as the quantity and quality of available habitat, availability of food and cover, and presence and abundance of potential competitors and predators, and non-biological factors such as existing and potential human impacts, potential conflicts with adjacent land uses, and any management or conservation strategies being implemented on the site. Of particular importance is determining whether the factors that caused the species to disappear from the site have been mitigated. Site selection and evaluation criteria for kit foxes were thoroughly reviewed by Bremner-Harrison and Cypher (2007).

We identified 5 potential sites for kit fox reintroductions. Kit foxes are not known to currently inhabit any of the sites. We then conducted a thorough review of available information to determine whether any of the sites was sufficiently suitable to attempt a reintroduction of kit foxes. Our specific objectives were to:

1. examine biological variables to assess the potential for successful reintroduction and population establishment at a given site,
2. examine non-biological variables to assess potential anthropogenic impediments to a successful reintroduction, and
3. develop recommendations for possible reintroduction of kit foxes to any of the sites assessed.

SITES ASSESSED

We identified 5 sites to assess for potential kit fox reintroductions (Figure 1). These sites were:

- Allensworth Ecological Reserve in Tulare County
- Pixley National Wildlife Refuge in Tulare County
- Kern National Wildlife Refuge in Kern County
- Wind Wolves Preserve in Kern County
- Private retired agricultural lands in western Fresno County

These sites were selected because they encompassed large areas of potential habitat for kit foxes, and kit foxes are not known to currently occur on any of the sites. Site descriptions are provided in detail in the individual site assessments below.

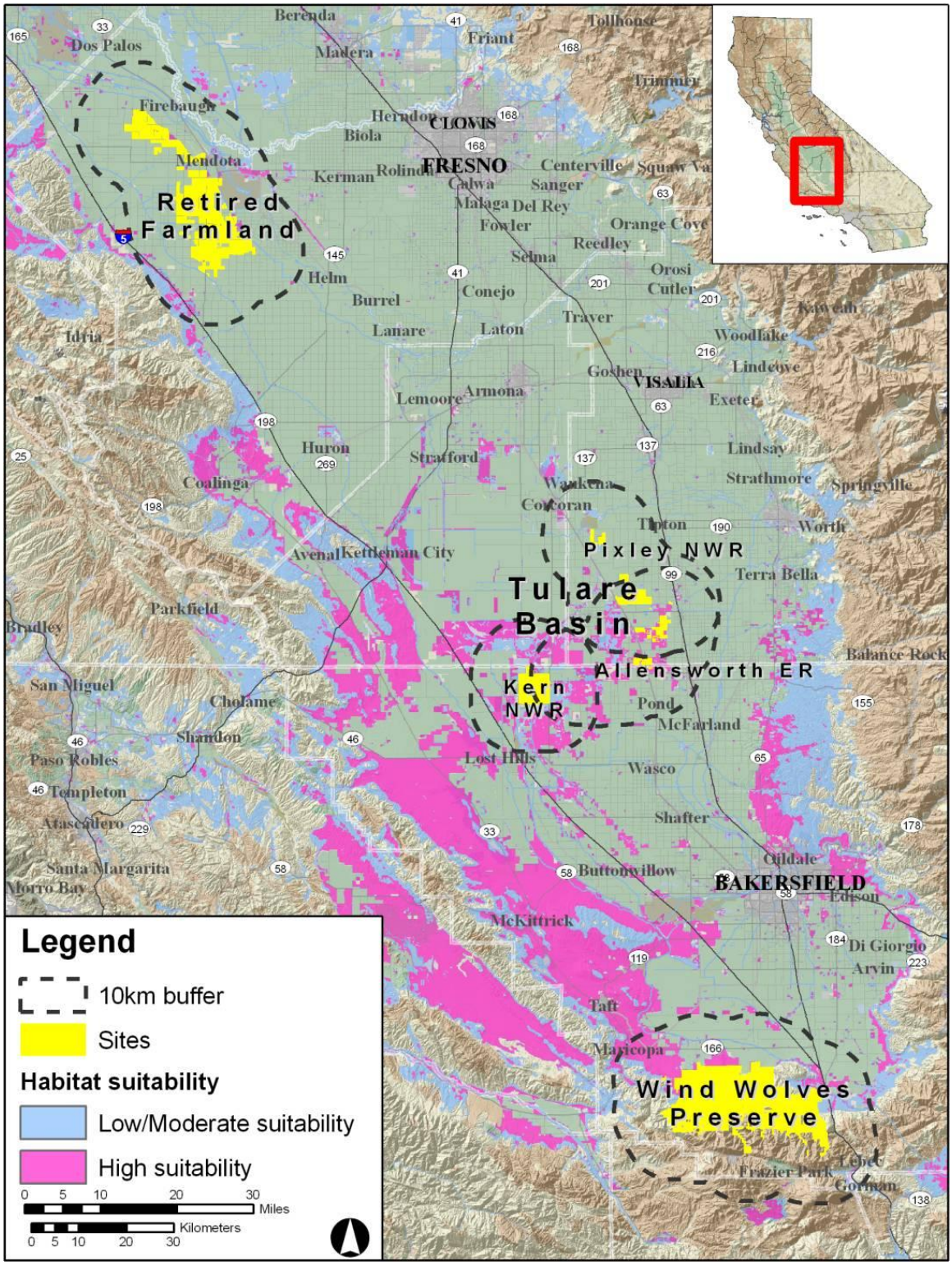

Figure 1. Location of 5 sites in the San Joaquin Valley of California assessed for potential reintroduction of San Joaquin kit foxes.

METHODS

Factors to be considered in assessing the suitability of sites for potential kit fox reintroductions are summarized in detail in Bremner-Harrison and Cypher 2007. These factors include various pertinent administrative and biological attributes, as described below. We conducted assessments of the suitability of sites for potential kit fox reintroductions by compiling and synthesizing information on each of the attributes. We used existing data available for each site. These data came from various sources including published technical reports, internal agency reports and summaries, pre-existing raw data from land managers, and interviews with land managers.

ADMINISTRATIVE ATTRIBUTES

Location – The county where each site is located was provided as was a map of the site.

Ownership – Ownership of sites is particularly important. Kit fox reintroduction has a higher probability of success on lands owned and managed by organizations whose primary mission is the conservation of natural resources. Such organizations could be federal, state, or private. Ideally, any potential reintroduction sites would be conserved in perpetuity. Private lands also have potential as reintroduction sites as long as the lands include long-term protections, such as conservation easements. Other private lands also could contribute to kit fox reintroduction efforts through voluntary participation by landowners or through more formal means such as Safe Harbor Agreements. However, due to the uncertain long-term conservation status of such lands, they should be considered as buffers or expansion areas instead of primary release areas.

Management and land uses – Conservation of natural communities and rare species is the optimal land use for potential kit fox reintroduction sites. This is more likely to ensure minimal disturbance and reduce risks from anthropogenic activities. One caveat to this is that grazing can be a compatible, and indeed even a beneficial, land use. Cattle or sheep grazing that is conducted in a careful and responsible manner generally does not adversely impact kit foxes. Grazing has been conducted for many years on the Carrizo Plain (U. S. Bureau of Land Management 2010) and Lokern area (Germano et al. 2006), both of which are core areas for kit foxes (U.S. Fish and Wildlife Service 1998). Such grazing also may be beneficial by reducing the cover of non-native plants, particularly grasses. Throughout the San Joaquin Valley, non-native species such as red brome (*Bromus madritensis*), ripgut brome (*Bromus diandrus*), and wild oats (*Avena spp.*) have become established and achieve densities that not only exclude native plants (Schierenbeck 1995, Minnich 2008), but also detrimentally affect some rodents (e.g., kangaroo rats [*Dipodomys spp.*]) that are important prey for kit foxes (Single et al. 1996, U.S. Fish and Wildlife Service 1998, Germano et al. 2001). Grazing may reduce the impacts of non-native plants. Certain other land uses (e.g., low density hydrocarbon extraction) might be compatible with kit foxes (Cypher et al. 2000), but would need to be evaluated on a case-by-case basis.

Conservation issues – The potential for issues that could impede or prevent the establishment of a kit fox population should also be addressed. Such issues are anthropogenic in origin and include activities and disturbances both on-site as well as on adjacent properties. Such activities could include hunting (both legal and illegal), the presence of pets or feral animals, off-highway vehicle activity, and other recreational

activities. Activities on adjacent properties could "spillover" onto reintroduction sites. For example, incursions by humans and domestic animals are common near residential areas. Pesticide use on adjacent agricultural lands could impact foxes or their prey. Fencing can help mitigate some issues, but not all.

BIOLOGICAL ATTRIBUTES

Historical and current status of kit foxes – Historically, kit foxes probably used all non-wetland areas on the San Joaquin Valley floor. Such use likely diminished as habitats became more fragmented and adverse anthropogenic influences increased. In the case of all 5 sites assessed, kit fox populations currently are not present. Introducing animals onto sites with resident populations generally is not advisable because the new animals could disrupt and displace residents who are already acclimated to the site or the residents might exclude introduced individuals forcing them into marginal areas or even off the reintroduction site. Even if densities of residents are low, introducing new animals still is not advisable unless the reasons for the low densities are known and can be mitigated. For example, if fox numbers have been markedly depressed by factors such as disease epidemic or a previous drought, then introductions of individuals could help the resident population recover more quickly to a viable level (Bremner-Harrison and Cypher 2007).

If kit foxes are not currently present, then it is imperative to determine the reason or reasons for this absence. Once these reasons are identified, then a determination needs to be made regarding whether these limiting factors can be sufficiently mitigated to permit occupancy by kit foxes. Factors such as poor habitat quality, overly rugged terrain, naturally low prey availability, inadequate acreage, or chronic anthropogenic disturbance may have low or no potential for mitigation. In such cases, the site would not be suitable for kit foxes and reintroduction should not be considered. Factors that have greater potential for mitigation include habitat quality (and possibly prey availability) that has been reduced by non-native plants, an abundance of competitors, insufficient den abundance, and incompatible land use. These factors could potentially be mitigated given sufficient time and resources.

Finally, the duration of absence needs to be considered. If foxes are only recently extirpated, then it is more probable that the factors responsible might be mitigated and that the site might also retain a higher level of suitability due to factors such as the presence of dens. However, if foxes have been absent for a long duration, then this might indicate the presence of a more serious impediment to re-establishment. Furthermore, the site likely will be less suitable due to the absence of dens, which are essential for cover (McGrew 1979, Koopman et al. 1998).

Suitable habitat – The quantity and quality of available habitat on a given site is of paramount importance is assessing the potential for reintroducing kit foxes. Preferred habitat conditions are arid and semi-arid vegetation communities, such as desert scrub and grassland communities (McGrew 1979, U.S. Fish and Wildlife Service 1998, Cypher 2003). While kit foxes can occur in other habitats, their demographic attributes may be less robust in these habitats, which reduces the probability of success for any reintroduction effort. Kit foxes also appear to prefer less rugged terrain due to decreased predation risk (Warrick and Cypher 1998, Cypher et al. 2000). Among foxes relocated to the Naval Petroleum Reserves and released in rugged terrain, many rapidly moved down to more gentle terrain (Scrivner et al. 1993).

The amount of suitable habitat also is extremely important. Each pair of kit foxes requires approximately 600 ha (1,500 ac) in high quality habitat (Nelson et al. 2007). Space requirements can be considerably higher (e.g., over 1,000 ha or 2,500 ac) in lower quality habitat (Cypher 2003). Potential reintroduction sites for kit foxes ideally should be of sufficient size to support at least 10 kit fox pairs (Bremner-Harrison and Cypher 2007). Thus, sites should encompass at least 6,000 ha (15,000 ac) of suitable habitat. Furthermore, this habitat should be contiguous and not fragmented. Habitat available in this quantity and configuration has a greater probability for successful establishment of a sufficient number of kit fox pairs to facilitate appropriate demographic, ecological, and social dynamics leading to a viable population.

In addition to the habitat available on the sites assessed, we also quantified the availability of suitable habitat within 10 km of each site. To accomplish this, we used habitat modeling techniques detailed in Cypher et al. 2007 and Constable et al. 2009. In brief, modeling was conducted by assessing a combination of terrain, current land use, and vegetation density to categorize lands as high, medium or low (essentially non-habitat) quality habitat. This information was expressed as a data layer and GIS analysis was used to determine the quantity of high and medium quality habitat occurring within 10 km of each site.

Available cover in the form of earthen dens should be assessed at any potential reintroduction site. As discussed previously, if a site currently is not occupied by kit foxes and has not been for more than a couple years, the probability is high that there will be few suitable dens present. In the absence of regular use, kit fox dens tend to degrade over time and eventually fill in or collapse. Given the dependency of kit foxes on dens for escape cover, daytime resting cover, avoidance of thermal extremes, moisture conservation, and rearing young (McGrew 1979, Koopman et al. 1998), the presence of dens is critical to the success of any reintroduction effort. Thus, if natural dens are not abundant, artificial dens may need to be installed at the site prior to any fox releases.

Prey availability – Prey availability needs to be evaluated on all potential reintroduction sites to ensure that sufficient food is available to support kit foxes. This is particularly important if the habitat has been altered in any way (e.g., grazed, former agricultural land, restored habitat). If sufficient food is not available, kit foxes are unlikely to remain on a release site, but instead will disperse. The Elk Hills reintroduction effort was conducted during a period when regional prey populations were depressed due to drought, and consequently most of the relocated animals left their release sites (Scrivner et al. 1993). The primary prey for kit foxes in natural areas is nocturnal rodents, particularly heteromyids such as kangaroo rats and pocket mice. Besides nocturnal rodents, kit foxes also will consume ground squirrels, rabbits, birds, various reptiles, and insects (McGrew 1979, Cypher 2003). Thus, assessments should be conducted to ensure that these items (or other suitable foods) are abundant on potential reintroduction sites.

Competitor abundance – The diversity and abundance of potential kit fox competitors and predators also should be evaluated at any potential reintroduction site. Coyotes, bobcats and non-native red foxes (*Vulpes vulpes*) have been identified as potential predators and competitors of kit foxes (Ralls and White 1995, Cypher et al. 2001, Clark et al. 2005, Nelson et al. 2007). Coyotes and bobcats are native and co-occur with kit foxes in many areas. Kit foxes are able to coexist with these competitors through year-round den use, habitat partitioning, and food partitioning (White et al. 1995, Cypher and

Spencer 1998, Nelson et al. 2007), but these strategies are effective only if dens are readily available, habitat composition is heterogeneous, prey are abundant, and competitors are not inordinately abundant. Red foxes are increasing and expanding their range in California (Lewis et al. 1993) and have been observed with increasing frequency in the San Joaquin Valley in the past 2 decades (B. Cypher, personal observation). Red foxes could potentially exclude kit foxes through interference or exploitative competition, but red fox abundance in natural lands also appears to be limited by competition from coyotes (Cypher et al. 2001). Other competitors that may also impact kit foxes include domestic dogs (*Canis familiaris*), domestic cats (*Felis catus*), badgers (*Taxidea taxus)*, raptors, and owls. Fragmented habitats could be particularly problematic in that parcels with habitat may function as refugia thereby concentrating competitor use of such areas and increasing the probability of encounters with kit foxes.

The abundance of species that could potentially transmit diseases to kit foxes is another consideration. Diseases of particular concern include rabies, distemper, and parvovirus (McCue and O'Farrell 1988, Cypher and Frost 1999, Cypher 2003). Other canids (e.g., coyotes, red foxes, domestic dogs) obviously are potential vectors. Other species of concern in the San Joaquin Valley include striped skunks (*Mephitis mephitis*), raccoons (*Procyon lotor*), bats, and domestic cats. In general, disease historically has not been a significant problem for kit foxes, but an inordinate number of vectors at a given site might be cause for some concern.

Connectivity – Any potential reintroduction site should include connectivity to other suitable kit fox habitat thereby allowing a reintroduced population to become part of the kit fox metapopulation. Such connectivity would provide dispersal potential for the reintroduced population, and also would facilitate demographic and genetic exchange with other kit fox populations, all of which would contribute to the long-term viability of the new population (Hilty et al. 2006). Connectivity would be provided by linkage areas consisting of habitat sufficiently suitable and permeable to facilitate kit fox movement.

Conclusions **-** Based on the available information, we developed conclusions and regarding the current suitability of each site for kit foxes and offered recommendations regarding whether an attempted kit fox reintroduction is warranted.

RESULTS

ALLENSWORTH ECOLOGICAL RESERVE

Location and ownership – Allensworth Ecological Reserve (AER, or "the Reserve") is located in Southern Tulare County, approximately 60 km north of Bakersfield, California (Figure 1). AER consists of a patchwork of land parcels that total 2,142 ha. The parcels are owned and managed by the California Department of Fish and Game. The Reserve currently consists of northern and southern portions, which are separated by 3-4 km. Each consists of a relatively large continuous block of land >500 ha as well as some non-contiguous smaller parcels that are intermixed with privately owned conservation, agricultural, and grazing lands.

The first land acquisitions for AER were made in 1980 and 1982 when 3 approximately 65-ha parcels were purchased through the State of California Wildlife Conservation

Board (WCB). These parcels were initially purchased to protect habitat for several listed species including the San Joaquin kit fox, blunt-nosed leopard lizard (*Gambelia sila*), and Tipton kangaroo rat (*Dipodomys nitratoides nitratiodes*). Additional parcels have been added to the Reserve since 1989 through WCB and mitigation acquisitions bringing AER to its current size.

Management and land uses – Currently, access to the AER is relatively open. Many of the parcels comprising the AER are fenced, but some are not. The AER can be accessed by a number of roads, both paved and dirt, and very few of the access points have locked gates. Signage is present along most boundaries, particularly those that front or intersect roads.

Prior land use on the parcels that form AER include farming, channelization of drainages, grazing, off-road vehicle use, hunting, and trash dumping. With the exception of farming and channelization, most of these prior land uses continue on the Reserve, albeit illegally. However, these uses are perhaps not as intensive as they were prior to the legal protection and fencing of the Reserve.

AER was purchased to protect threatened and endangered species, and to minimize disturbance to these species, public access is restricted to wildlife viewing on foot. The Reserve is not officially open to hunting or any other type of public recreation activity. Management objectives for the AER, set forth in a 2003 draft management plan, include maintaining and increasing populations of threatened or endangered species on the Reserve, including the San Joaquin kit fox.

Past and present vegetation management on the AER consists of trespass grazing by adjacent landowners' cattle. This grazing method is generally inconsistent, as portions of the Reserve are grazed at different levels, while other portions are not grazed at all. In the future, CDFG plans to let a grazing lease on the entirety of the AER, thereby allowing staff to better control grazing levels in different sections of the Reserve.

Some mitigation funds are available for management of the AER. However, the majority of properties within the AER were purchased through WCB, and this acquisition process does not provide funds for managing the lands. Thus, depending on allotments from the state general fund, money for management and monitoring activities on the Reserve may be limited.

Adjacent land uses are primarily cattle grazing and agriculture. Within the last 3 years, several parcels bordering the northern portion of the reserve were converted from native habitat to irrigated orchard.

Conservation issues – While the AER is conserved in perpetuity and managed for the protection of sensitive species by CDFG, the relatively small total area, fragmentation, lack of resources for management, and adjacent land uses all could pose a threat to integrity of the Reserve. For example, lack of funds for fencing, patrolling, and vegetation management are an issue. Some parcels have been fenced, but trespass issues continue to plague the Reserve, including the dumping of tires, agricultural waste, and other household trash. Other illegal activities include off-road vehicle use, abandonment of stolen vehicles, hunting, and target shooting. Currently, no formal vegetation management is being conducted, although efforts have been initiated to establish a grazing lease on the property. Some *de facto* management currently occurs due to

trespass grazing, but this grazing is localized and is not managed. This lack of vegetation management may contribute to low small mammal abundance on the AER (see below).

On lands adjacent to the AER, habitat conversion continues to be an issue. This conversion, primarily to agricultural uses, further fragments habitat and reduces overall habitat availability for kit foxes. The number of small ranchettes also has been growing in the area. These ranchettes increase vehicle traffic (often through the Reserve itself) and also increase the abundance of domestic dogs and cats, many of which are free-roaming. In 2006, two dairy facilities were proposed for lands adjacent to the AER. Additional threats come from a high-speed rail line proposed to pass through or near the area. Kit foxes would be excluded from the rail line corridor, which would prevent direct mortality from train strikes, but such exclusion also could function to block movement corridors, unless adequate crossing structures were constructed.

Historical and current status of kit foxes – Kit foxes were once routinely observed in the AER area, although densities were apparently low compared to core areas (e.g., Lokern Natural Area, Carrizo Plain National Monument). Surveys for kit foxes in the area have consisted primarily of occasional spotlighting along established routes. Since 1991, spotlighting surveys have been conducted more regularly by CDFG biologists. The survey route begins near the Northern Semitropic Ridge Ecological Reserve and Kern National Wildlife Refuge and continues for approximately 30 miles, ending near Earlimart. The goal is to survey the route once each season (i.e., fall, winter, spring, and summer), although typically the survey has been conducted approximately twice each year (T. Krocker, CDFG, unpublished data). Kit foxes were observed, usually at a low frequency, until 2004 (Figure 2). No kit foxes have been observed along the route since then.

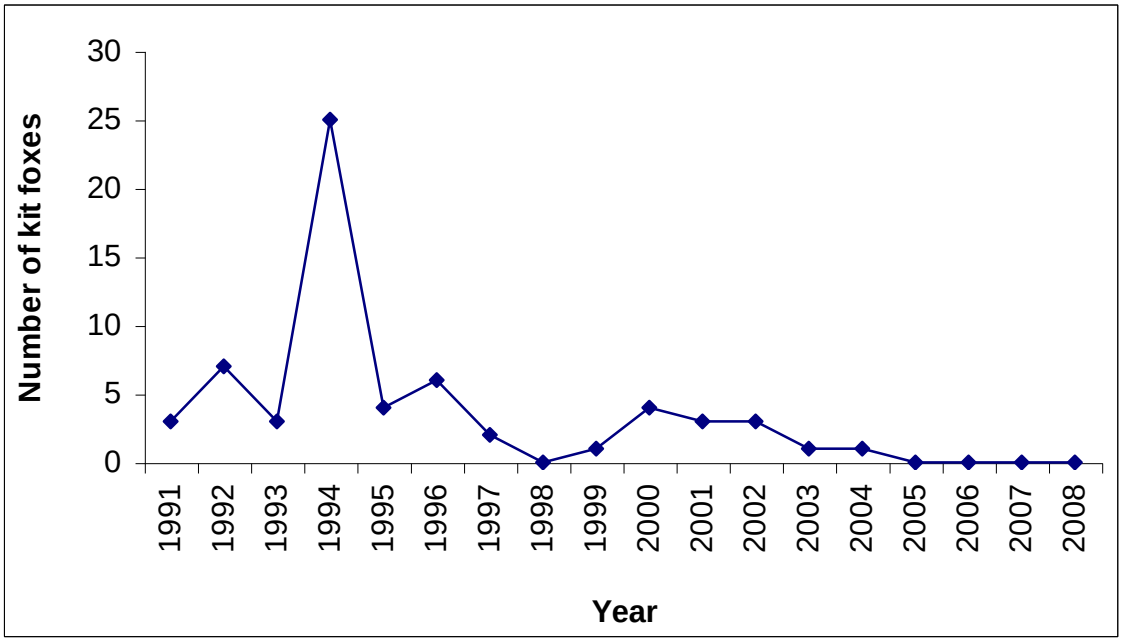

Figure 2. Number of San Joaquin kit foxes observed during spotlight surveys in the Allensworth Ecological Reserve area during 1991-2008.

In 1993, 5 natal kit fox dens were observed on the AER, and 2 were observed in 1994 (Potter 1997). Since 1994, only one kit fox den has been observed, which was in 2004 on the northern part of the Reserve.

The spotlighting data and natal den observations indicate that the highest densities of kit fox were recorded in 1993 and 1994, followed by a rapid decline in observations. The decline in kit foxes numbers in the AER area is likely a function of a catastrophic reduction in their primary prey. In the mid-to-late 1990s, kangaroo rat populations throughout the San Joaquin Valley "crashed," possibly due to unidentified factors (e.g., disease, flooding, unfavorable habitat conditions) associated with several years of high precipitation (Single et al. 1996, Germano et al. 2001). Alternative food sources for kit foxes apparently were unavailable and wide-spread flooding also may have directly impacted foxes.

Suitable habitat – The lands within the AER consist of predominately flat terrain, although some natural and man-made microtopography does exist. Vegetation communities are classified as Valley Sink Scrub, Valley Saltbush Scrub, and Non-native Grassland (Holland 1986). These communities consist of non-native grasses and forbs mixed with desert and spiny saltbush (*Atriplex polycarpa* and *A. spinifera*, respectively), iodine bush (*Allenrolfea occidentalis)*, and bush seepweed (*Suaeda moquinii*). Soils at Allensworth are primarily sandy to fine-loam and typically highly alkali with moderate to poor drainage (NRCS 2003).

AER only encompasses 2,142 ha, which is not sufficient to support a kit fox population. A number of public and private conservation lands occur in close proximity to AER. Colonel Allensworth State Park (ca. 400 ha) is approximately 2 km west of the Reserve, and Pixley National Wildlife Refuge (ca. 2,500 ha) is 5 km north of the Reserve. Intermixed between these protected areas are parcels in private ownership. Some of these parcels have been converted to agriculture, some are primarily rangelands used for cattle grazing, some support small residences or businesses (e.g. junk yards), and some are conservation lands in private ownership. For example, bordering one of the AER parcels in the northern portion of the Reserve is a conservation property owned and managed by Wildlands, Inc. Based on habitat modeling, 31,400 ha of highly or moderately suitable habitat occurs within 10 km of AER (Figure 3). However, much of this habitat is highly fragmented. If larger patches of habitat could be created and connected by functional movement corridors, then the establishment and maintenance of a kit fox population might be possible.

Availability of dens for kit foxes at AER likely is low. The area has received little use by foxes in recent years, and any kit fox dens that may have been present in the past likely are no longer usable. California ground squirrels (*Spermophilis beecheyi*) are abundant on the Reserve, and kit foxes potentially could expand squirrel burrows into dens, although this would take some time. Ten artificial dens were installed on the area in 2009 (Harrison et al. 2011), but more likely would be necessary to provide sufficient refugia for kit foxes.

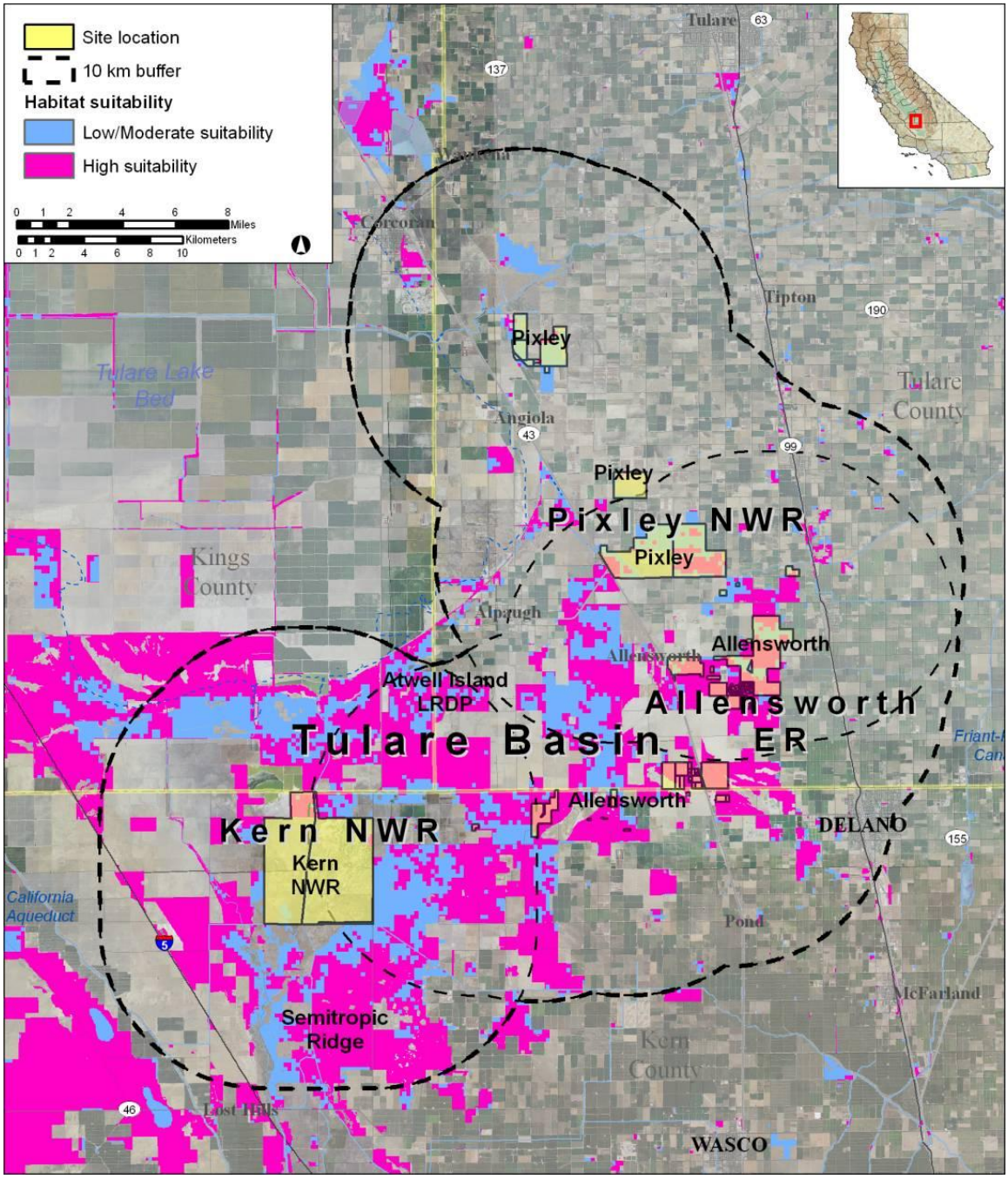

Figure 3. Habitat suitability for San Joaquin kit foxes within 10 km of sites in the Tulare Basin including Allensworth Ecological Reserve, Kern National Wildlife Refuge and Pixley National Wildlife Refuge.

Prey availability – Rodents recorded on AER include Heermann's kangaroo rat (*D. heermanni*), Tipton kangaroo rat (*D. nitratoides nitratoides*), house mouse (*Mus musculus*), southern grasshopper mouse (*Onychomys torridus*), San Joaquin pocket mouse (*Perognathus inornatus*), deer mouse (*Peromyscus maniculatus*), western harvest mouse (*Reithrodontomys megalotis*), and pocket gopher (*Thomomys bottae*). Ground squirrels include the San Joaquin antelope squirrel (*Ammospermophilus nelsoni*) and the California ground squirrel. Two species of rabbit are found in the San Joaquin Valley and AER: the black-tailed jackrabbit (*Lepus californicus*) and the desert cottontail

(*Sylvilagus audubonii*). Reptiles that may be a prey source for kit foxes are the Western whiptail lizard (*Cnemidophorus tigris*), side-blotched lizard (*Uta stansburiana*), coast horned lizard (*Phrynsoma coronatum*), gopher snake (*Pituophis melanoleucus*), and ringneck snake (*Diadophis punctatus*). Common ground-nesting birds found on the Reserve include horned larks (*Eremophila alpestris*), western meadowlarks (*Sturnella neglecta*), and several sparrow species. Potential insect prey on the Reserve include beetles, grasshoppers, and crickets.

Small mammal trapping surveys were conducted at AER on an annual basis during 1993-1996 and 2002-2010 (California Department of Fish and Game, unpublished data). In 1993 and 1994, kangaroo rats were abundant on the Reserve (Table 1). Kangaroo rat populations at AER and across the San Joaquin Valley declined sharply in the mid to late 1990s. Numbers have recovered somewhat in recent years, but kangaroo rats are still patchily distributed at AER.

Table 1. Small mammal trapping survey results at the Allensworth Ecological Reserve during 1993-1996 and 2002-2010. (Source: CDFG, unpublished data)

Date	Area	Kangaroo rats per 100 trapnights	Total rodents per 100 trapnights
Summer 1993	North - multiple grids	66.0	67.0
Summer 1994	North - multiple grids	23.7	27.7
Summer 1995	North - multiple grids	0.5	1.3
Summer 1996	North - multiple grids	0.25	6.3
Fall 2002	North - multiple sites	1.9	2.7
Summer 2003	North and South - multiple sites	2.35	4.2
Summer 2004	North and South - multiple sites	0.7	1.1
Summer 2005	North and South - multiple sites	0.05	0.05
Summer 2006	North - new grids[1]	0.25	0.5
Fall 2006	North - multiple sites	0.27	0.56
Summer 2007	North - translocation area[2]	4.1	N/A
Fall 2007	North - translocation area	3.2	3.2
Fall 2008	North - translocation area	11.8	12.8
Fall 2009	North - translocation area	9.8	10.7
Fall 2010[3]	North - translocation area	9.6	14.5

[1] For this session, DFG reported two trap checks per night as two trap nights. We reduced the number of trap nights by half so that the data were comparable to previous sessions.

[2] In Winter 2006, 144 Tipton kangaroo rats were translocated to a site in north AER.

[3] During 2009-2010, an experimental removal of 43 Heermann's kangaroo rats was conducted as part of a study of Heermann's and Tipton kangaroo rat interactions.

As described previously, spotlighting surveys have been conducted regularly in and around AER since 1991. Prey species also have been recorded on these surveys. Similar to data compiled from small mammal trapping efforts, prey species were most abundant in 1993 and 1994 (Table 2).

Also, surveys were conducted for blunt-nosed leopard lizards from 1994 to present, and all lizards observed were tallied (Table 3). The length of the transect lines were variable, but the reported results provide a gross index of lizard abundance and annual trends. Mostly, the results show that lizards were consistently present on the site. Side-blotched lizards were the species most commonly observed.

The CDFG survey results indicate that various prey for kit foxes are present on the AER. It was not possible from the results to determine whether the prey were sufficiently abundant to support a kit fox population. In particular, kangaroo rat abundance appears to have been low in recent years, although numbers seem to be slowly increasing.

Table 2. Prey species observed during spotlighting surveys conducted on and near the Allensworth Ecological Reserve during 1991-2008. (Source: CDFG, unpublished data)

	Number observed		
Date	Jackrabbit	Cottontail	Kangaroo rat
June 1991	15	2	4
Sept 1991	6	0	5
Apr 1992	6	1	12
Sept 1992	24	5	35
Mar 1993	38	12	43
May 1994	78	9	20
Aug 1994	111	16	4
May 1995	38	5	0
Apr 1996	39	0	0
Jul 1996	12	1	0
Sept 1996	10	0	0
Mar 1997	6	0	0
Aug 1997	3	1	0
Mar 1999	5	4	1
June 1999	6	4	2
Oct 1999	7	15	5
Mar 2000	2	10	0
June 2000	17	28	0
Aug 2000	2	5	0
Dec 2000	14	18	0
Mar 2001	22	10	0
June 2001	24	14	8
Aug 2001	5	1	0
Dec 2001	1	21	0
Mar 2002	12	13	0
Aug 2002	6	0	0
Dec 2002	16	0	2
Mar 2003	21	9	0
May 2003	56	4	1
Aug 2003	0	0	0
June 2004	10	7	2
Aug 2004	3	0	2
June 2005	5	0	0
Aug 2005	7	0	0
June 2007	4	21	39
Mar 2008	8	9	1

Competitor abundance – Data on predator and competitor abundance on the AER have been collected by CDFG staff through spotlighting and camera station surveys. Results

from spotlight surveys indicate that coyotes are consistently present on AER (Table 4). Coyotes also are commonly observed during the day on the Reserve. A number of other canids observed during the spotlight surveys could not be positively identified, but most likely were also coyotes as no other species were identified during the surveys. Other potential competitors that have been periodically observed on the AER include domestic and feral dogs, feral cats, and striped skunks. Most dogs observed were free-ranging pets associated with residences adjacent to the Reserve. Currently, there are no records of non-native red foxes from the AER area.

Table 3. Results of lizard surveys conducted at the Allensworth Ecological Reserve during 1994-2010. (Source: CDFG, unpublished data)

Date	Area / number of survey days	Mean number of lizards per day
1994	North / 10 days	135.2
1995	North / 10 days	66.0
1996	North / 10 days	59.7
1998	North / 3 days	2.7
1999	North / 10 days	41.6
2001	North and South areas / 3 days	61.3
2002	North and South areas / 6 days	34.7
2003	North and South areas / 4 days	83.3
2004	North and South areas / 5 days	67.0
2005	North and South areas / 4 days	42.5
2006	North area / 1 day	16.0
2007	South area / 1 day	27.0
2008	North area / 2 days	51.5
2009	No surveys completed	-
2010	North area / 6 days	109.7

Connectivity – Habitat in and around the AER is not contiguous with other regional kit fox habitat. However, other areas potentially suitable for kit foxes are located in relatively close proximity to the Reserve (Figure 3) and include Pixley NWR (ca. 5 km north), Kern NWR (ca. 20 km southwest), and the Atwell Island Land Retirement Demonstration Project (ca. 5 km west). These areas are well within the movement and dispersal capabilities of kit foxes (Cypher 2003). Parcels with suitable habitat, mostly on private lands, are present between the AER and these other sites, and these parcels could function as "stepping stones" to facilitate kit fox movements between sites. Furthermore, parcels with habitat between AER and Kern NWR are being targeted for acquisition under the Metropolitan Bakersfield Habitat Conservation Plan (MBHCP), and this will eventually improve connectivity between the AER and extant kit fox populations to the southwest (e.g., Northern Semitropic Ridge Ecological Reserve located just south of Kern NWR).

Conclusions - Our analysis suggests that AER may not be suitable for reintroduction of kit foxes at this time for several reasons. A sufficient quantity of suitable habitat currently is not available to support what we estimate to be minimum population size (i.e., 10 pairs) necessary to provide a reasonable probability of persistence. Much of the available habitat currently is highly fragmented and consists of parcels smaller than the mean home range size for even 1 pair of kit foxes. This high degree of fragmentation

produces considerable "edge", whereby natural lands are adjacent to agricultural and developed lands. This increases the potential for external threats. In particular, it increases the probability of incursions into the natural lands by people, domestic animals, and toxins, all of which could have adverse impacts to kit foxes through direct mortality, injury, reduced prey, increased competitors, and disturbance.

Table 4. Potential competitors observed on the Allensworth Ecological Reserve during spotlighting surveys conducted during 1991-2008.

Date	Coyote	Unidentified Candid
June 1991	0	3
Sept 1991	0	1
Apr 1992	0	3
Sept 1992	1	3
Mar 1993	1	1
May 1994	3	6
Aug 1994	1	1
May 1995	0	0
Apr 1996	2	0
Jul 1996	1	1
Sept 1996	1	0
Mar 1997	1	2
Aug 1997	1	2
Mar 1999	0	0
June 1999	1	2
Oct 1999	0	0
Mar 2000	2	1
June 2000	1	5
Aug 2000	0	0
Dec 2000	1	1
Mar 2001	0	0
June 2001	0	1
Aug 2001	3	3
Dec 2001	2	0
Mar 2002	0	0
Aug 2002	5	0
Dec 2002	9	1
Mar 2003	6	0
May 2003	2	0
Aug 2003	2	1
June 2004	2	3
Aug 2004	4	4
June 2005	1	1
Aug 2005	3	4
June 2007	1	4
Mar 2008	2	4

Furthermore, habitat conditions at AER currently are not optimal for kit foxes. Vegetation density can be high on the Reserve, particularly in years with above-average precipitation. Currently, no vegetation management is being conducted on AER. Although some vegetation reduction occurs from trespass grazing, this effect is localized, unregulated, and inconsistent, and therefore does not adequately improve habitat conditions for kit foxes. Possibly as a result of these suboptimal habitat conditions, the availability of prey, particularly kangaroo rats, is inconsistent both temporally and spatially.

Although conditions at AER may not currently be suitable to warrant an attempt to reintroduce kit foxes, this situation could change in the future. Additional lands are being conserved adjacent to and near AER, and eventually a sufficient quantity of suitable habitat may become available to support a population of kit foxes. Additional lands also would reduce edge effects and associated external threats. Furthermore, CDFG currently is working to implement a grazing lease for the AER. Once implemented, this would result in a highly regulated and consistent vegetation management program that would improve and maintain habitat suitability for kit foxes and their prey. Thus, it is possible that a kit fox reintroduction attempt at AER could be warranted in the future.

PIXLEY NATIONAL WILDLIFE REFUGE

Location and ownership – Pixley National Wildlife Refuge (PNWR or "the Refuge") is located in southern Tulare County, approximately 70 km north of Bakersfield, California (Figure 1), near the towns of Earlimart (13 km east) and Alpaugh (13 km west). PNWR consists of approximately 2,584 ha in three main areas, and is owned and managed by the United States Fish and Wildlife Service (USFWS) for both wetland and upland species. While there are some parcels around PNWR remaining in native upland habitat that are privately owned, the majority of the surrounding area is agricultural lands and dairy farms (USFWS 2005).

In the 1920s and 1930s, unclaimed homestead tracks near Pixley, California that were considered marginal for farming reverted to the U.S. government and were eventually turned over to the Department of the Interior (USFWS 2005). In 1959, 1,760 ha were transferred creating Pixley National Wildlife Refuge, which was administered under the Migratory Bird Conservation Act (USFWS 2005). PNWR later consolidated and expanded land holdings to include upland habitat for threatened and endangered species. The Refuge continues to acquire additional lands as opportunities and funds permit.

Management and land uses – All lands within PNWR are fenced and well marked with signs. All access roads into the Refuge have locked gates. Thus, public access to most of the Refuge generally is restricted and is limited to a few visitor facilities such as parking areas, short trails, and wildlife viewing areas.

The western portion of PNWR was once cultivated, and historical remnants of this past use, such as irrigation drainage ditches, are still evident in some areas. Cultivation efforts were eventually abandoned in these areas by the time the lands were purchased by USFWS, possibly due to soil salinity (USFWS 2005). Historical uses of the eastern portion of the Refuge consisted mostly of grazing (USFWS 2005).

As with most national wildlife refuges, a primary function of PNWR is to serve as a migration stopover or over-wintering habitat for birds in the Pacific Flyway (USFWS

2005). Another function is to protect, restore and enhance habitats for threatened and endangered species (USFWS 2005). At PNWR these species include the San Joaquin kit fox, blunt-nosed leopard lizard, and Tipton kangaroo rat.

In 1972, in order to provide for an appropriate grazing program on the uplands, a stock water well was created in the Center Field Unit of the Refuge (USFWS 2005). Currently, there is a managed grazing program on 1,914 ha through a grazing lease. The grazing program on upland areas of PNWR is managed and monitored for the benefit of threatened and endangered species (USWFS 2005; P. Williams, personal communication).

Current land uses on PNWR include managed upland and wetland habitats. Upland habitats important to kit foxes are managed through grazing. Other uses include recreational activities like bird watching on the wetland unit from an observation platform and hiking along short interpretive trail (USFWS 2005). While there are some privately owned parcels around PNWR with native upland habitat, land uses on the majority of the surrounding area is agriculture and dairy farms (USFWS 2005).

Funding for management of PNWR comes from annual federal appropriations for the USFWS, which is part of the Department of Interior. Funding can vary annually, but generally is sufficient each year for most core management activities.

Conservation issues – The PNWR is conserved in perpetuity and managed for the protection of sensitive species by USFWS. The total area is relatively small and the Refuge lands are somewhat fragmented. This increases the amount of edge and the potential for trespass issues. However, Refuge parcels are primarily bordered by small farm roads, which are actively used by local farmers. Consequently, trespass frequency appears to be low (P. Williams, personal communication). Some vandalism and dumping does occur on the refuge, but incidents are infrequent and primarily occur along a main county road. As opportunities and funding become available, the Refuge is attempting to increase parcel size and decrease fragmentation by acquiring additional nearby lands.

On lands adjacent to PNWR, habitat conversion continues to be an issue. This conversion, primarily to agricultural uses, further fragments habitat and reduces overall habitat availability for kit foxes.

Historical and current status of kit foxes – Similar to the AER area, kit foxes have occurred historically in the PNWR area, but densities apparently are generally low compared to core areas (e.g., Lokern Natural Area, Carrizo Plain National Monument). Kit foxes were regularly observed on the Refuge in the early 1990s (Figure 4), including several family groups with pups indicating that kit foxes were reproducing in the area (P. Williams, USFWS, unpublished data). Kit fox observations dropped off sharply after 1993. This may have been partly related to a significant reduction in spotlighting efforts after that year. However, continued low numbers after that likely were related to a significant regional decline in kangaroo rat abundance (Single et al. 1996, Germano et al. 2001). From 1996-2000, only 15 kit fox sightings were recorded during spotlight surveys on the Refuge (USFWS 2005). The last known kit fox den on PNWR was found in the summer of 1996 on the Deer Creek East section of the Refuge (P. Williams, USFWS, unpublished data). This was a natal den with 3 pups. In 1999 during a spotlight survey, two foxes were detected in the wetland unit (P.Williams, unpublished data), and this was the last record of a kit fox on PNWR. The lack of recent sightings suggests that the population has not recovered.

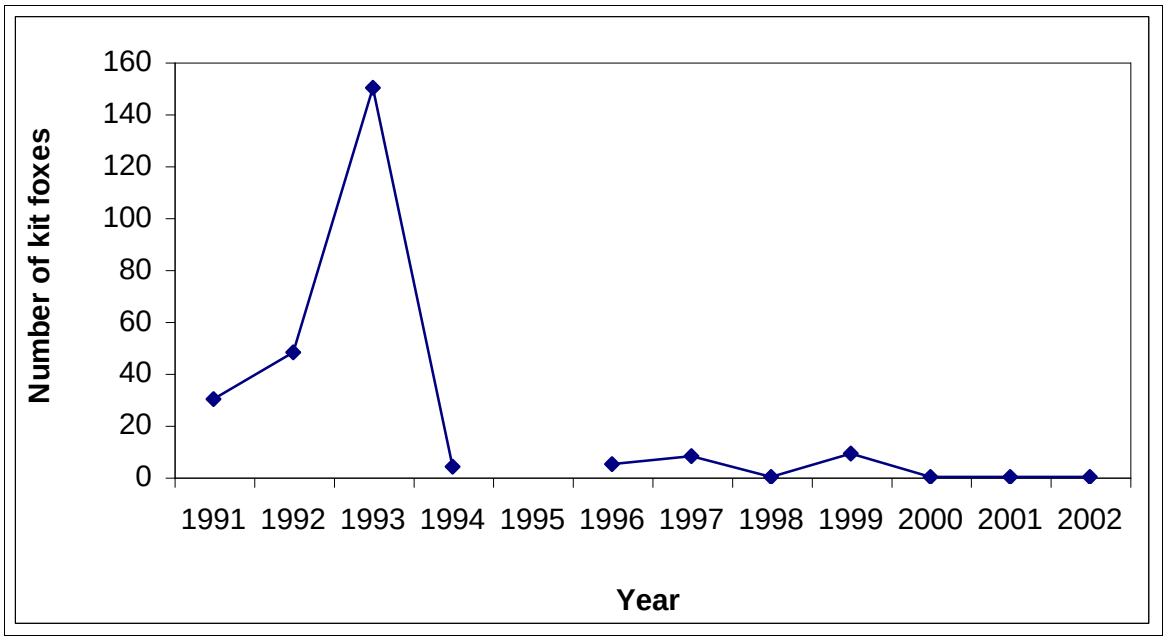

Figure 4. Number of San Joaquin kit foxes observed during spotlight surveys in the Pixley National Wildlife Refugre area during 1991-2002.

Suitable habitat – The lands within PNWR consist of predominately flat terrain, although some natural microtopography does exist. Approximately 74% of the habitat consists of non-native annual grassland (Holland 1986, USFWS 2005). Other habitat types include wetland, riparian, alkali playa, northern claypan vernal pool, and valley saltbush scrub (Holland 1986, USFWS 2005). The non-native annual grassland community has a mix of non-native grasses and forbs such as red brome (*Bromus rubens*) red-stem filaree (*Erodium cicutarium*), mixed with some native forbs such as alkali heath and common spikeweed (*Hemizonia pungens*). Aalkali goldenbush (*Isocoma acradenia*) is sparsely distributed in some areas of the grassland community. The Valley saltbush scrub community is dominated by desert saltbush, iodine bush, and bush seepweed. Other habitat types have low or no suitability for kit foxes. Soils at PNWR are primarily sandy, silt, or clay loam and typically are highly alkali with moderate to poor drainage (NRCS 2003, USFWS 2005).

PNWR only encompasses 2,584 ha, which is not sufficient to support a kit fox population. A number of public and private conservation lands occur in close proximity to PNWR. For example, the Bureau of Land Management's Atwell Island Land Retirement Demonstration Project (ca. 2,700 ha) is approximately 10 km to the southwest and Colonel Allensworth State Park (ca. 400 ha) is approximately 5 km to the southwest. The northern portion of Allensworth Ecological Reserve is approximately 5 km to the south. Kern NWR (ca. 4,300 ha), also managed by USFWS, is approximately 25 km southwest of PNWR. Intermixed between these protected areas are parcels in private ownership. These parcels have a variety of land uses including agriculture, cattle grazing, residences, and small businesses (e.g. junk yards) while some are conservation lands in private ownership. Based on habitat modeling, 13,600 ha of highly or moderately suitable habitat occurs within 10 km of PNWR (Figure 3). However, much of

this habitat is highly fragmented. If larger patches of habitat could be created and connected by functional movement corridors, then the establishment and maintenance of a kit fox population might be possible.

Availability of dens for kit foxes at PNWR likely is low. The area has received little use by foxes in recent years, and any kit fox dens that may have been present in the past likely are no longer usable. California ground squirrels are abundant on the Refuge, and kit foxes potentially could expand squirrel burrows into dens, although this would take some time.

Prey availability – Rodents recorded on PNWR include Heermann's kangaroo rat, Tipton kangaroo rat, house mouse, southern grasshopper mouse, San Joaquin pocket mouse, deer mouse, western harvest mouse, pocket gopher, and California ground squirrel. Black-tailed jackrabbits and desert cottontails are common. Reptiles that may be a prey source for kit foxes include western whiptail lizard, side-blotched lizard, coast horned lizard, gopher snake, and California kingsnake (*Lampropeltis getula*), western long-nosed snake (*Rhinocheilus lecontei*), and southwestern black-headed snake (*Tantilla hobartsmithi*). Common ground-nesting birds on PNWR include horned larks, western meadowlarks, and several sparrow species (USFWS 2005). Potential insect prey on the Refuge include beetles, grasshoppers, and crickets.

Small mammal trapping surveys have been conducted on PNWR and were conducted regularly from 1992-2002 (Table 5). In 1992 and 1993, kangaroo rats were abundant on the Refuge. Kangaroo rat populations at PNWR and across the San Joaquin Valley declined sharply in the mid to late 1990s. Numbers have recovered in other locations, but appear to still be low on the Refuge.

Spotlight surveys were conducted on PNWR in 2009 and 2010 (Table 6). Observations of potential prey included kangaroo rats, pocket mice, jackrabbits, and cottontails.

Competitor abundance – Relatively few data are available on the abundance of potential competitors at PNWR. Spotlight surveys were conducted on the Refuge in 2009 and 2010 (Table 7). Observations of potential competitors included coyotes, striped skunks, badgers, and cats. Currently, there are no records of non-native red foxes from the PNWR area.

Connectivity – Habitat in and around PNWR is not contiguous with other regional kit fox habitat. However, other areas potentially suitable for kit foxes are located in relatively close proximity to the Reserve (Figure 3) and include Allensworth Ecological Reserve (ca. 5 km south), Kern NWR (ca. 25 km southwest), and the Atwell Island Land Retirement Demonstration Project (ca. 10 km southwest). These areas are well within the movement and dispersal capabilities of kit foxes (Cypher 2003). Parcels with suitable habitat, mostly on private lands, are present between the AER and these other sites, and these parcels could function as "stepping stones" to facilitate kit fox movements between sites.

Table 5. Small mammal trapping survey results at Pixley National Wildlife Refuge. (Source: USFWS, unpublished data)

Date	Area	Kangaroo rats per 100 trapnights	Total rodents per 100 trapnights
1981	Deer Creek East	8.25	8.33
Summer 1991	Deer Creek East	1.16	1.84
Summer 1992	Two Well	7.57	N/A
	Deer Creek	15.27	N/A
Fall 1992	Two Well	9.23	N/A
	Deer Creek	21.24	N/A
	NW Two Well	13.37	N/A
Spring 1993	Two Well	10.89	N/A
	Deer Creek	22.19	N/A
	NW Two Well	17.93	N/A
Fall 1993	Two Well	12.96	N/A
	Deer Creek	22.43	N/A
	NW Two Well	17.51	N/A
Spring 1994	Two Well	6.65	N/A
	Deer Creek	10.47	N/A
	NW Two Well	10.59	N/A
Fall 1994	Two Well	1.65	N/A
	Deer Creek	3.60	N/A
	NW Two Well	2.26	N/A
Spring 1995	Two Well	0	N/A
	Deer Creek	0.43	N/A
	NW Two Well	0.37	N/A
Fall 1995	Two Well	0	N/A
	Deer Creek	0.49	N/A
	NW Two Well	0.43	N/A
Fall 1997	Deer Creek East	0.19	N/A
Winter 1998	Deer Creek East	0	0.10
Fall 1998	Deer Creek East	0.94	2.36
Winter 1999	Deer Creek East	0.87	1.94
Spring 1999	Deer Creek East	0.49	1.65
Summer 1999	Deer Creek East	1.55	3.30
Summer 2000	Deer Creek East	0	0.09
Summer 2001	Deer Creek East	0.27	0.71
Fall 2001	Deer Creek East	0.09	0.09
Summer 2002	Deer Creek East	0.18	0.35
Fall 2002	Deer Creek East	0.20	0.50
Fall 2010	Deer Creek East	0.83	1.39

Table 6. Potential prey species observed during spotlighting surveys at Pixley National Wildlife Refuge in 2009 and 2010. Numbers are combined results from surveys in 3 units of the Refuge: Deer Creek/Center Field, Horse Pasture, and Los Felix units.

	Number observed			
Date	Kangaroo rat	Pocket mouse	Cottontail	Jackrabbit
July 2009	30	1	62	5
Aug 2010	25	0	31	4

Table 7. Potential competitor species observed during spotlighting surveys at Pixley National Wildlife Refuge in 2009 and 2010. Numbers are combined results from surveys in 3 units of the Refuge: Deer Creek/Center Field, Horse Pasture, and Los Felix units.

	Number observed			
Date	Coyote	Striped skunk	Badger	Cat
July 2009	6	2	4	6
Aug 2010	16	12	2	2

Conclusions **-** Our analysis suggests that PNWR may not be suitable for reintroduction of kit foxes at this time for several reasons. A sufficient quantity of suitable habitat currently is not available to support what we estimate to be a minimum population size (i.e., 10 pairs) necessary to provide a reasonable probability of persistence. Much of the available habitat currently is fragmented and consists of parcels smaller than the mean home range size for even 1 pair of kit foxes. This fragmentation produces considerable "edge", whereby natural lands are adjacent to agricultural and developed lands. This increases the potential for external threats. In particular, it increases the probability of incursions into the natural lands by people, domestic animals, and toxins, all of which could have adverse impacts to kit foxes through direct mortality, injury, reduced prey, increased competitors, and disturbance.

Current vegetation management being implemented on PNWR should benefit potential prey for kit foxes, particularly kangaroo rats. However, for reasons not yet clear, kangaroo rat abundance appears to be quite low and likely is not sufficient to support a population of kit foxes.

Although conditions at PNWR may not currently be suitable to warrant an attempt to reintroduce kit foxes, this situation could change in the future. Additional lands are being conserved adjacent to and near the Refuge, and eventually a sufficient quantity of suitable habitat may become available to support a population of kit foxes. Additional lands also would reduce edge effects and associated external threats. Also, kangaroo rat abundance may eventually increase on the Refuge. Thus, it is possible that a kit fox reintroduction attempt at PNWR could be warranted in the future.

KERN NATIONAL WILDLIFE REFUGE

Location and ownership – Kern National Wildlife Refuge (KNWR or "the Refuge") is located in northern Kern County, approximately 30 km west of Delano, California (Figure 1). KNWR consists of one large unit encompassing approximately 4,552 ha. The Refuge is owned and managed by the United States Fish and Wildlife Service.

KNWR was established in 1958 under the authority of the Migratory Bird Conservation Act (USFWS 2005). Historically, the Allison Holland Company owned the 16 sections of land that became the Refuge and leveled and bermed the area for farming small grain crops. The Refuge was established as a wintering ground for migratory birds on the Pacific Flyway and to provide an opportunity for public waterfowl hunting. An additional 255 ha of upland habitat was acquired in 2006 as part of mitigation for Delano Prison II (USFWS 2005). The Refuge continues to acquire additional lands as opportunities and funds permit.

Management and land uses – All lands within KNWR are fenced and well-marked with signs. Access roads into the Refuge have locked gates. Thus, public access to most of the Refuge generally is restricted and is limited to a few visitor facilities such as parking areas, short trails, an auto tour, and wildlife viewing areas. Additional Refuge lands are opened to public access during the fall waterfowl hunting season.

Historically, much of the area was farmed for small grain crops or used for grazing. Numerous levees and canals were constructed to facilitate water distribution and drainage. Development of KNWR involved creating or improving habitat for waterfowl. Development activities included creating drilling deep water wells, constructing or renovating levees to create seasonal wetlands, constructing water delivery and control structures, and constructing road and support facilities (USFWS 2005).

As with most national wildlife refuges, a primary function of KNWR is to serve as a migration stopover or over-wintering habitat for birds in the Pacific Flyway. Under a Master Plan developed in 1986 and Conservation Plan finalized in 2005, management objectives include: creating and maintaining quality wetland habitat for migratory birds, with an emphasis on waterfowl and water birds; protecting threatened and endangered species and enhancing their habitats; and providing quality wildlife-related recreational opportunities (USFWS 2005). Consequently, with the emphasis on wetland birds, much of the Refuge is managed for habitat that is not suitable for kit foxes. However, upland habitat is present on some portions of the Refuge and these areas are managed for threatened and endangered species, such as the San Joaquin kit fox, blunt-nosed leopard lizard, and Tipton kangaroo rat.

Current land uses on KNWR include managing both wetland and upland habitats. Upland habitats important to kit foxes are managed through a closely monitored grazing program. The Refuge also has an aggressive control program for invasive non-native plants. Public uses include recreational activities like waterfowl hunting and wildlife viewing (USFWS 2005). Considerable upland habitat is present on lands adjacent to KNWR. These lands generally are used for cattle grazing. Other land uses adjacent to the Refuge include agriculture (primarily row crops) and waterfowl hunting. Conserved or created wetlands are present on many parcels near the refuge and many of these are owned and managed by private duck clubs.

Funding for management of KNWR comes from annual federal appropriations for the USFWS, which is part of the Department of Interior. Funding can vary annually, but generally is sufficient each year for most core management activities.

Conservation issues – KNWR is conserved in perpetuity and managed in part for the protection of sensitive species by USFWS. Refuge lands are consolidated into a large contiguous block, and therefore, fragmentation is not an issue and edge effect is minimal. The Refuge is well fenced and signed, and trespass frequency appears to be low (P.

Williams, USFWS, personal communication). As opportunities and funding become available, the Refuge is attempting to increase parcel size and decrease fragmentation by acquiring additional nearby lands. On lands adjacent to KNWR, some habitat conversion may still occur, primarily to agricultural uses. Such conversion could reduce overall habitat availability for kit foxes.

Historical and current status of kit foxes – Similar to the AER and PNWR areas, kit foxes have occurred historically in the KNWR area, but densities apparently are generally low compared to core areas (e.g., Lokern Natural Area, Carrizo Plain National Monument). Kit foxes were regularly observed on the Refuge in the early 1990s (Figure 5), including several family groups with pups, indicating that kit foxes were reproducing in the area (P. Williams, USFWS, unpublished data). Kit fox observations dropped off sharply after 1994. However, continued low numbers after that likely were related to a significant regional decline in kangaroo rat abundance (Single et al. 1996, Germano et al. 2001). Three kit foxes were relocated to KNWR from Bakersfield in 1994, but their fate after release is unknown. Kit foxes continued to be observed on or near the Refuge in most years, although unfortunately, a number of these observations were animals struck and killed by vehicles on roads near the Refuge (USFWS, unpublished data). There has been no evidence of kit foxes residing on KNWR in at least a decade and many of the sightings in the 2000s were on lands near the Refuge. Sightings in recent years may primarily consist of dispersers originating on CDFG and CMLM lands just to the south of the Refuge.

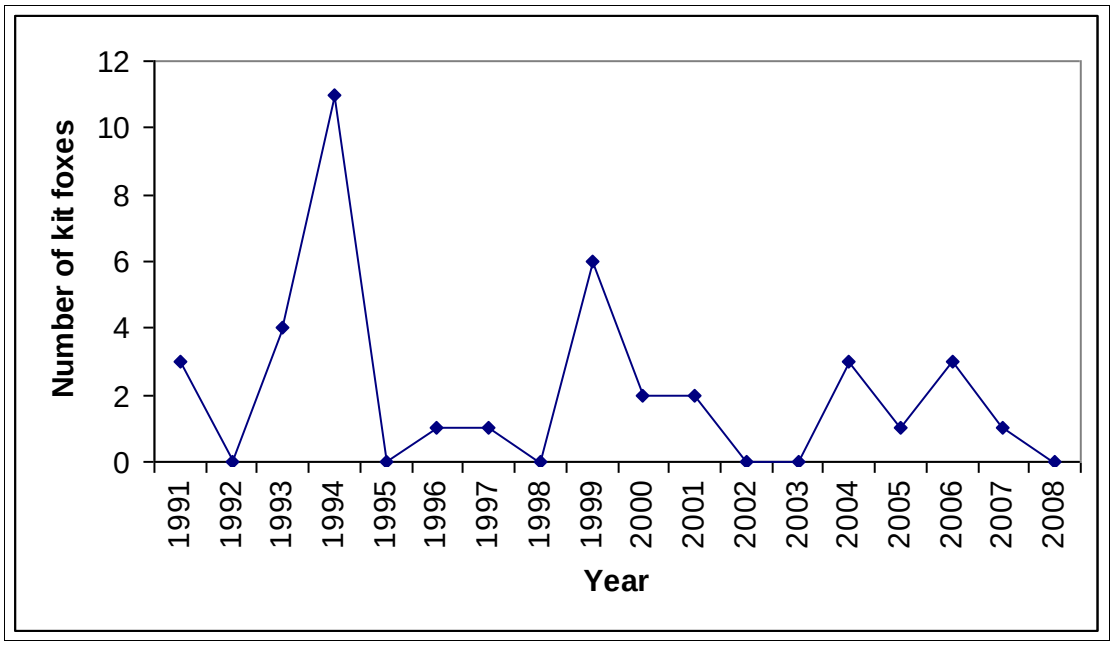

Figure 5. Number of San Joaquin kit foxes observed opportunistically and during spotlight surveys at the Kern National Wildlife Refuge area during 1991-2008.

Suitable habitat – The lands within KNWR consist of predominately flat terrain, although some natural microtopography does exist. Habitat types within the Refuge include grassland, alkali playa, grassland/alkali playa, valley sink scrub, salt cedar, seasonal marsh, moist soil wetland, and riparian (Holland 1986, USFWS 2005). Of the 4,552 ha within KNWR, upland habitats (e.g., grassland, alkali playa, grassland/alkali

playa, valley sink scrub) cover about 1,760 ha. Some of the valley sink scrub habitat occurs in small patches surrounded by habitats unsuitable for kit foxes (e.g., seasonal marsh). Common plant species in upland areas include red brome, barley (*Hordeum spp.*), various native and non-native forbs, saltbush, iodine bush and bush seepweed. Non-native grasses can become dense in some areas and cattle grazing is used to decrease vegetation density and improve habitat conditions for kit foxes and other sensitive species. Soils at KNWR consist of a mix of clay and sandy types (USFWS 2005).

KNWR only encompasses 4,552 ha, which is not sufficient to support a kit fox population. A number of public and private conservation lands occur in close proximity to KNWR. The CDFG's Northern Semitropic Ridge Ecological Reserve (ca. 1,900 ha) and Center for Natural Lands Management's Semitropic Ridge Preserve (ca. 1,200 ha) are 4-6 km to the south. The U.S. Bureau of Land Management's Atwell Island Land Demonstration Project (ca. 2,700 ha) is approximately 9 km to the northeast. The southern portion of Allensworth Ecological Reserve is approximately 20 km to the northeast. Intermixed between these protected areas are parcels in public and private ownership with a variety of land uses including agriculture, cattle grazing, residences, and small businesses (e.g., junk yards). Between KNWR and the AER area are a number of parcels with native habitat that have been purchased as mitigation properties through the MBHCP) in the last five years. These properties are managed by CDFG with endowment and enhancement funds provided through the MBHCP program. Based on habitat modeling, 31,400 ha of highly or moderately suitable habitat occurs within 10 km of KNWR (Figure 3). However, much of this habitat is highly fragmented. If larger patches of habitat could be created and connected by functional movement corridors, then the establishment and maintenance of a kit fox population might be possible.

Availability of dens for kit foxes at KNWR likely is low. The area has received little use by foxes in recent years, and any kit fox dens that may have been present in the past likely are no longer usable. California ground squirrels are present on the Refuge, and kit foxes potentially could expand squirrel burrows into dens, although this would take some time. An artificial kit fox den was installed in the northern portion of the Refuge in 1992 and another was added in 1993 (USFWS 2005). Additionally, 14 more dens were installed in 2008. Some of these were chambered dens and primarily were installed in the Refuge's newly acquired Unit 15 at the north end of KNWR. The other 8 dens were escape dens installed along the Goose Lake Canal levee that transverses the Refuge from south to north (Harrison et al. 2011).

Prey availability – Rodents recorded on KNWR include Heermann's kangaroo rat, Tipton kangaroo rat, house mouse, roof rat (*Rattus rattus*), southern grasshopper mouse, San Joaquin pocket mouse, deer mouse, western harvest mouse, pocket gopher, and California ground squirrel. Black-tailed jackrabbits and desert cottontails are common. Reptiles that may be a prey source for kit foxes include western whiptail lizard, side-blotched lizard, coast horned lizard, gopher snake, and California kingsnake, western long-nosed snake, and southwestern black-headed snake. Common ground-nesting birds on PNWR include horned larks, western meadowlarks, and several sparrow species (USFWS 2005). Potential insect prey on the Refuge include beetles, grasshoppers, and crickets.

Regular small mammal trapping surveys have not been conducted on KNWR. Trapping was conducted in 2005, 2007, and 2010 (Table 8) as part of 3 special projects (Newman

et al. 2005, Tomlinson et al. 2008, CSUS ESRP unpublished data). The 2005 trapping was conducted in various locations while the 2007 and 2010 trapping were both conducted on the north end of the Refuge in Unit 15, which consists primarily of grassland and valley sink scrub habitat. Kangaroo rats are abundant in this area. Also, 80 Tipton kangaroo rats were translocated to this area in 2010 (CSUS ESRP, unpublished data).

Table 8. Small mammal trapping survey results at Kern National Wildlife Refuge. (Sources: Newman et al. 2005, Tomlinson et al. 2008, CSUS ESRP unpublished data)

Date	Area	Kangaroo rats per 100 trapnights	Total rodents per 100 trapnights
2005	Various	13.46	14.77
June 2007	Unit 15	2.49	3.10
April 2010	Unit 15	4.58	5.00
October 2010	Unit 15	34.67	37.33

Spotlight surveys were conducted on KNWR in 2009 and 2010 (Table 9). Observations of potential prey included kangaroo rats, pocket mice, jackrabbits, and cottontails.

Table 9. Potential prey species observed during spotlighting surveys at Kern National Wildlife Refuge in 2009 and 2010.

	Number observed			
Date	Kangaroo rat	Pocket mouse	Cottontail	Jackrabbit
July 2009	45	0	21	3
Aug 2010	115	1	33	7

Competitor abundance **–** Relatively few quantitative data are available on the abundance of potential competitors at KNWR. Spotlight surveys were conducted on the Refuge in 2009 and 2010 (Table 10). Species of potential competitors observed included coyote, striped skunk, spotted skunk (*Spilogale gracilis*), and bobcat. Also, raccoons are abundant on and near the Refuge. In general, coyote densities in particular are considered to be very high on and around KNWR (P. Williams, USFWS, unpublished data). Currently, there are no records of non-native red foxes from the KNWR area.

Table 10. Potential competitor species observed during spotlighting surveys at Kern National Wildlife Refuge in 2009 and 2010.

	Number observed			
Date	Coyote	Striped skunk	Spotted skunk	Bobcat
July 2009	6	1	0	0
Aug 2010	9	2	1	1

Connectivity – A number of public and private conservation lands occur in close proximity to KNWR. The CDFG's Northern Semitropic Ridge Ecological Reserve (ca. 1,900 ha) and Center for Natural Lands Management's Semitropic Ridge Preserve (ca. 1,200 ha) are 4-6 km to the south. A persistent kit fox population is present on these protected areas (CDFG, unpublished data). KNWR is connected to these protected areas

by upland habitat on intervening private lands (that are mostly used for cattle grazing). Thus, kit foxes can easily disperse to KNWR from these protected areas. Indeed, many of the recent kit fox sightings on and near KNWR may be foxes dispersing from these areas. The U.S. Bureau of Land Management's Atwell Island Land Demonstration Project (ca. 2,700 ha) is approximately 10 km to the northeast. The southern portion of Allensworth Ecological Reserve is approximately 20 km to the northeast. Between KNWR and the AER area are a number of parcels with habitat that have been purchased as mitigation properties through the MBHCP in the last five years. These properties are managed by CDFG with endowment and enhancement funds provided through the MBHCP program and could function as "stepping stones" to facilitate kit fox movements between sites. Also, more properties are gradually being acquired in this area, which will enhance the potential for this area to function as a movement corridor for kit foxes.

Conclusions – Our analysis suggests that KNWR may not be suitable for reintroduction of kit foxes at this time for several reasons. Although the Refuge encompasses a relatively large, contiguous block of habitat, much of this habitat is not suitable for kit foxes. The portion of the Refuge with suitable habitat is relatively small and would not be adequate to support what we estimate to be a minimum population size (i.e., 10 pairs) necessary to provide a reasonable probability of persistence.

Suitable habitat for kit foxes occurs on lands adjacent to KNWR, and these lands in combination with Refuge lands potentially could support a kit fox population. Kit foxes are periodically observed in the KNWR area, and it is possible that foxes may already be resident on these adjacent lands. Even if foxes do not already occupy these lands, the occasional sightings of foxes indicates that animals are reaching this area, probably from the resident population on CDFG and CNLM lands just to the south. Thus, the potential for natural colonization of the KNWR area by foxes seems high precluding the need to reintroduce foxes. Factors which potentially could be impeding colonization (if it has not already occurred) could include low availability of suitable dens or high abundance of competitors, particularly coyotes.

WIND WOLVES PRESERVE

Location and ownership – The Wind Wolves Preserve (WWP or "Preserve") is located in southern Kern County, approximately 40 km south of Bakersfield, California (Figure 1). WWP consists of a large, contiguous area encompassing approximately 38,891 ha. The Preserve is owned and managed by The Wildlands Conservancy (TWC), a non-profit organization dedicated to the preservation of natural lands and environmental education.

The Wind Wolves Preserve was established by TWC in 1995. Prior to purchase by TWC, the property had been an operating cattle ranch since 1842. Low-density oil and gas extraction has been conducted on the property for several decades. TWC continues to acquire additional lands and expand the Preserve as opportunities and funds permit.

Management and land uses – All lands within the WWP are fenced and well marked with signs. Access roads into the Preserve have locked gates. Thus, public access to most of the Preserve generally is restricted and is limited to a few visitor facilities such as parking areas, trails, and wildlife viewing areas. Grazing lessees and oil field workers have access to some portions of the Preserve

The primary land use historically has been cattle grazing, which dates back to 1842. The land was a working cattle ranch until acquired by TWC. Many structures and facilities associated with ranch operations have been removed, and grazing currently is conducted by lessees who truck cattle on and off the Preserve. Oil and gas extraction were initiated on the property decades ago and low density operations continue. These operations primarily include the maintenance of wells, pipelines, and storage tanks. Environmental education programs and limited public recreational activities are the only other significant activities on the property.

The mission of the TWC is conservation of natural lands and environmental education. Thus, the Preserve is managed in a manner to advance these goals. This management includes limiting public access, patrolling with a team of rangers, protecting sensitive resources, and managing habitat. Habitat management consists primarily of grazing with cattle to reduce the density of herbaceous vegetation. This management is conducted primarily to benefit sensitive species such as the San Joaquin kit fox and blunt-nosed leopard lizard. Primary land uses on properties surrounding the WWP include cattle grazing, oil and gas production, intensive irrigated agriculture, and gravel mining. Tejon Ranch lands border the Preserve on the east. Much of the Ranch has been placed under conservation easement and is managed by the Tejon Ranch Conservancy. Conservation of sensitive species, such as kit foxes, is a prime goal of the Conservancy. Ranch lands are primarily managed through cattle grazing.

Conservation issues – KNWR is protected and managed for the conservation of natural resources, including sensitive species such as the San Joaquin kit fox. Preserve lands are consolidated into a large, contiguous block, and therefore, fragmentation is not an issue and edge effect is minimal. The Preserve is well fenced and signed, and trespass frequency appears to be relatively low (D. Clendenen, personal communication). Oil and gas production activities, including vehicular traffic, occur at relatively low levels and likely present minimal threat to kit foxes. On lands adjacent to the WWP, use of pesticides on agricultural lands, particularly rodenticides, could present a threat to kit foxes.

Historical and current status of kit foxes – Kit foxes have occasionally been observed on or near the WWP. Several occurrence records are listed in the California Natural Diversity Database, although the most recent record is from 1998 (Cypher et al. 2011). Extensive surveys for kit foxes or their sign were conducted on the Preserve in 2010, but no kit foxes were detected. It is unknown whether a resident population of kit foxes has ever occurred on the WWP.

Suitable habitat – Although the WWP encompasses 38,891 ha, the Preserve extends from the San Joaquin Valley floor up to an elevation of 1,830 m. Thus, much of the Preserve is too rugged with inappropriate vegetation communities to be used by kit foxes. The valley floor portion that is potentially suitable for kit foxes encompasses approximately 8,300 ha. The terrain in this area is generally flat with gently sloping alluvial fans and well-developed washes present where creeks (dry most of the year) flow northward out of the San Emigdio Range. Grasslands comprising a diversity of native and non-native grasses and forbs are the dominant habitat in these areas. Scattered stands of desert saltbush are present in some portions of the area.

The valley floor portion of the WWP encompasses 8,300 ha, which would be sufficient to support a kit fox population. Additionally, other suitable habitat is present on lands to the

east and west of the Preserve. As discussed previously, Tejon Ranch lands border the Preserve on the east and are managed for conservation. Based on habitat modeling, 32,200 ha of highly or moderately suitable habitat occur within 10 km of the WWP (Figure 6).

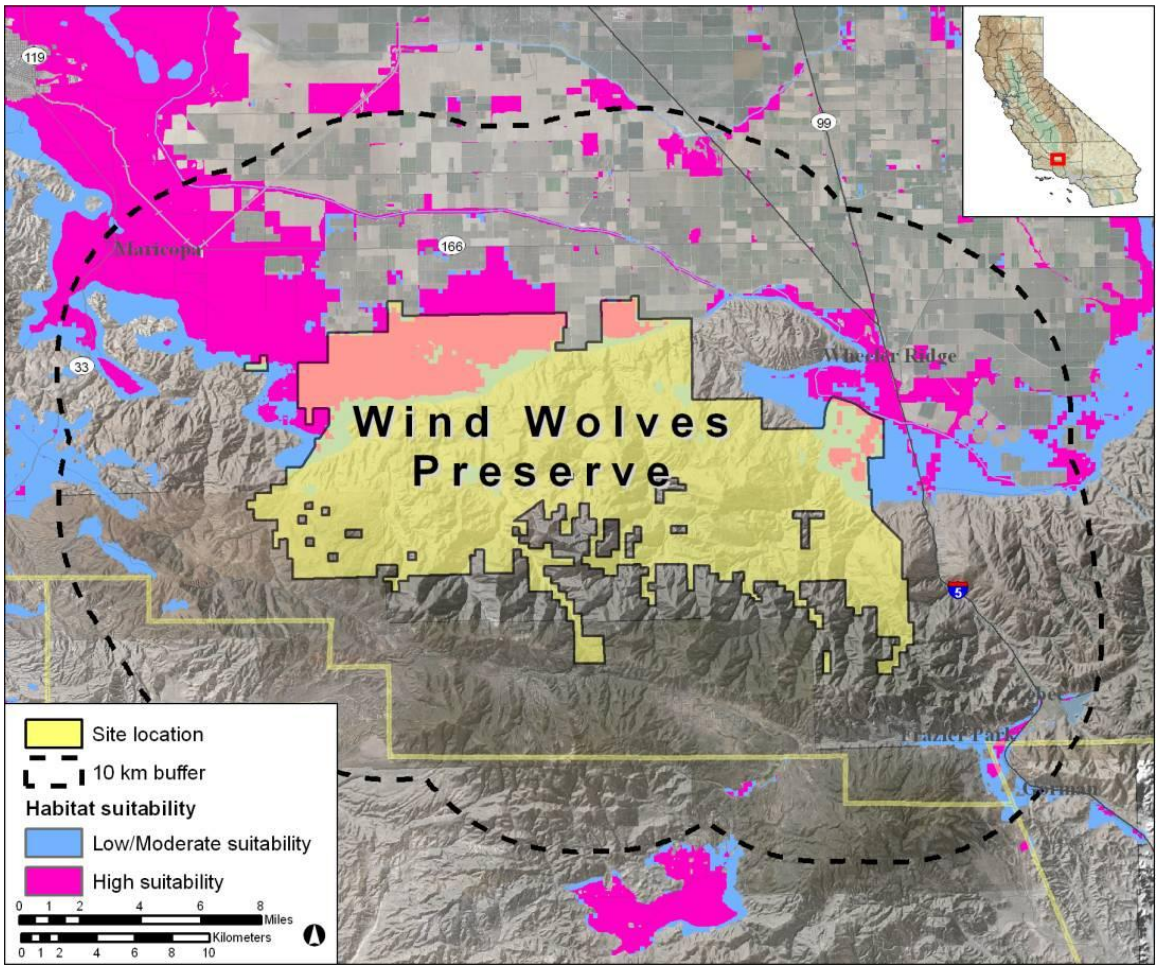

Figure 6. Habitat suitability for San Joaquin kit foxes on and near the Wind Wolves Preserve in Kern County, California.

Availability of dens for kit foxes at the WWP likely is low. The area has received little use by foxes in recent years, and any kit fox dens that may have been present in the past likely are no longer usable. California ground squirrels are abundant on the Preserve, and kit foxes potentially could expand squirrel burrows into dens, although this would take some time. Also, in 2010, the Preserve was supplied with materials for constructing 25 artificial dens, and installation has been initiated (Harrison et al. 2011).

Prey availability – Rodents occurring on WWP include Heermann's kangaroo rat, house mouse, southern grasshopper mouse, San Joaquin pocket mouse, deer mouse, western harvest mouse, pocket gopher, San Joaquin antelope squirrel, and California ground squirrel (Cypher et al. 2011; The Wildlands Conservancy, unpublished data). Black-tailed jackrabbits and desert cottontails are common. Reptiles that may be a prey source for kit foxes include western whiptail lizard, side-blotched lizard, coast horned lizard, gopher snake, and California kingsnake, and western long-nosed snake. Common

ground-nesting birds on the WWP include California quail (*Callipepla californica*), horned larks, western meadowlarks, and several sparrow species (USFWS 2005). Potential insect prey on the Preserve include beetles, grasshoppers, and crickets.

Regular small mammal trapping surveys have not been conducted on the WWP. Trapping was conducted in 2010 as part of a special survey project (Cypher et al. 2011), and 15 traplines were established in 4 areas within the valley floor portion of the Preserve (Table 11). Kangaroo rats were caught in all areas.

Table 11. Small mammal trapping survey results from 4 areas at the Wind Wolves Preserve. (Source: Cypher et al. 2011)

	Live-Trapping Areas							
	Salt Creek (360 trapnights)		Pleito Creek (330 trapnights)		Muddy Creek (270 trapnights)		Santiago Creek (270 trapnights)	
Species	No.	No. per 100 TN	No.	No. per 100 TN	No.	No. per 100 TN	No.	No. per 100 TN
San Joaquin pocket mouse	20	5.6	74	22.4	17	6.3	12	4.4
Heermann's kangaroo rat	20	5.6	19	5.8	15	5.6	8	3.0
California pocket mouse[1]	-	-	1	0.3	-	-	2	0.7
Deer mouse	5	1.4	6	1.8	1	0.4	-	-
Total	45	12.5	100	30.3	33	12.2	22	8.1

[1] *Chaetodipus californicus*

***Competitor abundance* –** Competitors appear to be quite abundant at the WWP. Coyote abundance in particular apparently is high, based on the frequency of observations (Cypher et al. 2011; D. Clendenen, The Wildlands Conservancy, personal communication). Camera station surveys were conducted on the Preserve in 2010 (Cypher et al. 2011). Coyotes were frequently detected on the cameras (Table 12). Raccoons, bobcats, and a striped skunk also were detected. Additionally, red foxes were detected on 3 occasions in the northeastern portion of the Preserve.

Table 12. Potential kit fox competitors detected at camera stations on the Wind Wolves Preserve. (Source: Cypher et al. 2011)

	Area							
	Rincon 8 cameras/ 300 nights		Pleito Creek 4 cameras/ 144 nights		San Emigdio Creek 13 cameras/ 495 nights		Santiago Creek 12 cameras/ 454 nights	
Species	No. Obs.	Rate	No. Obs.	Rate	No. Obs.	Rate	No. Obs.	Rate
Coyote	2	0.06	4	2.8	26	5.3	9	2.0
Red fox	3	1.0	-	-	-	-	-	-
Bobcat	-	-	2	1.4	-	-	-	-
Striped skunk	-	-	1	0.7	-	-	-	-
Raccoon	-	-	11	7.6	-	-	-	-

Connectivity – Habitat suitable for kit foxes is present on lands to the west and east of the WWP. As discussed previously, Tejon Ranch lands border the Preserve on the east and are managed by the Tejon Ranch Conservancy, in part to provide habitat for sensitive species including kit foxes. Private and some public lands are present on WWP's western boundary. The private lands are used primarily for grazing. Public lands are managed by the U.S. Bureau of Land Management and primary land uses include oil and gas production and grazing. At current activity levels, kit foxes are able to use these lands. The lands on the western side of the WWP connect to the Western Kern County core area for kit foxes (U.S. Fish and Wildlife Service 1998), which is approximately 15 km to the northwest. These lands also connect to the Carrizo Plain core area, which is approximately 30 km to the west. Thus, kit foxes should have relatively high access to the Preserve.

Conclusions – Our analysis suggests that the WWP may not be suitable for reintroduction of kit foxes for several reasons. The Preserve encompasses an adequate quantity of potentially suitable habitat to support what we estimate to be a minimum population size (i.e., 10 pairs) necessary to provide a reasonable probability of persistence. Such a minimum population size would require approximately 6,000 ha, and the valley floor portion of the Preserve encompasses approximately 8,300 ha, much of which appears to be highly suitable based on habitat modeling. However, the current absence of kit foxes on the Preserve is cause for concern. Given the high connectivity to areas with large populations of kit foxes, the potential for colonization of the Preserve through natural dispersal seems high. The reasons that this has not occurred are unclear. Potential reasons could include a high density of competitors, low prey availability, low den availability, or a combination of factors.

The suitability model we developed for kit foxes is largely based on terrain and ground cover density. The flat to gently rolling terrain throughout the valley floor portion of the WWP is optimal for kit foxes. Vegetation density may vary temporally and this may offer a potential explanation for the lack of kit foxes. The vegetation values used in the model (Normalized Difference Vegetation Index) were from 2001-2006, which were years of generally lower annual precipitation. Lower vegetation density values would result in a higher suitability value. During years of higher annual precipitation, vegetation density would be higher and habitat suitability would be lower. Furthermore, much of the Wind Wolves Preserve has been grazed historically, and grazing intensity also can affect habitat suitability for kit foxes. As grazing intensity increases, vegetation density decreases and habitat suitability for kit foxes increases. Grazing intensity has been reduced on the Preserve in recent years (D. Clendenen, The Wildlands Conservancy, personal communication).

The relationship between kit foxes and vegetation density is complex as it also involves kangaroo rats, which are the primary prey for kit foxes. Kit foxes are adapted to arid environments and a relatively short, open vegetation structure facilitates mobility and predator detection. Furthermore, kangaroo rats also are adapted to arid environments. Dense vegetation, particularly that associated with the non-native grasses that now dominate herbaceous plant communities in the San Joaquin Valley, can significantly limit kangaroo rat populations and even cause local extirpations under certain conditions (Single et al. 1994, Germano et al. 2001). During live-trapping surveys on the Wind Wolves Preserve, capture rates for kangaroo rats were relatively low in general, and most

kangaroo rats were captured in or near washes where vegetation usually was more sparse. Very few kangaroo rats were captured in areas where vegetation density was relatively high, and particularly if a dense thatch layer was present. One possible scenario is that kangaroo rat populations on the Preserve have been reduced in the past by periods of high precipitation and dense ground cover, particularly when such conditions persist for multiple years. Under such a scenario, kangaroo rats might be restricted to areas where conditions are more favorable, such as in and near washes. This situation would be further exacerbated by any reductions or elimination of grazing. Such a scenario could explain the limited distribution and abundance of kangaroo rats observed on the Preserve and concomitant absence of kit foxes.

RETIRED AGRICULTURAL LANDS

Location and ownership – Large acreages of land in the western San Joaquin Valley have been retired from agricultural production, primarily due to issues regarding irrigation water availability or drainage of soil contaminants (Cypher et al. 2007). The largest contiguous blocks of retired farmland are located in western Fresno County (Figure 1) but, less contiguous blocks of retired farmland are located in in Kings and Tulare counties. In the western Fresno County region, most retired lands are privately owned (primarily by Westlands Water District) with the exception of an 868-ha land retirement demonstration site owned by the U.S. Bureau of Reclamation (LRDP Tranquillity, Figure 7). As of 2008, approximately 24,000 ha of land had been retired in the western Fresno county area, of which 96% were privately owned. Approximately half of the privately-owned retired farmlands are permanently retired (with a non-irrigation agreement) and the rest are retired, but could be irrigated in the future.

Management and land uses – All of the lands being retired were previously in agricultural production, almost exclusively as irrigated row crops. While in active production, the lands were unsuitable for use by kit foxes. As part of the plan to retire agricultural lands, the U.S. Bureau of Reclamation was to target lands that potentially could contribute to kit fox conservation and recovery efforts (U.S. Bureau of Reclamation 2007). Retired agricultural lands usually are not suitable for use by kit foxes in the absence of vegetation management or habitat restoration. Commonly, fallowed agricultural lands in this region suffer from profound alterations associated with previous agricultural production activities (Ritter and Lair 2007). These alterations include intermixed soil horizons, soil compaction, loss of microtopography, absence of native plant species, possible absence of nearby native seed sources, chemical (e.g., pesticide, fertilizer) residues, and nearby sources of non-native plant species. As a result, retired agricultural lands may quickly become dominated by dense stands of non-native plants that inhibit or even prevent colonization by native plant species (Ritter and Lair 2007). This could result in a sub-optimal plant community composition for kit foxes or their prey. Equally if not more important, this dense non-native vegetation results in a habitat structure that is less favorable to kit foxes or their prey species. Consequently, appropriate restoration and management strategies will be necessary to render retired agricultural lands suitable for kit foxes and their prey. However, such restoration and management can be challenging and potentially expensive (Ritter and Lair 2007), and there is no evidence that any habitat remediation efforts have been initiated to date on these lands.

Conservation issues – Conservation challenges on retired lands are likely to be considerable. The lands are owned by multiple private owners, and therefore there currently is no over-arching entity to organize, coordinate, and oversee actions necessary for kit fox conservation. Furthermore, to date, no efforts have been initiated by any of the landowners to implement actions necessary for kit fox conservation.

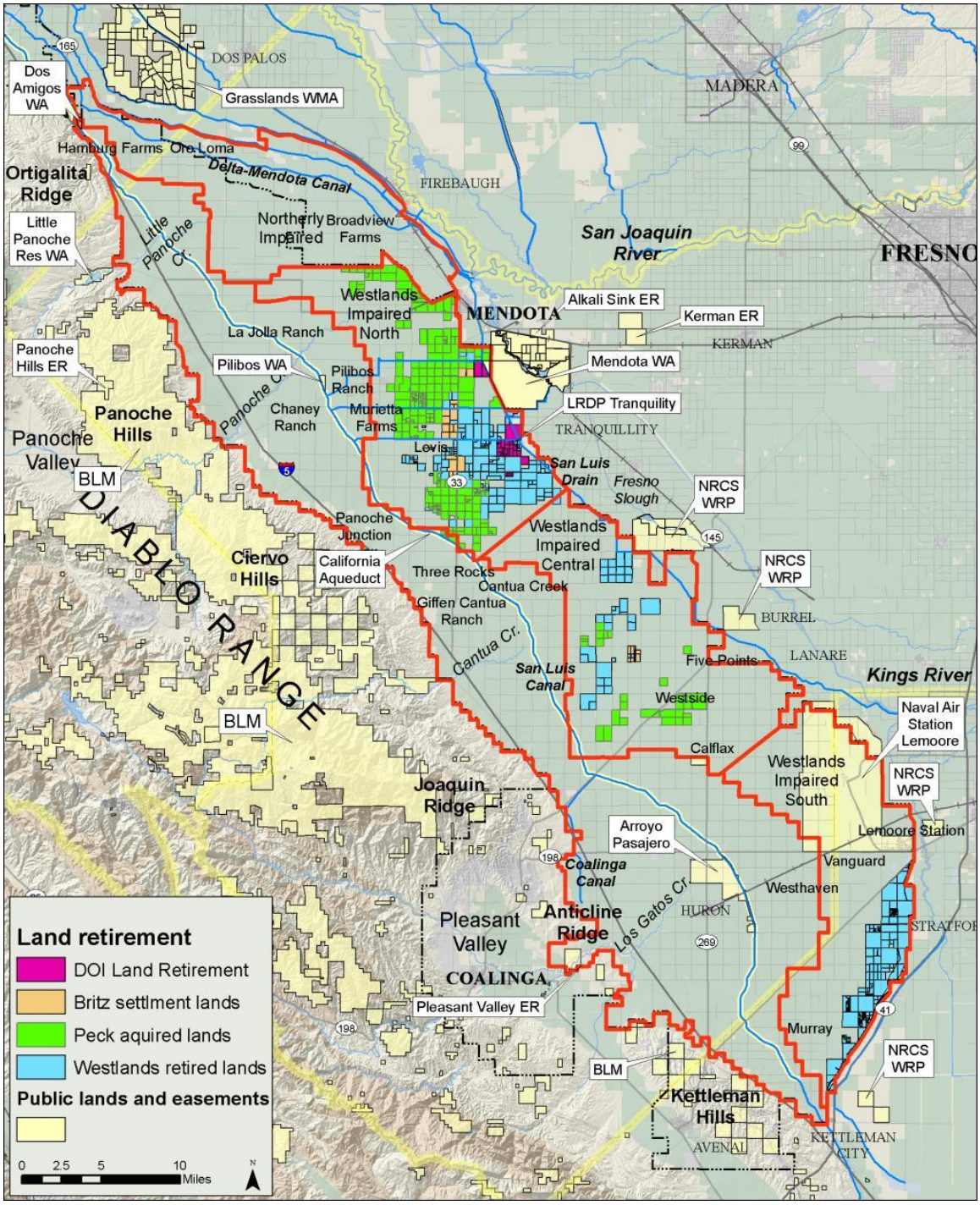

Figure 7. Retired agricultural lands in western Fresno, and Kings counties, California (Phillips 2006).

Historical and current status of kit foxes – Historical and current kit fox presence and use of the retired lands are unknown. Kit foxes were present in this region prior to natural habitat being converted to agricultural uses. As previously stated, the lands were unsuitable for kit foxes when in agricultural production. There is no evidence to suggest that suitability has improved post-retirement. Thus, kit foxes probably have not been present on these lands for decades, and are not likely present now.

Suitable habitat – The terrain in this area is generally flat, but the lands have been markedly altered and natural vegetation is mostly absent. Consequently, relatively little suitable habitat currently is available for kit foxes, which is also evident from habitat suitability modeling (Figure 8). Based on modeling, approximately 5,559 ha may be suitable for kit foxes while 12,300 ha of highly or moderately suitable habitat occurs within 10 km of the retired lands. However, most of this habitat occurs as very scattered fragments that are too small in size to support even a single kit fox family group. If larger patches of habitat could be created and connected by functional movement corridors, then the establishment and maintenance of a kit fox population might be possible.

Availability of dens for kit foxes in the area likely is low. The area has received little use by foxes in recent years, and any kit fox dens that may have been present in the past likely are no longer usable.

Prey availability – Prey availability for kit foxes in the retired lands area is unknown. However, some information on potential prey for kit foxes is available from a 5-year effort to restore habitat at a site on the eastern edge of the retired lands area (U.S. Department of Interior 2005). Rodents captured during monitoring on the site include deer mouse, Heermann's kangaroo rat, house mouse, California vole (*Microtus californicus*), western harvest mouse, and pocket gopher (Table 13). Black-tailed jackrabbits, desert cottontails, and California ground squirrels were present at this site and probably are locally abundant in the retired lands area. Potential reptilian prey on the site included gopher snake, king snake, western whiptail, and western fence lizard (*Sceloporus occidentalis*). Beetles and grasshoppers were common insects and are potential prey for kit foxes.

Table 13. Rodents captured on the Tranquility Land Retirement Demonstration Site, Fresno County, California during 1999-2003. (Source: U.S. Department of Interior 2005)

	Number of individuals captured				
Species	**1999**	**2000**	**2001**	**2002**	**2003**
Live-trap					
Heermann's kangaroo rat	0	0	0	12	5
California vole	0	0	1	0	0
House mouse	2	14	47	1	0
Deer mouse	24	592	2310	1830	1849
Western harvest mouse	0	0	0	1	0
Pitfall trap					
California vole	3	0	37	2	1
Deer mouse	0	0	0	40	14
Pocket gopher	0	0	0	2	0

Competitor abundance **–** Abundance of potential kit fox competitors in the retired lands area is unknown. Coyotes, domestic dogs, and domestic cats are commonly observed in the area. Other potential competitors that likely are present include striped skunks and raccoons. It is unknown whether red foxes are present in the area.

Connectivity – Current retired lands are surrounded by active agriculture. Habitat suitable for kit foxes, including the Panoche core area, is present approximately 10-40 km west of the retired lands. However, foxes coming from this habitat would have to negotiate the agricultural lands as well as cross the California Aqueduct and Interstate 5 to reach the retired lands. The distance between the area and existing habitat may be reduced as additional lands are retired.

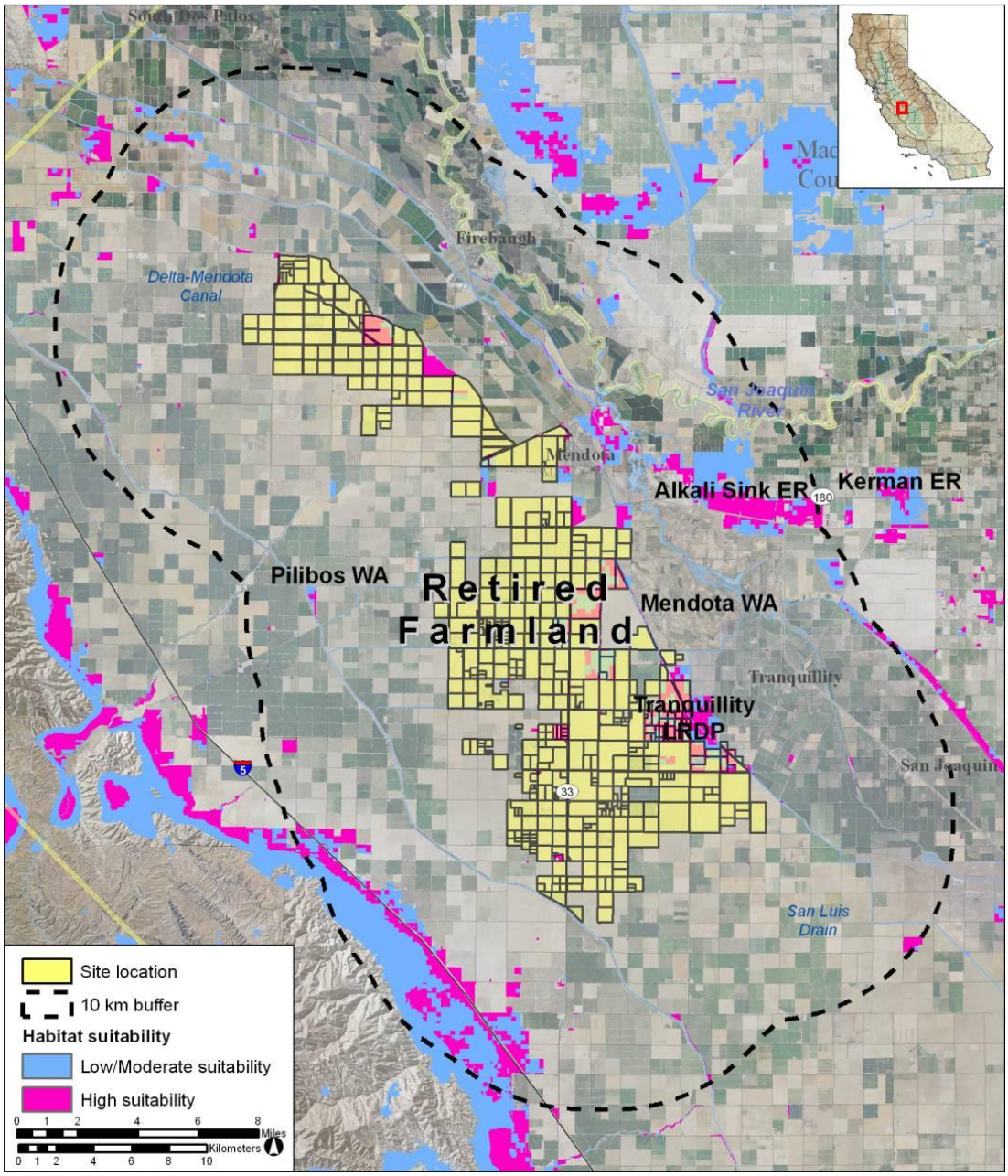

Figure 8. Habitat suitability for San Joaquin kit foxes on and near retired agricultural lands in western Merced, Fresno, and Kings Counties, California.

Conclusions – Our analysis suggests that the retired lands may not be suitable for reintroduction of kit foxes for several reasons. The total acreage of retired lands would be adequate to support a reintroduced kit fox population. However, this acreage is highly fragmented with some patches being highly isolated and most patches being too small to support even a single family group. Also, the habitat quality on most of the retired lands currently is unsuitable for kit foxes. Suitability could be enhanced significantly through habitat restoration, or possibly even just through vegetation management. In particularly, any management that reduces vegetation height and density would improve habitat quality for kit foxes. Restoration or management also would improve habitat quality for kit fox prey, particularly kangaroo rats. Kangaroo rats are present in low numbers, but could increase with a reduction in vegetation structure and density.

Another significant impediment to the reintroduction of kit foxes in the retired lands area is the fact that virtually all of the land is in private ownership. This raises 2 main issues. The first is that the permission of numerous landowners would need to be secured prior to any reintroduction. Securing such permission is unlikely in this area in which landowners have not generally been supportive of endangered species conservation. The second issue is that even if permission to reintroduce foxes was granted, agencies and organizations responsible for the reintroduction and continuing conservation of foxes would have little control over activities on private lands, including activities that could present a risk to kit foxes such as use of rodenticides, off-highway vehicle use, hunting, and conversion of lands to other uses.

DISCUSSION

Reintroductions of any species typically involve considerable risk and expense, and failures are not uncommon (Chivers 1991, Kleiman 1996, Bremner-Harrison and Cypher 2007). Therefore, a reintroduction should not be attempted unless all conditions meet at least some minimum requirements such that the probability of success is maximized to the extent possible. This is even more important when dealing with a rare species, particularly because remaining populations usually are not large, there are few if any "surplus" individuals, and removing animals presents a risk to source populations (Bremner-Harrison and Cypher 2007).

The 5 sites evaluated in this assessment were chosen because all appeared to comprise large areas of known or potential kit fox habitat, and most had relatively recent evidence of use of foxes but fox populations were not currently present. Thus, further in-depth evaluation of the potential for these sites for reintroductions of kit foxes was warranted. However, based on our assessments, none of the 5 sites currently appears sufficiently suitable to attempt a fox reintroduction. The current conditions at each site are such that we conclude that the probability of a successful reintroduction is unacceptably low. Reasons for this include insufficient quantity of contiguous suitable habitat, questionable prey availability, high competitor abundance, inappropriate (usually lack of) habitat management, and inadequate protections for kit foxes. Conditions and issues relevant to kit fox reintroduction (synthesized from Bremner-Harrison and Cypher 2007) are summarized for each site in Table 14.

Table 14. Summary of conditions and issues relevant to kit fox reintroduction for 5 sites in the San Joaquin Valley, California.

	Allensworth ER	Pixley NWR	Kern NWR	Wind Wolves Preserve	Retired agricultural lands
Habitat					
Type	Valley sink scrub, grassland	Valley sink scrub, grassland	Valley sink scrub, grassland, alkali playa	Grassland	Grassland, fallow crop land
Quantity	ca. 2,142 ha on AER; ca.31,400 ha within 10 km	ca. 1,914 ha on PNWR; ca. 13,600 ha within 10 km	ca. 1,760 ha on KNWR; ca. 31,400 ha within 10 km	ca. 8,300 ha on WWP; ca. 32,200 ha within 10 km	ca. 5,559 ha on retired lands; ca. 12,300 ha within 10 km
Fragmentation	High	High	Moderate	Low	High
Terrain	Flat	Flat	Flat	Gentle, flat	Flat
Den availability	Low; some artificial dens	Low	Low; some artificial dens	Low; some artificial dens	Low
Prey abundance	Low-moderate; krats, leporids, squirrels, insects	Low-moderate; krats, leporids, squirrels, insects	Moderate; krats, leporids, insects	Low-moderate; krats, leporids, squirrels, insects	Low; leporids, squirrels, insects
Competitors	Moderate; coyotes, domestic dogs	Moderate; coyotes, domestic dogs	Moderate; coyotes	High; coyotes, red foxes, bobcats	Low-moderate; coyotes
Administration					
Ownership	CA Dept. Fish and Game	U.S. Fish and Wildlife Service	U.S. Fish and Wildlife Service	The Wildlands Conservancy	Multiple private owners
Compatible goals	Yes	Yes	Yes	Yes	No
Fox protections	Moderate; most areas fenced, open access	High; all areas fenced, restricted access	High; all areas fenced, restricted access	High; all areas fenced, restricted access	Low; open access, no control over owner actions
Land uses	Conservation	Conservation, grazing	Conservation, grazing, hunting	Conservation, grazing, some oil production	Fallow crop land, grazing, hunting, other
External threats	Moderate; agriculture, low-density housing	Moderate; agriculture	Low; agriculture, hunting	Low; agriculture	High; agriculture, hunting, OHV, other
Habitat management	Trespass grazing	Grazing, exotic plant control	Grazing, exotic plant control	Grazing, shrub restoration	Grazing on some lands
Kit fox population					
Connectivity	Low	Low	Moderate	High	Low
Fox status	Last observed 2004; prior reproduction documented	Last observed 1999; prior reproduction documented	Last observed 2008; prior reproduction documented	Last observed 1998	Unknown
Reasons for absence	Possible krat decline, low recolonization potential	Possible krat decline, low recolonization potential	Possible krat decline, low habitat availability, high competitor abundance	Low krat availability, high competitor abundance	Incompatible land uses, low food availability, low recolonization potential

Although no sites are currently recommended for a kit fox reintroduction, this situation could change if conditions improve on a given site. Acquiring additional habitat, implementing appropriate habitat management, reducing external threats, and installing artificial dens are all actions that could improve the suitability of a site for a kit fox reintroduction. The WWP is the only site that currently encompasses a sufficient quantity of habitat to support a kit fox population. The reasons for the current absence of kit foxes are unclear, but could include a vegetation structure unsuitable for both kit foxes and their preferred prey, kangaroo rats. Managing the vegetation, probably through grazing, might significantly increase habitat suitability. The retired agricultural lands will likely be more of a challenge due to a myriad of biological and administrative issues, but even these could eventually be suitable for a reintroduction attempt if these issues are mitigated.

Resident, reproducing populations of kit foxes were present on the AER, PNWR, and KNWR in the past 10-20 years. The reasons for their extirpation from these sites are unclear but could include continuing regional habitat loss, fragmentation of remaining habitat, marked fluctuations in prey availability including the near extirpation of kangaroo rats in the late 1990s, and increasing competitor abundance. All of these factors plus the absence of appropriate habitat management such as on AER, slow recovery of kangaroo rats, and low availability of dens may be impeding natural recolonization of these sites by foxes. Finally, even if foxes were to overcome these challenges and reoccupy one or more of these sites, the quantity of available suitable habitat would limit number of kit foxes that could be supported and would reduce the probability of population persistence. Thus, the potential for future extirpation would be high.

However, one potential scenario involving these sites could offer some hope for the future establishment and persistence of a kit fox population. The USFWS may add additional lands to PNWR and KNWR as funds and opportunities become available, and CDFG may do the same at AER. Furthermore, under the MBHCP, additional conservation lands are being acquired in this region, and will be administered by CDFG. Many of these lands have been disturbed, usually by previous agricultural activities, but with recovery time or active restoration could eventually become suitable for kit foxes. Finally, the U.S. Bureau of Land Management has established the Atwell Island Land Retirement Demonstration Project in close proximity to the AER, PNWR, and KNWR. This site is approximately 2,700 ha in size and also is being expanded as funds and opportunities permit. Although only a portion of the site is suitable for kit foxes, it adds to the total kit fox habitat in the region. Indeed, considered as a single entity, the region within 10 km of this combined site encompasses approximately 52,100 ha of potential habitat for kit foxes, based on suitability modeling (Figure 14). If the AER, PNWR, KNWR and Atwell Island sites continue to expand and especially if connectivity between these sites is increased, then this might provide sufficient habitat to support a persistent kit fox population.

One final consideration is that this assessment obviously does not preclude use and even occupation by kit foxes of any of the areas considered. Our goal was to estimate the probability of successfully reintroducing kit foxes to these sites. Although no sites were recommended for reintroduction due to estimated risks, kit foxes potentially could colonize these sites without human assistance. Therefore, planning for such an exigency might be prudent and would even enhance the possibility for natural recolonization.

Actions that could facilitate recolonizations include habitat management (e.g., grazing) to improve suitability for both foxes and their prey, installation of artificial dens, restricting pesticide use on or near the sites, reducing trespass activities, and removing feral dogs and cats.

RECOMMENDATIONS

We assessed the suitability of 5 sites for a potential reintroduction of San Joaquin kit foxes. Based on these assessments, all of the sites currently have deficiencies that would significantly impair the probability of successful establishment of a kit fox population. Therefore, no site is recommended for a kit fox reintroduction at this time. We offer the following recommendations based on our results.

1. Do not reintroduce kit foxes to any of the sites at this time

None of the sites currently has conditions that provide an acceptable probability of a successful kit fox reintroduction. Reintroductions typically have low success rates unless conditions are optimal. Without a high probability of success, the risk to source populations, particularly for an endangered species, and the expense of a reintroduction effort are not justified.

2. Continue habitat acquisitions

At 4 of the 5 sites assessed, the available suitable habitat for kit foxes is insufficient to support 10 pairs of foxes, which is the number that we estimate may be necessary to establish a persistent population. Also, the available habitat at 3 of the sites is highly fragmented with few fragments large enough to support even a single family group. Additional habitat acquisitions in these areas may eventually result in sufficient contiguous habitat to warrant a reintroduction attempt, assuming that all other issues are resolved. Habitat in these areas could be secured through direct acquisition, or also through conservation easements.

3. Manage and enhance existing habitat to improve suitability

Habitat conditions at several sites are sub-optimal for kit foxes or their preferred prey, kangaroo rats. In particular, herbaceous vegetation that is tall and/or dense creates conditions less suitable for kit foxes and kangaroo rats. Such conditions are common throughout most of the San Joaquin Valley due to invasion and domination by non-native grasses. Grazing, particularly by cattle, probably is the most effective strategy for managing vegetation and improving habitat suitability. Another potential habitat enhancement is the installation of artificial dens for kit foxes. Den installation is relatively easy and inexpensive. Managing vegetation and enhancing habitat through den installation help mitigate 2 significant issues common to most of the sites: low availability of preferred food and dens. These actions will increase the suitability of sites for possible reintroductions, and may even facilitate natural recolonization thereby negating the need to reintroduce foxes.

4. Create and enhance corridors

In addition to securing lands to create larger blocks of habitat that potentially can support kit foxes, habitat also should be protected to increase connectivity between blocks. This could be achieved either by securing good habitat where available, or by securing and enhancing less optimal lands (e.g., fallow agricultural lands). Creating corridors between large blocks of habitat will serve 2 purposes. First, it will increase the potential for natural recolonization of vacant habitat, thereby negating the need for expensive and risky reintroduction efforts. Second, once foxes are established on the larger blocks, corridors will facilitate genetic and demographic exchange between populations, which will enhance the viability of any newly established population. Furthermore, once corridors are established, they should be managed and enhanced (e.g., grazing to reduce vegetation structure, installation of artificial dens) to encourage use by kit foxes.

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