Sarcoptic Mange in Urban Kit Foxes: Potential for Cross-Species Transmission

Erica C. Kelly, **Brian L. Cypher**, **Tory L. Westall**, and **Nicole A. Deatherage**
California State University-Stanislaus, Endangered Species Recovery Program, Turlock, California
Jaime L. Rudd and **Deana L. Clifford**
University of California-Davis, School of Veterinary Medicine, Department of Medicine and Epidemiology, Davis, California; and California Department of Fish and Wildlife, Wildlife Health Laboratory, Rancho Cordova, California
Janet E. Foley
University of California-Davis, School of Veterinary Medicine, Department of Medicine and Epidemiology, Davis, California

ABSTRACT: A robust population of endangered San Joaquin kit foxes occurs in the city of Bakersfield, CA. In March 2013, sarcoptic mange was detected in this population and the disease quickly spread. In January 2019, mange also appeared in a smaller kit fox population in the neighboring town of Taft, CA. To date there have been more than 430 confirmed cases in and 100 confirmed deaths of kit foxes. An additional 118 unrecovered individuals are presumed deceased because there is no indication that kit foxes survive without medical intervention. These numbers are also presumed underestimations of the actual number of kit foxes that have contracted and died from mange. In addition to capturing and treating kit foxes, the Endangered Species Recovery Program has conducted a yearly citywide camera survey in Bakersfield since 2015 and Taft since 2019 to assess the occurrence of mange among kit foxes and the spatial pattern of spread. Based on the Bakersfield survey, the urban kit fox population has declined by 67% since 2015. This annual camera survey also provides information on co-occurring species that could contract or transmit mange. Of the total number of cameras that have detected kit foxes with mange, 88% of those also detected at least one secondary species including raccoons, opossums, striped skunks, California ground squirrels, and domestic cats and dogs. The annual camera surveys have also detected coyotes, red foxes, gray foxes, and opossums with active mange infestations. Transmission routes for all of these species remain uncertain and the potential for transmitting mites to new areas or new individuals of multiple species is possible. Overall, mange presents a risk to multiple species in the urban environment, including domestics, for as long as it continues to circulate.

KEY WORDS: camera survey, co-occurring, domestic species, endangered species, San Joaquin kit fox, *Sarcoptes scabiei*, sarcoptic mange, urban wildlife, *Vulpes macrotis mutica*

Proceedings, 30th Vertebrate Pest Conference (D. M. Woods, Ed.)
Paper No. 18. Published December 20, 2022. 7 pp.

INTRODUCTION

The San Joaquin kit fox (*Vulpes macrotis mutica*) is a small, desert-adapted canid endemic to the San Joaquin Valley of California (McGrew 1979, Cypher et al. 2013). Due to substantial habitat loss, the San Joaquin kit fox is federally listed as endangered, and state listed as threatened [U.S. Fish and Wildlife Service (USFWS) 1998]. Less than 5,000 individuals persist in a metapopulation consisting of three "core" populations and fewer than a dozen smaller "satellite" populations (USFWS 2010, Cypher et al. 2013, Cypher et al. 2017).

Many San Joaquin kit foxes (henceforth, kit foxes) remain in what is left of their fragmented natural habitat while urban populations also exist in Bakersfield and Taft, CA (Harrison et al. 2011, Cypher et al. 2017, USFWS 2020). Kit foxes are routinely observed in both municipalities and the Bakersfield population has historically been considered relatively stable at 200-500 individuals (Cypher and Frost 1999, Cypher 2010, Cypher et al. 2017). This genetically robust population is vital for overall kit fox conservation due to its potential as a source population for reintroductions into remaining natural lands and a defense against further decline in kit fox numbers (Cypher 2010, Cypher and Van Horn Job 2012, Cypher et al. 2017).

Kit foxes can contract a variety of viral, bacterial, fungal, and protozoal pathogens (McCue and O'Farrell 1988, Standley and McCue 1997, Cypher and Frost 1999), as well as endo- and ectoparasites (Egoscue 1962, McGrew 1979, Bjotvedt et al. 1980). In 2018-2019, canine distemper was confirmed as the cause of death of three kit foxes in Panoche Valley, CA (Rudd, pers. commun.). Documentation of a disease-causing significant decline in a kit fox population is rare, but not unheard of. White et al. (2000) documented a catastrophic decline in an isolated kit fox population due to a rabies outbreak. Within the span of nine years kit foxes were considered regionally extinct at the California Army National Guard Training Site, Camp Roberts (White et al. 2000).

Because of the abnormally high density of kit foxes in Bakersfield, the threat of a disease outbreak sweeping through the population was plausible. In March 2013 the first case of a kit fox infected with sarcoptic mange was documented in Bakersfield and the outbreak quickly spread within the city (Cypher et al. 2017). In January 2019 kit foxes in Taft, approximately 35 km west of Bakersfield, also became infected with sarcoptic mange (Cypher et al. *In Press*). To date more than 430 confirmed cases and 100 confirmed deaths from sarcoptic mange have been documented in the urban kit fox populations (CSUS ESRP unpubl. data). An additional 118 individuals were never recovered and are considered deceased because there is no indication that kit foxes recover without medical intervention (CSUS ESRP unpubl. data). These numbers are likely gross underestimations of the actual number of kit foxes

that have contracted and died from the disease.

Sarcoptic mange (hereafter, mange) is a skin disease caused by a microscopic mite, *Sarcoptes scabiei*, that burrows into the epidermal layers of its host causing a multitude of symptoms including intense itching, alopecia, thickened and inflamed skin, deep lesions, secondary infections, and eventual morbidity and death (Pence and Ueckermann 2002, Niedringhaus et al. 2019). Mange mites are highly contagious, have the ability to be infectious off host for about three days, and detect their host by smell and body temperature (Arlian et al. 1984, Bornstein et al. 2001). Thus, even if a mite was not passed from host to host by direct contact, it is possible for the mite to be transmitted by falling off one host and being picked up by another within a three-day period.

Mange has been documented in more than 100 species of mammals worldwide, including 12 canid species (Bornstein et al. 2001, Pence and Ueckermann 2002); kit foxes are number 13. It remains unclear how mange was introduced into these two urban kit fox populations, but coyotes (*Canis latrans*) or domestic dogs (*C. lupus familiaris*) are a likely source from both a genetic standpoint (Rudd et al. 2020) and direct observations of mangy individuals within Bakersfield (Cypher et al. 2021). The urban environment is also host to many additional species that could harbor and share afflictions, including mange. In addition to coyotes and kit foxes, both cities have a diverse mammal community that includes gray foxes (*Urocyon cinereoargenteus*), raccoons (*Procyon lotor*), red foxes (*Vulpes vulpes*), striped skunks (*Mephitis mephitis*), Virginia opossums (*Didelphis virginiana*), American badgers (*Taxidea taxus*), California ground squirrels (*Otospermophilus beecheyi*), fox squirrels (*Sciurus niger*), black-tailed jackrabbits (*Lepus californicus*), desert cottontails (*Sylvilagus audubonii*), pocket mice (*Perognathus inornatus* and *Chaetodipus californicus*) and domestic cats (*Felis catus*) and dogs (Cypher et al. 2017).

A citywide annual camera survey was initiated in Bakersfield in 2015 and Taft in 2019 to obtain an estimate of the urban kit fox population and to document the spread of mange. We not only documented healthy and mangy kit foxes, but a plethora of other urban wildlife and domestic species. Thus, we were able to use camera station images to assess the potential for cross-species transmission of mange in the urban environment.

METHODS

Study Site

This study was conducted within the cities of Bakersfield and Taft, California (Figure 1). Both cities are in the southern San Joaquin Valley in Kern County. Bakersfield is substantially larger, encompassing 392 km^2 with approximately 380,000 human inhabitants. Urbanized lands abut natural lands to the north, northeast, and southwest with irrigated agriculture bordering the rest of the city. Taft, located 35 km southwest of Bakersfield, is a smaller town of 39.5 km^2 and approximately 10,000 inhabitants. Taft is surrounded on all sides by suitable kit fox habitat. Both study sites have a climate characterized by hot, dry summers and cool winters with infrequent precipitation in the form of rain.

Data Collection

Annual city-wide camera station surveys have been conducted each summer since 2015 in Bakersfield and 2019 in Taft to assess the pattern of mange spread among kit foxes throughout both cities and to evaluate population trends. To conduct the surveys, we applied a 1-km^2 grid cell matrix over a map of both cities. Cells with >50% residential development were excluded from sampling due to a low probability of fox occurrence. We then utilized the randomization function in Excel 2010 (Microsoft, Redmond, WA) to randomly choose grid cells to sample. Our goal was to survey approximately 40% of the detection area (roughly 100 cells in Bakersfield and 10 in Taft). Within each selected grid cell, one wildlife camera was deployed in a location that was accessible to kit foxes and where the risk of camera theft was reduced (i.e., locations with restricted public access or where a camera could be placed in a cryptic location). Consequently, most camera stations were placed within school campuses, city or county storm water drainage basins, municipal facilities, churches, golf courses, private businesses (with owner permission), and undeveloped parcels. Whenever possible we used the same grid cells and specific camera location from year to year.

At each chosen location, we employed an automated camera station design and methodology developed specifically to survey for kit foxes and other sympatric carnivores (Westall and Cypher 2017). We used Cuddeback IR cameras (Attack Black Flash Models E3 or C3, Cuddeback Digital, De Pere, WI) that employ a "black flash" infrared LED flash that creates almost no light visible to humans (therefore reducing the potential for theft or vandalism) and is less startling for animals. The cameras take high-resolution images (20 megapixels) that facilitate the detection of symptoms typical of mange. The cameras were programmed to take multiple images at 1-sec intervals when motion triggered, and then employ a 15-sec delay before triggering again. When possible, cameras were placed in a lock box (CuddeSafe Model 3327, Cuddeback Digital, De Pere, WI) and secured to a stable object (i.e., fence, tree, light pole) with zip-ties and locked down with a cable lock to deter theft. In safer locations, we secured the cameras to 1.2 m (3 ft) U-posts using zip-ties.

To attract foxes, we placed several drops of a scent lure (Carman's Canine Call Lure, New Milford, PA) in front of the camera and on surrounding vegetation. We also staked a 155-g can of cat food to the ground approximately 2 m in front of each camera using 30-cm nails. The cat food cans were perforated to allow scent to void, but limit access to the food. The staked cat food cans functioned as a further attractant for foxes and also caused them to remain in the camera's field of view for an extended period as foxes attempted to access the food and/or defecate on the cans.

Camera stations were collected after seven nights. All images were downloaded and examined for mammals. Photos of foxes and other mammals were carefully examined for any characteristic signs of mange, such as rough pelage, patches of alopecia, thickened and crusty skin, and lesions on the hips (Cypher et al. 2017). For each year and all years combined, we documented the total number of cameras with visits by kit foxes and at least one other mammal species during the entire camera session (seven nights). We also investigated the number of visits by kit

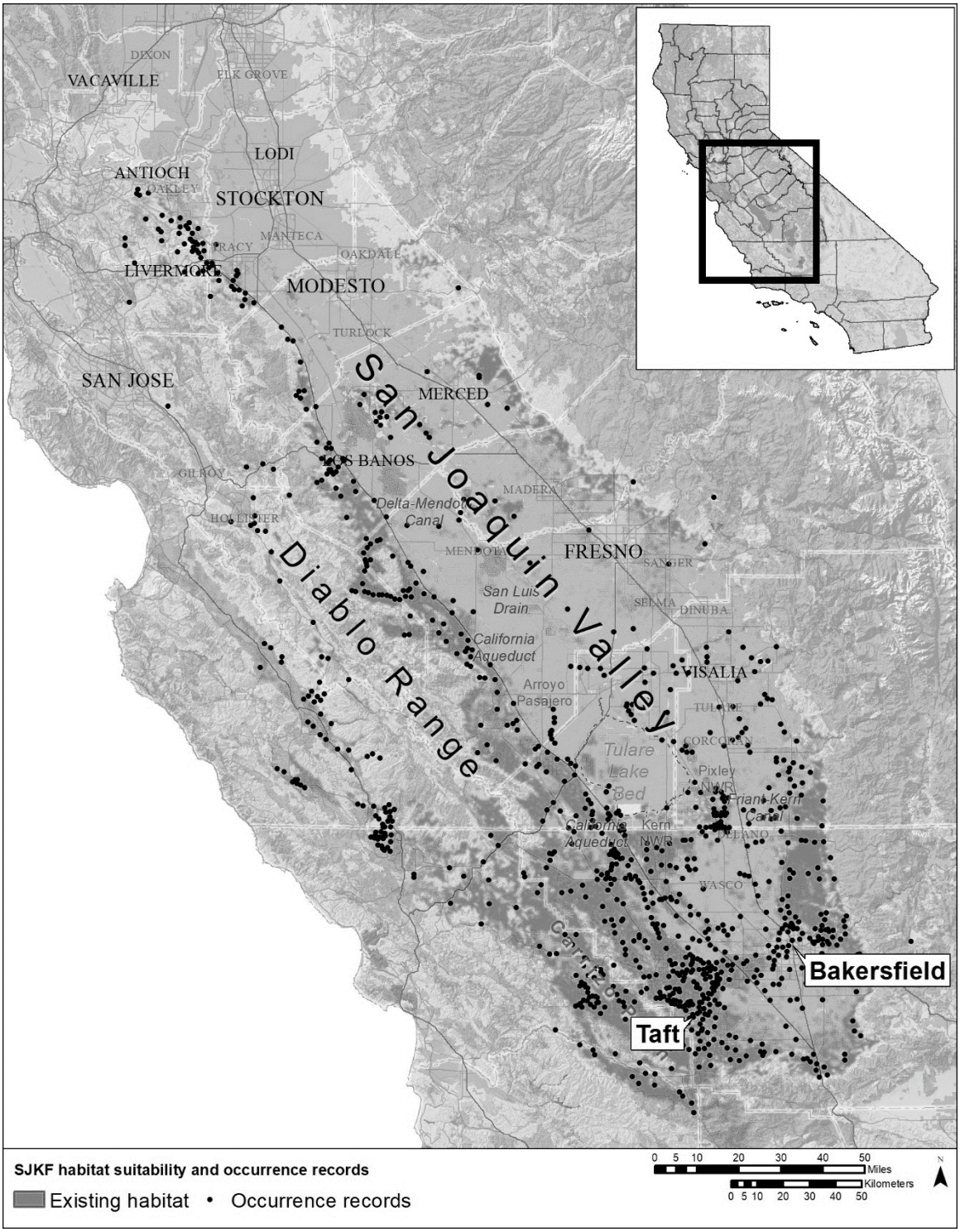

Figure 1. Locations of the cities of Bakersfield and Taft within the range of the San Joaquin kit fox (*V. macrotis mutica*) in the San Joaquin Valley of California.

foxes and other mammal species to the same station on the same night. For the purpose of our analyses, the camera results from both locations were combined to reflect results for the urban environment.

RESULTS

From 2015 to 2021 we deployed 796 wildlife cameras (762 cameras in Bakersfield and 34 in Taft), the majority of which were in Bakersfield due to the size of the town and greater number of monitoring years. A minimum of 3,223 individual mammals, both wild and domestic, were detected during the seven years of summer surveys. Kit foxes were detected at 285 cameras (263 cameras in Bakersfield and 22 cameras in Taft). Out of the total number of cameras that detected kit foxes, 252 cameras (88%) detected at least one additional mammal species during the seven days. Thirty-three cameras detected kit foxes with mange of which 29 (88%) had at least one additional mammal species visit the camera during the week.

There were many times where a camera documented multiple mammal species over the course of the week. At one particularly active camera station we had photos of at least one kit fox, opossum, gray fox, domestic cat, and striped skunk. The animal that occurred most frequently at the same camera station as kit foxes was domestic cats, followed by domestic dogs, striped skunks, and raccoons (Table 1). In all years combined, there were 475 instances of kit foxes and at least one additional species visiting a camera station during the course of the seven-day survey session.

We also investigated the number of visits by kit foxes and one or more additional mammal species to the same station on the same night. Cameras were deployed for a total of 5,551 trap nights (5,313 in Bakersfield and 238 in Taft). For all years combined there were 856 (15%) trap nights where kit foxes were detected (Table 2). Of these, there were 508 (59%) trap nights where at least one additional species was detected (Table 2). By year, the proportion of nights with kit foxes and a minimum of one additional species was typically higher than the proportion of nights with just kit foxes (Table 2). Overall, it was more common for kit foxes and at least one additional species to be captured on camera within the same night than kit foxes alone.

It was not uncommon for multiple additional species to visit the camera on the same night as kit foxes. To assess species-specific visits with kit foxes, we documented each occurrence where kit foxes and a specific additional species were present during the same trap night (Table 3). By far, kit foxes occurred most frequently with domestic cats on the same night, followed by occurrences with striped skunks, opossums, and domestic dogs. Observing multiple species on camera at the same time was rare.

After careful examination of each photo of a mammal species, we recorded five different species where at least one individual was afflicted with mange. The majority of mangy animals were kit foxes. From 2015 to 2021 our camera study detected mange in 45 individual kit foxes (10 in 2015, eight in 2016, 13 in 2017, eight in 2018, four in 2019, and one in both 2020 and 2021). Over the seven-year camera study we also observed signs of mange in three coyotes (in 2019), two red foxes (one in 2017 and 2021), two opossums (one in 2017 and 2018), and one grey fox (in 2017).

Table 1. Number of cameras that captured San Joaquin kit foxes (*V. macrotis mutica*) and at least one other species during the seven-day survey session, by year.

Additional Species		2015	2016	2017	2018	2019	2020	2021	Total
American badger		0	0	0	0	0	0	1	1
Black-tailed jackrabbit		2	1	1	2	7	4	5	22
California ground squirrel		5	4	3	2	3	2	1	20
Coyote		0	2	0	1	6	4	8	21
Desert cottontail		2	1	2	1	6	1	1	14
Domestic cat		50	42	30	22	17	19	24	204
Domestic dog		12	6	6	3	8	5	13	53
Fox squirrel		2	1	2	0	0	0	0	5
Gray fox		2	2	0	0	1	1	1	7
Pocket mouse		0	1	0	0	0	0	0	1
Raccoon		6	6	6	6	6	6	6	42
Red fox		2	0	0	0	0	1	1	4
Striped skunk		13	8	9	4	3	4	2	43
Virginia opossum		11	6	4	4	5	4	4	38

Table 2. The number and proportion of trap nights with San Joaquin kit foxes (*V. macrotis mutica*) captured on camera; and the number and proportion of trap nights with kit foxes and at least one other species on camera in the same night, by year.

	2015	2016	2017	2018	2019	2020	2021	All Years
Nights w/ kit fox detected	226	180	113	96	73	87	81	856
Nights w/ kit fox only	104	96	39	37	13	39	20	348
Nights w/ kit fox and ≥1 other species	122	84	74	59	60	48	61	508
Proportion nights w/ kit fox only	46%	53%	35%	39%	18%	45%	25%	41%
Proportion nights w/ kit fox and ≥1 other species	54%	47%	65%	61%	82%	55%	75%	59%

Table 3. The number of occurrences that San Joaquin kit foxes (*V. macrotis mutica*) and other mammal species were detected, by year.

Additional Species	2015	2016	2017	2018	2019	2020	2021	All Years
Black-tailed jackrabbit	5	0	0	1	16	5	3	30
California ground squirrel	3	3	10	1	3	2	3	25
Coyote	0	2	0	0	6	3	9	20
Desert cottontail	1	1	6	5	6	2	1	22
Domestic cat	89	70	52	44	31	32	36	354
Domestic dog	12	5	4	1	4	2	14	42
Fox squirrel	2	1	1	0	0	0	0	4
Gray fox	1	1	0	0	0	1	2	5
Raccoon	3	1	2	8	1	3	1	19
Red fox	0	0	0	0	0	1	0	1
Striped skunk	19	6	14	3	5	6	2	55
Virginia opossum	15	7	3	7	5	3	4	44

DISCUSSION

Over the last seven years, our camera surveys have documented thousands of mammals living in Bakersfield and Taft. All could be potential vectors for mange, and some showed clinical signs of an active mange infestation. Camera stations were baited with cat food and a commercial scent lure in an effort to attract mangy foxes in the vicinity, which may have inadvertently caused animals to come into close proximity with one another although no physical contact between species was captured on camera. By conducting the survey during the hot, dry summer months, mites that may have been shed at the camera would desiccate and die relatively quickly (Arlian 1989, Bornstein et al. 2001). These standard camera trapping methods also provided a valid assessment of species and their relative abundance in the area that the camera was deployed. In general, kit foxes and other mammals can occur within the same area and may cross paths either directly or within hours or a few days of each other. Thus, the potential for transmission of mange mites between species exists.

Studies have shown that direct contact is the most likely mode of mange transfer (Arlian and Morgan 2017) and many species do not normally cohabitate with one another. Kit foxes are small and avoid most other species, especially those that are larger or heavier. Coyotes, red foxes, and domestic dogs are known to kill kit foxes (Cypher and Scrivner 1992, Gosselink et al. 2003) and gray foxes, raccoons, most domestic cats, and many skunks and opossums weigh more than kit foxes. Thus, kit foxes avoid contact with these species.

There are instances of close contact between species where mites could be transferred from an infested individual to a new host. For example, coyotes are attracted to active kit fox dens and mangy coyotes have been observed investigating and attempting to gain access to kit fox dens (CSUS ESRP unpubl. data). It is possible for mites to be dislodged at this time, contaminating the den entrance and exposing kit foxes to mange mites. Harrison et al. (2011) also found that 30% of the known denning sites at California State University, Bakersfield were utilized by kit foxes and striped skunks, albeit not concomitantly, although simultaneous den use by kit foxes and striped skunks was documented on four separate occasions (Harrison et al. 2011). Red foxes, opossums, California ground squirrels, and domestic cats have all been documented using kit fox dens. Even if they are not using the dens simultaneously, mange mites can live off-host and remain infectious for up to three days and subsequently infest a previously healthy individual (Gerasimov 1958, Arlian et al. 1984).

An additional mode of mite transfer could be at shared feeding sites. Feral cat-feeding stations are a common occurrence throughout Bakersfield, causing many individuals of multiple species to congregate in the same area. Kit foxes, skunks, and red foxes have all been documented at these cat feeding stations, sometimes at the same time, and other species such as raccoons and opossums also are attracted to this easily attainable food source (Harrison et al. 2011). Additionally, animals in the urban environment may come into close proximity around trash cans and improperly discarded food waste.

Both Bakersfield and Taft also have substantial free-ranging or feral dog and cat populations. Although we did not document any dogs or cats with mange during any of the camera surveys, local vets and animal shelter staff have reported some cases among feral dogs over the years (Cypher et al. 2021). During our study domestic cats and dogs were the most common species to be documented visiting a camera the same week as kit foxes. Indeed, domestic cats were the most common species detected at camera stations on the same night as kit foxes and domestic cats occurred six and a half times more often than any other urban species.

Despite the possibility for cross-species transmission of mange mites, the majority of mange cases in Bakersfield and Taft have been limited to the kit fox population, and genetic analyses of the mites suggest that mange is typically passed from kit fox to kit fox (Rudd et al. 2020). During our camera study we only documented a few coyotes, red foxes, and opossums with mange signs and unfortunately were unable to sample the individuals. Coyotes and red foxes have tested positive for mange in Bakersfield (Rudd et al. 2020), but coyotes are also known to be afflicted with noncontagious demodectic mange (*Demodex canis*; Hernández and Laundré 2019, Rudd, pers. commun.). The source of mange in these additional species remains unknown.

To date, mange does not appear to be severely impacting other species that co-occur with kit foxes in urban environments. Although it is quite prevalent in the kit fox populations, mange mostly seems to be perpetuated in

these populations through transmission among conspecifics (Rudd et al. 2020). The source of mange in populations of the other species and modes of transmission are unknown. Importantly from both an animal health and public relations perspective, mange remains quite rare in domestic animals in Bakersfield and Taft.

The urban kit fox population in Bakersfield has suffered considerably from an almost decade long outbreak of mange (Cypher et al. 2017, Rudd et al. 2020, Cypher et al. *In Press*). Mange has caused a significant population decline of over 67% (Cypher et al. 2022, CSUS ESRP unpubl. data). Numerous kit foxes have died in Taft as well, and this population likely has also declined. Efforts to treat kit foxes with mange in both cities continues. To date, 143 kit foxes have been hospitalized for severe mange infestations and hundreds of field treatments have been administered to actively sick or exposed individuals (CSUS ESRP unpubl. data). Fortunately, no mange has been detected in nearby non-urban populations (Cypher et al. 2022). It remains to be seen if this changes in the future. Continued response, research, and monitoring of the urban kit fox populations are imperative to better understand this outbreak and its implications for this endangered species.

ACKNOWLEDGEMENTS

Funding for this project was generously provided by multiple entities: The Morris Animal Foundation (grant D17ZO-066), the U.S. Bureau of Reclamation's Central Valley Project Conservation Program (grant R19AP000068), Sacramento Field Office of the U.S. Fish and Wildlife Service, and the California Department of Fish and Wildlife.

We greatly appreciate the dozens of small business owners and employees, school districts and campuses, private schools, golf courses, Meadows Field Airport police and staff, churches, city and county staff, and many local residents for use of their property to place cameras. Without their permission to access their sites this project would not have been possible.

LITERATURE CITED

Arlian, L. G. 1989. Biology, host relations, and epidemiology of *Sarcoptes scabiei*. Annual Review of Entomology 34:139-161.

Arlian, L. G., and M. S. Morgan. 2017. A review of *Sarcoptes scabiei*: past, present, and future. Parasites & Vectors 10: 297.

Arlian, L. G., R. A. Runyan, L. B. Sorlie, and S. A. Estes. 1984. Host-seeking behavior of *Sarcoptes scabiei*. Journal of the American Academy of Dermatology 11:594-598.

Bjotvedt, G., S. M. Tomkiewicz Jr., and R. T. Golightly. 1980. A description of helminths in a kit fox (*Vulpes macrotis*). Veterinary Medicine, Small Animal Clinician 75:881-884.

Bornstein, S., T. Mörner, and W. M. Samuel. 2001. *Sarcoptes scabiei* and sarcoptic mange. Pages 107-119 *in* W. M. Samuel, M. J. Pybus, and A. A. Kocan, editors. Parasitic diseases of wild mammals, 2nd Ed. Iowa State University Press, Ames, IA.

Cypher, B. L. 2010. Kit foxes. Pages 49-60 *in* S. D. Gehrt, S. P. D. Riley, and B. L. Cypher, editors. Urban carnivores: ecology, conflict, and conservation. Johns Hopkins University Press, Baltimore, MD.

Cypher, B. L., N. A. Deatherage, T. L. Westall, E. C. Kelly, J. E. Foley, D. L. Clifford, and J. L Rudd. (*In Press*.) Movements by endangered kit foxes between urban and non-urban habitats: implications for inter-population disease transfer. Journal of Wildlife Diseases

Cypher, B. L., N. A. Deatherage, T. L. Westall, E. C. Kelly, and S. E. Phillips. 2022. Potential habitat and carrying capacity of endangered San Joaquin kit foxes in an urban environment: implications for conservation and recovery. Urban Ecosystems https://doi.org/10.1007/ s11252-022-01287-8

Cypher, B. L., and N. Frost. 1999. Condition of kit foxes in urban and exurban habitats. Journal of Wildlife Management 63: 930-939.

Cypher, B. L., S. E. Phillips, and P. A. Kelly. 2013. Quantity and distribution of suitable habitat for endangered San Joaquin kit foxes: conservation implications. Canid Biology and Conservation 16:25-31.

Cypher, B. L., J. L. Rudd, T. L. Westall, E. C. Kelly, N. A. Deatherage, D. L. Clifford, J. E. Foley, and P. Foley. 2021. Epidemiological attributes of sarcoptic mange in a population of San Joaquin kit foxes: development and implementation of strategies to mitigate an epidemic. Report to U.S. Bureau of Reclamation, Central Valley Project Conservation Program, Sacramento, CA.

Cypher, B. L., J. L. Rudd, T. L. Westall, L. W. Woods, N. Stephenson, J. E. Foley, D. Richardson, and D. L. Clifford. 2017. Sarcoptic mange in endangered kit foxes (*Vulpes macrotis mutica*): case histories, diagnoses, and implications for conservation. Journal of Wildlife Diseases 53:46-53

Cypher, B. L., and J. H. Scrivner. 1992. Coyote control to protect endangered San Joaquin Kit Foxes at the Naval Petroleum Reserves, California. Proceedings of Vertebrate Pest Conference 15:42-47.

Cypher, B. L., and C. L. Van Horn Job. 2012. Management and conservation of San Joaquin kit foxes in urban environments. Proceedings of Vertebrate Pest Conference 25:347-352.

Egoscue, H. J. 1962. Ecology and life history of the kit fox in Tooele County, Utah. Ecology 43:481-497.

Gerasimov, Y. 1958. Mange in wild foxes. Translation of Russian game reports, Canadian Department of Northern Affairs National Resources, Ottawa, Canada.

Gosselink, T. E., R. E. Warner, M. G. Joselyn, and T. R. Van Deelen. 2003. Temporal habitat partitioning and spatial use of coyotes and red foxes in east-central Illinois. Journal of Wildlife Management 67:90-103.

Harrison, S. W. R., B. L. Cypher, S. Bremner-Harrison, and C. L. Van Horn Job. 2011. Resource use overlap between urban carnivores: implications for endangered San Joaquin kit foxes (*Vulpes macrotis mutica*). Urban Ecosystems 14:303-311.

Hernández, L., and J. W. Laundré. 2019. Coyote in Mexico. Pages 187-205 *in* R. Valdez, and J. Alfonso Ortega-Santos, editors. Wildlife Ecology and Management in Mexico. Texas A&M University Press, College Station, TX.

McCue, P. M., and T. P. O'Farrell. 1988. Serological survey for selected diseases in the endangered San Joaquin kit fox (*Vulpes macrotis mutica*). Journal of Wildlife Diseases 24: 274-281.

McGrew, J. C. 1979. *Vulpes macrotis*. Mammal Species 123:1-6.

Niedringhaus, K. D., J. D. Brown, K. M. Sweeley, and M. J. Yabsley. 2019. A review of sarcoptic mange in North American wildlife. Parasites and Wildlife 9:285-297.

Pence, D. B., and E. Ueckermann. 2002. Sarcoptic mange in wildlife. Revue Scientifique et Technique (International Office of Epizootics) 21:385-398.

Rudd, J. L., D. L. Clifford, B. L. Cypher, J. M. Hull, A. J. Riner, and J. E. Foley. 2020. Molecular epidemiology of a fatal sarcoptic mange epidemic in endangered San Joaquin kit foxes (*Vulpes macrotis mutica*). Parasites and Vectors 13:1-11

Standley W. G., and P. M. McCue. 1997. Prevalence of antibodies against selected diseases in San Joaquin kit foxes at Camp Roberts, California. California Fish Game 83:30-37.

US Fish and Wildlife Service (USFWS). 1998. Recovery plan for upland species of the San Joaquin Valley, California. U.S. Fish and Wildlife Service, Region 1, Portland, OR.

USFWS. 2010. San Joaquin kit fox (*Vulpes macrotis mutica*) 5-year review: summary and evaluation. U.S. Fish and Wildlife Service, Sacramento, CA.

USFWS. 2020. Species Status Assessment Report for the San Joaquin kit fox (*Vulpes macrotis mutica*). U.S. Fish and Wildlife Service, Sacramento, CA.

Westall, T. L., and B. L. Cypher. 2017. Latency to first detection of kit foxes (*Vulpes macrotis*) during camera surveys. Canid Biology and Conservation 20:32-37.

White P. J., W. H. Berry, J. J. Eliason, and M. T. Hanson. 2000. Catastrophic decrease in an isolated population of kit foxes. The Southwestern Naturalist 45:204-211.