Management and Conservation of San Joaquin Kit Foxes in Urban Environments

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Abstract: The San Joaquin kit fox is listed as federally Endangered and California Threatened, primarily due to habitat loss from agricultural, industrial, and urban developments. However, a population of kit foxes estimated at 200-400 persists within the city of Bakersfield, CA. This population appears to be demographically robust with a high probability of persistence. Thus, this population potentially could contribute to range-wide conservation and recovery efforts. The presence of this population in an urban environment creates management challenges. Management issues include human and pet safety, dens in inconvenient locations, and carcass disposal. Resolution of these issues generally is not difficult. Conservation challenges include roads and vehicles, rodenticides and other toxins, sports netting, den destruction during routine maintenance operations, interspecific competition and disease transmission, movement corridors, and regulatory policy. Although the Metropolitan Bakersfield Habitat Conservation Plan provides protective measures for kit foxes during new construction, such measures do not extend to operations, maintenance, and other routine activities. Furthermore, formal policies regarding management and conservation of urban kit foxes have not yet been developed by the U.S. Fish and Wildlife Service and California Department of Fish and Game, resulting in inconsistent responses to urban kit fox issues. Based on a public opinion survey, Bakersfield residents generally support conservation of urban kit foxes. Successful resolution of management issues will minimize conflicts and enhance efforts to conserve kit foxes.

Key Words: conflict management, conservation, dens, endangered species, interspecific competition, San Joaquin kit fox, urban environment, *Vulpes macrotis mutica*

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INTRODUCTION

The San Joaquin kit fox (*Vulpes macrotis mutica*) is endemic to arid shrubland and grassland habitats in the San Joaquin Valley region of central California. Although hunting, trapping, and predator control programs may have contributed to declining numbers in the past, the primary threat to kit foxes has been and continues to be profound habitat fragmentation, degradation, and loss, largely resulting from agricultural, industrial, and urban development. Of the over 3.9 million ha of historical habitat in the San Joaquin Valley (e.g., grasslands, shrublands, wetlands), approximately 50% was converted to agricultural, urban, or industrial uses by 1945, and approximately 70% by 2004 (Kelly et al. 2005). Much of the remaining habitat is fragmented and degraded and subject to adverse impacts such as off-road vehicle use, trash dumping, rodent poisoning, and domestic dogs (USFWS 1998). Consequently, the San Joaquin kit fox was listed as Federally Endangered in 1967 and as California Threatened in 1971 (USFWS 1998). The remaining number of individuals is unknown, but because of continuing habitat loss, kit fox numbers are assumed to still be declining (USFWS 2010).

Although urban development is one cause of kit fox decline, ironically, kit fox populations occur in several urban areas in the San Joaquin Valley (Figure 1). Extensive research conducted in the city of Bakersfield since 1997 indicates that urban kit foxes appear to be faring well both demographically and ecologically (Cypher 2010). Survival and reproductive rates among urban kit foxes are significantly higher than rates among non-urban foxes. Based on casual estimates, the kit fox population in Bakersfield could be as large as 200-400 animals. Kit foxes forage and create dens in undeveloped lands (e.g., vacant lots, fallow crop fields), storm water catchment basins (sumps), industrial areas (e.g., manufacturing facilities, shipping yards), commercial areas (e.g., office and retail facilities), manicured open space (e.g., parks, school campuses, golf courses), and linear rights-of-way (e.g., canals, railroad

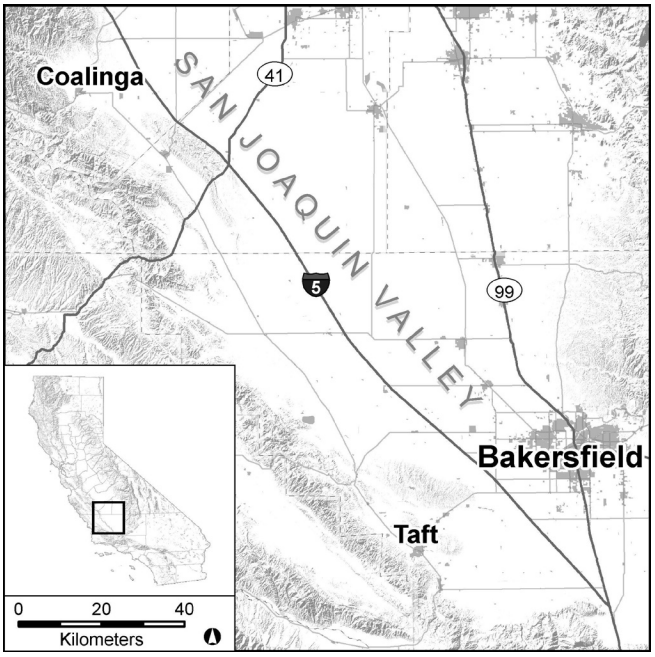

Figure 1. A viable population of San Joaquin kit fox is found in urban Bakersfield, in the southern San Joaquin Valley.

corridors, power line corridors). Only high-density residential areas with their abundant fences, walls, and dogs appear to be avoided. Also, food is abundant and includes rodents (particularly pocket gophers, *Thomomys bottae*, and California ground squirrels, *Spermophilus beecheyi*), birds, insects, and a multitude of anthropogenic items including trash, food left out for feral cats, and handouts. Consequently, the Bakersfield kit fox population appears robust, wide-spread, and persistent, and therefore conservation efforts are warranted.

Urban kit fox populations can contribute to conservation and recovery efforts for the species in a number of ways (Cypher 2010). These populations add to the total number of populations and number of surviving kit foxes, and increase the genetic diversity of San Joaquin kit foxes range-wide. Urban environments are less prone to the environmental variation observed in natural habitats (such as annual rainfall fluctuations and the resulting effects on prey availability) and thus, urban populations appear more stable and could serve as a "hedge" against catastrophic events (e.g., disease epidemic) among non-urban populations. Urban populations can also provide individuals to repopulate either existing natural lands after a catastrophic event or restored habitats within the species' range. An additional benefit of urban populations is increased public awareness and interest by local residents due to more frequent observations or encounters with kit foxes. Based on survey results, Bakersfield residents who had observed kit foxes had greater appreciation and knowledge of them and expressed greater support for conserving both urban and non-urban foxes (Bjurlin and Cypher 2005).

Our objectives are to 1) identify urban kit fox management issues and potential mitigation measures, 2) identify potential challenges for conserving urban kit foxes, and 3) offer recommendations for strategies to manage and conserve kit foxes in urban environments.

MANAGEMENT ISSUES

For a carnivore residing in an urban environment, San Joaquin kit foxes generate few conflicts. They are small, secretive, nocturnal, virtually silent, unaggressive, and rarely cause any damage or nuisance situations. The most common complaint is from golfers who claim that foxes residing on golf courses run out and steal their balls! The most significant management issues are probably 1) concerns regarding human and pet safety, 2) dens in inconvenient locations, and 3) collection and disposal of dead foxes.

Although safety is valid concern when a carnivore is living in close proximity to people, humans are at minimal risk from kit foxes. We are aware of only 2 instances of people being bitten by kit foxes, and in both cases the individuals bitten were trying to handle foxes (one fox was entangled in a soccer goal net, and the other fox was cornered and captured at a school). Similarly, we are not aware of any verified attacks on pets or livestock by kit foxes. Kit foxes carrying dead kittens have been reported but not substantiated. Domestic cat hair occurred in 2 of 180 urban kit fox scats in one study (Cypher and Warrick 1993) and 1 out of 2,081 scats in another study (B. L. Cypher, unpubl. data). However, it is unknown whether these occurrences represent predation or scavenging, or whether they involved companion or feral cats.

Kit fox dens in inconvenient locations likely constitute the most common conflict issue. In these situations, the presence of the den impedes some activity, creates a hazardous situation, or creates a nuisance situation. Kit fox dens on construction sites are an example of an impeded activity. In some instances the dens are present prior to the initiation of construction, and in other instances foxes create dens on active construction sites, where they may be attracted by easy digging in disturbed soil or food dropped by workers. Kit foxes occasionally have even created dens in partially constructed buildings. Construction activities in the immediate vicinity of a den cannot proceed while the den is occupied by the fox. Hazardous situations result when a den is in a location where a person might accidentally step in the den, causing them an injury. Examples include some dens on golf courses, where grass may obscure the den entrance, and dens on athletic fields or areas with heavy foot traffic on school campuses. Nuisance situations are those that are not dangerous but create an undesirable result. Examples include dens in which the excavated dirt lands on a sidewalk (in one instance, a door to a business was partially blocked by excavated dirt from a den). On one occasion, foxes constructed dens in a golf course sand bunker requiring repair of the bunker. Another example involves dens under homes, particularly mobile homes, and portable classroom buildings on school campuses. Nuisance problems resulting from these dens include fecal material on sidewalks, odors, flea infestations, and noise.

The mitigation strategy for a den in an inconvenient location is to remove the den, and there are protocols established by the U.S. Fish & Wildlife Service (USFWS) and the California Department of Fish and Game (CDFG) for doing so. Typically, a den is monitored for fox activity either by using tracking media or using an automated field camera. Once the den exhibits no sign of use by foxes for 3 nights, then it can be carefully excavated (in a manner that would allow any foxes inside to escape), collapsed, and compacted. In situations where time is more critical, a one-way door can be installed on a den to prevent foxes from reentering after they leave the den. Once it is certain that all foxes have exited the den, it can be excavated and collapsed. Foxes typically have multiple dens within their home range, and therefore the loss of one den usually does not adversely affect a fox. Natal dens with pups are more problematic, as no disturbance of such dens is allowed until the foxes leave the dens on their own, which could be a matter of weeks. When fox dens are removed, the loss can be mitigated by installing artificial dens (see below).

Another more recent management issue in Bakersfield is the collection and disposal of fox carcasses. With the large number of animals in the urban environment, foxes are not uncommonly struck and killed by vehicles while crossing roads. City and County Animal Control staff are responsible for collecting road-killed animals, but these organizations are reluctant to pick up dead kit foxes because they are an endangered species. This has resulted in frustrations on the part of individuals when a malodorous, unsightly carcass lies outside their home or business for multiple days.

Table 1. Causes of mortality for 78 radio-collared San Joaquin kit foxes found dead in Bakersfield, CA, 2001-2004. Total number of foxes monitored was 229.

Cause of Mortality	Number
Vehicle	27
Predator	17
Entombment	4
Poison	4
Drowning	1
Pellet gun	1
Entanglement	1
Birth complications	1
Undetermined	22

CONSERVATION CHALLENGES

Conserving populations of desirable wildlife, particularly a rare species, in urban environments is inherently challenging. Particular challenges for conserving urban populations of San Joaquin kit foxes are described below.

Roads

Vehicles are the primary cause of mortality for urban kit foxes (Table 1; Bjurlin et al. 2005, Cypher 2010). The pervasive nature of roads in urban environments makes them difficult to avoid, particularly for a highly mobile species like kit foxes. Furthermore, because kit foxes use so many different areas within urban environments, they rarely use well defined road crossing areas. Consequently, common strategies for reducing vehicle strikes (e.g., warning signs, reduced speed limits, crossing structures) have low probabilities of success. Also, kit foxes seem to have an inherent reluctance to use under-road crossing structures, particularly small ones where foxes may fear ambush by larger predators (Bremner-Harrison et al. 2007, Clevenger et al. 2010). Thus, mitigating vehicle mortality is difficult. In situations where a natal den is located in close proximity to a road, temporary signage to encourage slower speeds or at least be alert for foxes may be helpful.

Toxins

Various substances toxic to kit foxes and other wildlife are present in urban environments. Rodenticides are a particular concern. First-generation (e.g., warfarin, cholorphacinone, diphacinone) and more toxic second-generation (e.g., brodifacoum, difethialone, bromadiolone) anticoagulant rodenticides are commonly used in urban environments to control commensal rodents (rats, mice) and ground squirrels. These materials are used by professional pest control applicators and also have been available in over-the-counter products for use by non-professionals. They typically are dispersed in stations consisting of a container with holes that allow rodents to access toxin-infused food within. First-generation anticoagulants require multiple feedings before they are fatal, while second-generation compounds can be lethal with a single feeding. With both compounds, death is not immediate and rodents are potentially able to move considerable distances from bait stations before dying.

Of 30 liver samples collected from foxes found dead in Bakersfield, 27 (90%) contained residues of at least one anticoagulant (McMillin et al. 2008). It is unknown whether the exposures are primary (i.e., foxes consuming baits) or secondary (i.e., foxes consuming dead or dying rodents). At least 3 foxes are presumed to have died directly from exposure to anticoagulants, based on residue levels in their livers and other post-mortem evidence (e.g., profuse internal bleeding). Other foxes may have died directly from these toxins, but laboratory and necropsy results were not conclusive. Also unknown is the number of foxes for which illness associated with rodenticide exposure predisposed them to death by another agent, such as a vehicle or predator. Finally, adverse sublethal effects, including neonatal mortality (e.g., Munday and Thompson 2003), have not been investigated.

Strychnine poisoning has been confirmed among 4 kit foxes found dead in Bakersfield (S. McMillin, CDFG, pers. commun.). The likely source of the poison is strychnine-infused grain bait used to control pocket gophers. As with the anticoagulants, it is unknown whether the poisoning was primary or secondary, although grain was found in the stomach of one fox.

Rodenticides currently do not appear to be a limiting factor for the urban fox population in Bakersfield, but the high exposure rates are a cause for concern. Recent limitations on access to second-generation anticoagulants by non-professional applicators imposed by the U.S. Environmental Protection Agency (McMillin et al. 2008) and a ban on use of strychnine baits in Bakersfield (R. Arroyo, Kern County Dept. of Agriculture, pers. commun.) hopefully will help mitigate adverse impacts to kit foxes from rodenticides.

Sports Netting

In a very urban-specific situation, kit foxes have been found entangled in sports netting on least 29 occasions that we are aware of (CSUS Endangered Species Recovery Program, unpubl. data). This netting includes soccer goals, portable and permanent baseball batting cages, and a low-hanging volleyball net. Most of the entanglements have occurred on high school or college campuses. The foxes have died in at least 12 of these instances, and the badly damaged hind leg of a fox had to be amputated in another. Because they are nocturnal, kit foxes are assumed to have superb night-vision, and therefore the reason for these entanglements is puzzling.

Den Destruction

Kit fox dens in urban environments can be destroyed through a number of routine activities. The loss of a den in itself may not be a significant impact because kit foxes typically have multiple dens within their home range. However, a significant impact obviously occurs if a den is destroyed while occupied by one or more kit foxes, particularly if it is a natal den harboring young. In Bakersfield, new construction involving earth disturbance requires a permit that is issued under the Metropolitan Bakersfield Habitat Conservation Plan (MBHCP). Requirements associated with these permits include monitoring and closing kit fox dens per established protocols (MBHCP 1994), and therefore the risk to foxes is minimized.

A number of routine maintenance and operations activities are not covered under the MBHCP and therefore are not subject to the den closure requirements. These activities include maintenance of sumps, maintenance of canals, weed control, and landscaping. During these activities, ground is bladed, dug, or disked to contour surfaces, repair erosion damage, and remove vegetation. These earth-disturbances can close or collapse dens. Destruction of dens during these activities frequently is unintentional, and indeed, individuals conducting the activities may not even be aware that dens are present. Surveys for dens are not required prior to initiating these activities and therefore such surveys are rarely conducted. Consequently, a number of instances of den destruction have occurred (Cypher 2010). Adult foxes commonly are able to vacate dens prior to destruction, but young foxes may be unable or too inexperienced to leave, resulting in entombment.

Interspecific Competition

Non-native red foxes (*Vulpes vulpes*), striped skunks (*Mephitis mephitis*), feral cats, opossums (*Didelphis virginiana*), and raccoons (*Procyon lotor*) all commonly occur in urban environments inhabited by kit foxes, and these species potentially engage in interspecific competition with foxes. These species could compete with kit foxes for resources such as food and dens (i.e., exploitative competition), or potentially could kill kit foxes or spatially exclude them (i.e., interference competition). Kit foxes have reportedly been killed by the larger red foxes (Ralls and White 1995, Clark et al. 2005), but no such mortalities have been detected in Bakersfield (Bjurlin et al. 2005), where both are commonly observed in close proximity. It is unclear whether red foxes spatially exclude kit foxes, although red foxes have been observed using dens previously used by kit foxes and dietary overlap between the two species is high in the urban environment (Cypher 2010, unpubl. data). Thus, some competition may occur between these 2 species, although it does not currently appear to be a limiting factor for kit foxes. The other species probably do not engage in interference competition with kit foxes, but do use kit fox dens and likely overlap in diet. Feral cats and striped skunks have been observed using kit fox dens (Cypher 2010, Harrison et al. 2011).

Another significant threat to kit foxes from these sympatric species is the potential for disease transmission. Because of space limitations in urban environments, these species all occur in close proximity. For example, all of the species have been observed, sometimes concurrently, at or near feeding stations established for feral cats (Harrison et al. 2011). Also, as mentioned previously, several of the species have been observed using kit fox dens. Indeed, radio-collared striped skunks and kit foxes were detected together in dens on 4 occasions (Harrison et al. 2011). Thus, the potential for the transmission of diseases to kit foxes is high. Of particular concern is rabies, which is highly lethal and could significantly impact urban kit fox populations. A rabies epidemic in striped skunks may have contributed to the marked decline of a non-urban kit fox population (White et al. 2000).

Movement Corridors

Various urban landscape features could impede or even constitute barriers to movements by kit foxes. Although foxes can and do cross roads and occasionally move through residential areas, both of these features present higher risks for kit foxes, and thus sometimes constitute barriers. Fences and particularly walls also present barriers to movements. In addition to impeding movements, kit foxes potentially could be trapped up against barriers when fleeing from larger predators or when crossing roads.

Regulatory Issues

The applicability of endangered species regulations to urban kit foxes is somewhat unclear because these populations are deliberately inhabiting landscapes altered and dominated by humans. Currently, few regulations afford protections to urban kit foxes and no official policies exist that promote conservation of these populations. Intentional "taking" (e.g., death, injury, capture) of kit foxes is prohibited under the Federal and California Endangered Species Acts. However, whether any policies or regulations concerning incidental taking or harassment of foxes apply in urban environments is uncertain. The MBHCP mandates the careful exclusion of kit foxes prior to the destruction of known dens, but only for projects requiring an earth grading permit from the City of Bakersfield or Kern County (MBHCP 1994).

The USFWS and CDFG are the two agencies primarily responsible for endangered species protection. To date, neither has taken a lead role in promoting urban kit fox conservation, although this likely is partly due to the fact that the conservation potential of these populations has only recently become evident, and both agencies have limited resources. These agencies are becoming more active in urban kit fox conservation as they are able. Other entities that also potentially could assume lead roles include the City of Bakersfield, conservation organizations, and citizen groups, but none have stepped forward to date. As regulatory and other entities consider strategies for conserving urban kit fox populations, an important issue will be determining whether measures will be mandatory or voluntary. Mandatory measures may ensure greater compliance and may be appropriate for protecting kit foxes from harm or adverse impacts. Voluntary measures may be more appropriate for encouraging proactive conservation actions, such as the installation of artificial dens and permeable fences or walls. The minimization of mandatory requirements may help to enhance and maintain public support for conserving kit foxes.

CONCLUSIONS AND RECOMMENDATIONS

Generally, urban kit fox populations appear to be thriving, despite the management issues and conservation challenges described above, the high potential for human impacts, and the current lack of specific conservation measures. However, this situation easily could change because of the inherent difficulty of controlling and managing conditions in a dynamic, human-dominated landscape. Thus, any actions implemented, particularly proactively, to facilitate the conservation of urban kit fox populations will contribute toward the goal of enhancing the probability of persistence and viability of these populations. The following recommendations are offered to assist in achieving this goal.

Conservation Measures in New Habitat Conservation Plan

The current MBHCP is due to expire in 2014 and work has begun on the preparation of a new Habitat Conservation Plan (HCP), tentatively referred to as the Bakersfield Regional HCP. We recommend that this HCP include decisive, proactive conservation measures for urban kit foxes. These measures should include the following:

1. Required surveys for kit fox dens for all projects permitted under the HCP, with no exceptions.
2. Funding for a biologist who can deal with kit fox issues and conflicts, help interested parties implement conservation measures, and conduct outreach and education efforts.
3. Maintenance of connectivity within urban populations through fox-friendly urban landscape design.
4. Encouragement of voluntary conservation measures by developers including open spaces connected by corridors, fox-permeable walls and fences, and artificial dens.
5. Conducting outreach programs to enhance awareness and education.

Development of a Disease Prevention/Response Plan

A team that includes, among others, wildlife biologists, wildlife epidemiologists, and public health officials should be formed to develop a plan to minimize the potential for and the impacts of a fatal disease epidemic among urban kit foxes. Considerations in such a plan should include 1) preventative measures such as proactive vaccination of foxes, probably via oral baits, in selected areas where such efforts might be feasible; 2) monitoring for the presence of diseases; 3) identifying mitigation and treatment strategies in the event of an outbreak; 4) protecting public health in the event of a zoonotic disease outbreak (e.g., rabies); and 5) identifying possible population recovery strategies in the event that population impacts are catastrophic.

Implementation of Earth-Moving Guidelines to Protect Dens

Such guidelines should include required surveys for kit fox dens prior to earth-moving, protocols for protecting dens or for eliminating them without harming foxes, and restrictions on activities near active natal dens.

Restrictions on Rodenticide Use

Measures to further restrict access by foxes to rodenticide baits and dead/dying rodents should be developed and implemented.

Sports Netting Mitigation

Through regulation or at least vigorous outreach targeting schools in particular, standard practices should be implemented to remove sports netting when not in use or at least elevate it (0.5 m minimum) to help avoid entanglement by kit foxes.

Barrier Permeability

Some barriers, such as fences and walls, are easily rendered permeable to kit foxes. Gaps as small as 10-15 cm wide will permit passage by foxes. Permeable structures can be installed initially or retroactively modified to allow passage by kit foxes.

Kit Fox Accommodation in Urban Landscape Planning

Kit fox population facilitation should be a consideration incorporated into urban planning in cities with resident kit fox populations. Non-residential areas, particularly golf courses, parks, sumps, campuses, and other open space, are all areas commonly used by kit foxes. In designing urban landscapes, efforts to connect these areas with movement corridors, such as canals, power line and railroad right-of-ways, green belts, and recreational trails, will help maintain connectivity and facilitate movements by kit foxes between areas thus enhancing genetic and demographic exchange.

Outreach and Education

Outreach and education programs will help improve community awareness regarding kit foxes and their conservation needs. Such programs can be funded by public or private sources, and should include information about urban kit fox identification, biology, threats, and conservation measures. These programs can target city managers and maintenance staff, property owners, urban planners, developers, golf course managers, canal operators, construction crews, educators, school children, and the general public.

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