 ISSN 1478-2677

Research report

Latency to first detection of kit foxes during camera surveys

Tory L. Westall[1*] and Brian L. Cypher[2]

[1] Endangered Species Recovery Program, California State University – Stanislaus, One University Circle, Turlock, CA 95382, USA. Email: http://twestall@esrp.csustan.edu.

[2] Endangered Species Recovery Program, California State University – Stanislaus, One University Circle, Turlock, CA 95382, USA. Email: bcypher@esrp.csustan.edu.

* Correspondence author

Key words: California, endangered species, presence-absence surveys.

Abstract

Remote cameras are being used extensively to survey and monitor numerous wildlife species. A question of interest is the length of camera deployment necessary to ensure detection of a species if it is present. We analysed camera station data from six projects to determine the latency to first detection of kit foxes. San Joaquin kit foxes are federally listed as Endangered and state listed as Threatened, and desert kit foxes are a species of conservation concern in the Mojave Desert of California. We deployed 278 remote cameras for 7-69 nights and detected kit foxes on 203 (73.0%) of them. The mean number of nights to first detection of a kit fox was 4.3 ± 0.7 in natural populations and 1.7 ± 0.3 in urban populations. In the urban population, 70.6% of cameras detected a kit fox on the first night and 97.1% of cameras had detected a fox after six nights. In natural populations, 45.9% of cameras detected a kit fox on the first night and 95.0% had detected a fox after 16 nights. Camera stations are an effective and efficient method for detecting kit foxes. To survey for presence of kit foxes, we recommend deploying cameras for at least 14 nights at a spacing of approximately two per kit fox home range (one camera per 2.9km^2).

Introduction

The San Joaquin kit fox *Vulpes macrotis mutica* is listed as Threatened by the California Department of Fish and Wildlife (CDFW) and Endangered by the United States Fish and Wildlife Service (USFWS) due to extensive habitat loss throughout its historical range (USFWS 1998). The desert kit fox (LC, *V. m. arsipus*), a related subspecies, is a species of Least Concern, but is considered to be a species of conservation concern in several parts of its range (IUCN 2008). The major threat to both subspecies is the continued conversion of habitat for agricultural, industrial and urban purposes. Surveys to determine presence or absence of kit foxes are frequently required prior to any disturbance of habitat so that proper mitigation measures can be taken. Surveying for presence of kit foxes is also important in assessing the quality of habitat for mitigation, as well as for monitoring populations on existing natural lands.

Remote cameras are increasingly being used to survey for wildlife (e.g. Harrison et al. 2002, Swann et al. 2004, Heilburn et al. 2006, Nielsen and McCollough 2009), measure relative abundance (e.g. Swann et al. 2004, Gompper et al. 2006, Heilburn et al. 2006, Brawata et al. 2013), and study activity and behaviour (e.g. Locke et al. 2005, McGee et al. 2005, Brawata et al. 2013). This method is particularly effective for some carnivores due to their secretive nature, nocturnal activity and low densities (Heilbrun et al. 2006, Swann et al. 2004, Crooks et al. 2008, Balme et al 2009, Nielsen and McCollough 2009). Use of remote cameras is beneficial because it is less invasive, more cost efficient and less time consuming than other methods, while at the same time providing verifiable proof of a species' presence (Heilbrun et al. 2006, Nielsen and McCollough 2009). Remote cameras are increasingly used to detect and monitor kit foxes (Constable et al. 2009, Cypher 2010, Fiehler and Cypher 2011) and are required for protocol level surveys (methodology required by regulatory agencies) to determine if the species is present (USFWS 1999). A question that arises is how long cameras should be deployed to maximize efficiency and probability of detection.

The purpose of this study was to conduct a retrospective analysis of existing camera survey data to determine latency to first detection of kit foxes in areas where they are known to occur. We analysed camera

The following is the established format for referencing this article:

Westall, T.L. and Cypher, B.L. 2017. Latency to first detection of kit foxes during camera surveys. *Canid Biology & Conservation* 20(8):32-37. URL: http://www.canids.org/CBC/20/kit_fox_detection_from_camera_surveys.pdf.

station detection data collected previously at six study sites to determine the latency to first detection of kit foxes at camera stations.

Methods

Study sites

All study sites used for this analysis were areas that are known to be consistently occupied by kit foxes based on previous work conducted by us and others. Cameras were only deployed in areas where the habitat was considered suitable for kit foxes. Camera stations were deployed during three seasons; spring (April through June), summer (July through September), and fall (October through December).

In 2008, the California State University, Stanislaus-Endangered Species Recovery Program (ESRP) conducted a study on oilfield effects on wildlife (Fiehler et al. 2017) in western Kern County, California (Figure 1). The vegetation in the plots consisted of arid shrub-land, annual grassland and disturbed oil production areas. Valley saltbush scrub is the predominant natural community in the study area (Fiehler et al. 2017). Remote cameras were used to detect the presence and relative abundance of carnivores on the study site, and camera locations were separated by at least 0.62km. From 2009 to 2014, ESRP conducted a study of coyote *Canis latrans* predation on desert tortoises *Gopherus agassizii* in the Mojave Desert (Cypher et al. 2014a) near Barstow, California (Figure 1). The region is primarily desert scrub vegetation dominated by creosote bush *Larrea tridentate* with an elevation ranging from 500-900m. Cameras were deployed in an effort to detect the presence and relative abundance of coyotes across the study area and all camera stations were at least 0.62km apart. Kit fox visits to stations exceeded those of coyotes (Cypher et al. 2014a). In 2012, ESRP collected ecological and demographic information for a satellite population of San Joaquin kit foxes (Cypher et al. 2014b) located on the Northern Semitropic Ridge Ecological Reserve (NSRER) in northern Kern County, California (Figure 1). The vegetation communities within the study area include alkali sink scrub, valley saltbush scrub, and non-native grassland. Cameras were deployed in an attempt to locate collared foxes prior to trapping, and stations were separated by 0.40–0.80km.

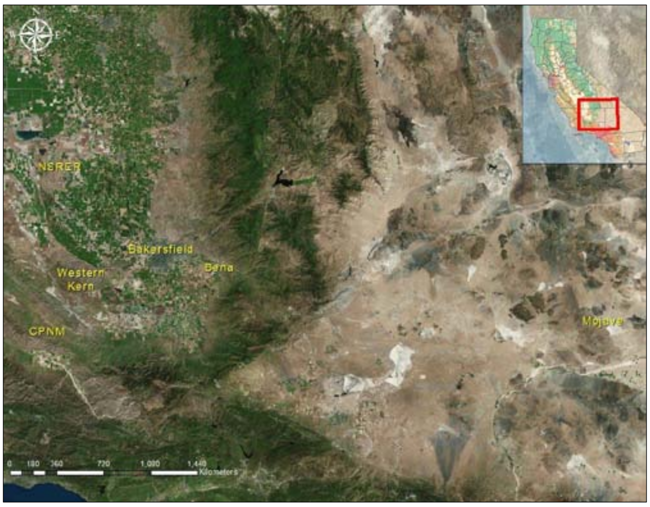

Figure 1. Study sites on which camera surveys were conducted to detect kit foxes in California from 2008 to 2015.

Since 1999, ESRP has been collecting demographic and ecological information on the San Joaquin kit fox population using the Bena Landfill (Cypher and Brown 2006) in Kern County, California (Figure 1). The habitat is primarily non-native grassland dominated by red brome *Bromus madritensis* and other annual grasses and forbs with small patches of valley saltbush scrub habitat in some of the drainages. Cameras were deployed to detect kit fox presence and determine reproduction success, and camera stations were separated by at least 0.40–0.80km. In 2014 ESRP began a study to quantify trophic interactions of the San Joaquin kit fox population on the Carrizo Plain National Monument (CPNM) in San Luis Obispo County, California (Figure 1). The habitat is primarily saltbush scrub and native and non-native grasslands. Cameras were used to assess the abundance patterns of kit foxes and coyotes across the project site, and stations were deployed a minimum of 1.6km apart. In March 2013, sarcoptic mange was diagnosed among kit foxes in Bakersfield, California (Figure 1). A city-wide survey was conducted to determine the location and extent of affected animals. The city was gridded into 1km^2 grid cells and cameras were deployed in 105 cells during the summer of 2015.

Field methods

We deployed a single remote camera at each station (Cuddeback Digital Attack IR, Model 1156, Non Typical Inc. Green Bay, WI, USA; Cuddeback Black Flash, Model E3, Non Typical Inc. Green Bay, WI, USA; Stealth Cam 3.0 MP Digital Scouting Cameras, Model STC-AD2/AD2RT, Stealth Cam LLC, Bedford, TX, USA) and stations were spaced out as appropriate for the objectives of each study, as described above. Cameras were set facing north and in areas with low vegetation to minimise unnecessary triggers (e.g. movement of the sun, grass, shrubs, etc.). Low vegetation also ensures a clear view of the target without obstruction. Camera settings varied depending on the model, but all cameras were set to the highest sensitivity and fastest trigger rate. We set Cuddeback Digital Attack IRs to take one picture every 15 seconds, Cuddeback Black Flash to take one picture every 20 seconds, and Stealth Cams to take three pictures once a minute. Cuddeback Digital Attack IRs used infrared flash, Cuddeback Black Flash used black flash, and Stealth Cams used a white light flash when triggered at night. We secured the cameras to 1.2m U-posts using zip ties and duct tape. Cameras were attached approximately 0.4m from the ground and angled to point the camera at a spot approximately 2m in front of the camera. To attract carnivores, we dripped a scent lure (Carman's Canine Call Lure, Russ Carman, New Milford, PA, USA) in front of the camera and on surrounding vegetation. We also staked a 0.03l can of cat food to the ground approximately 2m in front of each camera using 30cm nails, tent stakes, or pieces of rebar to provide a novel object for defecation as well as incentive to remain in the camera's field of view.

Statistical analyses

To determine latency to first detection of a kit fox, we analysed camera survey data from the six study sites and recorded the number of nights to the first detection for each camera. Each camera station was considered a sample. We calculated the mean number of nights $\pm$ standard error by study site, habitat type, and season. The western Kern County, Mojave Desert, NSRER, CPNM, and Bena Landfill sites are natural habitat whereas the Bakersfield site is urban habitat. We used a Kruskal-Wallis test with $\alpha = 0.05$ significance level to compare number of nights to first detection between sites, habitats, and seasons. For pairwise comparisons, we used multiple Mann-Whitney tests with a Bonferroni correction.

Results

We summarized detection data from a total of 277 camera stations. Of those, 203 (73.3%) camera stations detected kit foxes and were used for this analysis (Table 1). There was a significant difference in latency to first detection between the Bakersfield site and the CPNM ($W = 2802.5$, $p < 0.0001$), but no significant difference between any other sites. The mean number of nights to first detection of kit foxes was significantly lower ($H = 44.03$, $df = 1$, $p < 0.01$) for the urban environment than all natural areas combined (Table 1).

On all study sites, kit foxes were detected on the first night by one or more cameras. For all 203 camera stations that detected foxes, 54.2% had a detection on the first night, 66.0% had a detection by the second night, and 76.4% had a detection by the third night. By the time camera stations had been deployed for 14 nights, 96.1% of all cameras had detected a kit fox. Out of 135 cameras in natural habitat, 45.9% detected a kit fox on the first night, 57.8% had detected a kit fox by the second night, and 71.1% had detected a kit fox by the third night (Figure 2). After 14 nights, 94.1% of camera stations in natural lands had detected a fox (Figure 2). In the urban environment, 70.6% of the camera stations detected a fox on the first night, 82.4% had a detection by the second night, and 86.8% had a detection by the third night (Figure 2). By the fifth night, 94.1% of urban camera stations had detected a kit fox (Figure 2). The average number of nights to first detection of kit fox was 2.5 ± 0.3 in summer, 4.8 ± 1.1 in spring, and 4.2 ± 0.8 in fall (Table 1). There was no significant difference in latency to first detection between seasons ($H = 5.7$; $df = 2$; $p = 0.06$).

While not all cameras detected foxes, there were a number of stations that had kit fox scat present. On the CPNM, 20 cameras did not detect kit foxes, but nine (45.0%) of those stations had kit fox scat present in the vicinity of the station. In addition, two (16.7%) of 12 stations in the Mojave Desert had kit fox scat present, but no camera detections of foxes. In Bakersfield there were no scats present at stations that did not detect kit foxes and at NSRER all cameras detected kit foxes. Scats were not collected from camera stations deployed in western Kern County or at Bena landfill, so the number of stations that had scat, but no detections, is unknown.

In addition to kit foxes, at least 39 other species were detected including a marsupial, two lagomorphs, five rodents, ten carnivores, three ungulates, 17 birds, and an amphibian (Table 2). Among these were a California Threatened species (San Joaquin antelope squirrel; *Ammospermophilus nelsoni*) and four California Species of Special Concern: American badger *Taxidea taxus*, burrowing owl *Athene cunicularia*, Leconte's thrasher *Toxostoma lecontei*, and loggerhead shrike *Lanius ludovicianus*. We also detected a non-native species, the red fox *Vuples vulpes*, which is considered to be a potential threat to San Joaquin kit foxes (Cypher et al. 2001, Clark et al. 2005).

Table 1. Number of cameras that detected kit fox, range, mean and median for total nights deployed and nights to the first detection of a kit fox by habitat and season in Western Kern County, the Mojave Desert, Northern Semitropic Ridge Ecological Reserve (NSRER), Bena Landfill, the Carrizo Plain National Monument (CPNM) and the city of Bakersfield between 2008 and 2014.

		No. nights deployed				Nights to first detection			
	No. cameras with kit fox detections	Range	Mean	SE	Median	Range	Mean	SE	Median
Site									
Western Kern	5 (62.5%)	30 - 41	36.4	2.1	35	1 - 10	3.8	1.8	1.0
Mojave Desert	78 (86.7%)	40 - 69	58.2	1.3	63	1 - 44	4.4	0.9	1.5
NSRER	7 (100.0%)	34 - 40	39.1	0.9	40	1 - 20	6.0	3.2	1.0
Bena Landfill	5 (71.4%)	14 - 22	18.4	1.6	17	1 - 3	1.6	0.4	1.0
CPNM	40 (66.7%)	33	33.0	0.0	33	1 - 23	4.6	0.8	3.0
Bakersfield	68 (64.7%)	7	7.0	0.0	7	1-7	1.8	0.2	1.0
Habitat									
Natural	135 (78.5%)	14 - 69	47.5	1.4	42	1 - 44	4.4	0.6	2.0
Urban	68 (64.7%)	7	7.0	0.0	7	1 - 7	1.8	0.2	1.0
Season									
Fall	88	14 - 69	54.7	1.6	63	1 - 44	4.2	0.8	1.0
Spring	26	33 - 40	34.7	0.6	33	1 - 20	4.8	1.1	3.0
Summer	89	7 - 33	13.1	1.2	7	1 - 23	2.5	0.3	1.0

Figure 2. Cumulative percentage by night of cameras that had detected a kit fox in natural (n = 135) and urban (n = 68) sites in California between 2008 and 2014.

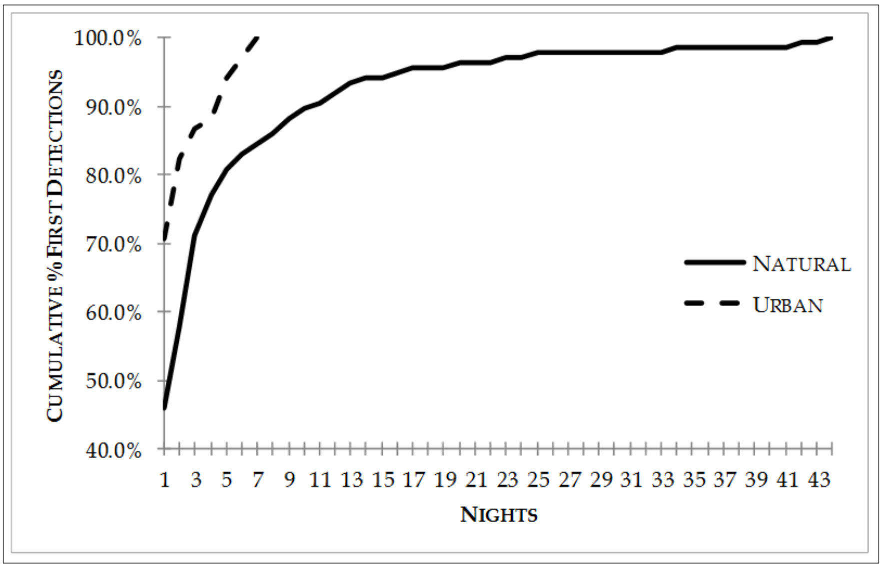

Table 2. Proportion of camera stations that detected species other than kit foxes on each of six study sites in California between 2008 and 2014.

Common name	Scientific name	Western Kern %	Mojave %	NSRER %	Bena %	CPNM %	Bakersfield %
Virginia opossum	*Didelphis virginiana*	-	-	-	-	-	15.2
Desert cottontail	*Sylvilagus audubonii*			57.1		6.7	3.8
Black-tailed jack-rabbit	*Lepus californicus*	25	66.7	85.7	_	58.3	1.9
Eastern fox squir-rel	*Sciurus carolinensis*	-	-	-	-	-	1.9
California ground squirrel	*Spermophilus beecheyi*	-	-	14.3	14.3	-	7.6
White-tailed ante-lope squirrel	*Ammospermophilus leucurus*	-	10	-	-	-	-
San Joaquin ante-lope squirrel	*Ammospermophilus nelsoni*	-	-	14.3	-	18.3	
Kangaroo rat spe-cies	*Dipodomys* sp.	-	4.4	14.3	-	11.7	-
Bobcat	*Lynx rufus*	-	10.0	-	-	6.7	-
Domestic cat	*Felis catus*	-	-	-	-	-	80.0
Coyote	*Canis latrans*	100.0	67.8	57.1	85.7	48.3	-
Domestic dog	*Canis familiaris*	-	12.2	-	14.3	-	15.2
San Joaquin kit fox	*Vulpes macrotis mutica*	62.5	-	100.0	71.4	66.7	64.8
Desert kit fox	*Vulpes macrotis arsipus*	-	85.6	-	-	-	-
Red fox	*Vulpes vulpes*	-	-	-	14.3	-	3.8
Grey fox	*Urocyon*	-	-	-	-	-	3.8
Northern raccoon	*Procyon lotor*	-	-	-	-	-	7.6
American badger	*Taxidea taxus*	-	8.9	14.3	-	18.3	-
Western spotted skunk	*Spilogale gracilis*	-	1.1	-	-	-	-
Striped skunk	*Mephitis mephitis*	-	-	14.3	-	-	18.1
Pronghorn	*Antilocapra americana*	-	-	-	-	1.7	-
Mule deer	*Odocoileus hemionus*	-	-	-	-	1.7	-
Cow	*Bos taurus*	-	-	-	57.1	-	-
Killdeer	*Charadrius vociferus*	-	-	-	-	1.7	-
Mourning dove	*Zenaida macroura*	-	-	-	-	1.7	10.5
Greater roadrun-ner	*Geococcyx californianus*	-	-	14.3	-	1.7	-
Burrowing owl	*Athene cunicularia*	-	1.1	-	28.6	-	1.0
Say's phoebe	*Sayornis saya*	-	1.1	-	-	-	-
Loggerhead shrike	*Lanius ludovicianus*	-	1.1	-	-	1.7	-
Western scrub-jay	*Aphelocoma californica*	-	-	-	-	-	2.9
Common raven	*Corvus corax*	12.5	13.3	85.7	14.3	3.3	-
Northern mocking bird	*Mimus polyglottos*	-	-	-	-	-	4.8
Leconte's thrasher	*Toxostoma lecontei*	-	-	-	-	3.3	-
Sage thrasher	*Oreoscoptes montanus*	-	-	-	-	1.7	-
European starling	*Sturnus vulgaris*	-	-	-	-	-	1.9
Sage sparrow	*Amphispiza belli*	-	1.1	-	-	-	-
Savannah sparrow	*Passerculus sandwichensis*	-	-	-	28.6	-	-
Lark sparrow	*Chondestes grammacus*	-	-	-	-	1.7	-
White-crowned sparrow	*Zonotrichia leucophrys*	-	-	-	-	-	-
Western meadow-lark	*Sturnella neglecta*	-	-	-	-	-	-
Unknown bird	*Aves*	-	-	-	-	5.0	-
Western toad	*Anaxyrus boreas*	-	-	-	-	-	2.9

Discussion

Our analysis indicated that remote cameras are an efficient method to quickly detect the presence of kit foxes. We detected the presence of kit foxes on all six of our study sites in just one night. Furthermore, out of 277 cameras, 73.2% successfully detected kit foxes. All six sites surveyed were known to have kit foxes present prior to camera deployment. In arid habitats in eastern Colorado, Stratman and Apker (2014) surveyed for swift foxes *V. velox* in 52 30.7km^2 grids. Of the 45 grids in which swift foxes were detected, 80% of the grids had detections after one night, 91% after two nights, and 98% after three nights. However, arrays of eight cameras were deployed in each grid and detection rates per camera were not reported.

Of the cameras in our study that did not have detections, four were due to camera malfunction. At 11 stations, foxes were not detected on cameras but fox scats were present. In some cases, the scats may have been deposited near the camera but not within the field of view of the camera. In other cases, it is possible that another animal or wind-blown vegetation may have triggered a camera and a fox then deposited a scat during the delay period between triggering events. Because a small proportion of cameras were visited and did not detect a kit fox, it is important to deploy multiple cameras at a site to determine presence. Regardless, the presence of scats at stations lacking camera detections indicates that our detection rates are conservative. Also, scats deposited at the stations can serve as another mode of detection.

In our study, the difference in latency to first detection between sites may be due to differences in kit fox population at each site. The CPNM had a slightly longer latency to first detection of kit fox than most other sites, and at the time of the survey the population was at its lowest estimate in 14 years due to an extended drought (California Department of Fish and Wildlife, unpublished data). Despite this, there was no significant difference between the latency to first detection on the CPNM and other natural sites with more robust populations. The only significant difference between sites was between the CPNM and Bakersfield which is likely due to increased fox density in the urban environment (Cypher 2003). While latency may be longer and there might be fewer overall camera detections in areas where density is lower, there is still a high likelihood of detecting foxes, if present, using this technique.

The use of remote cameras has many technical and logistical advantages over other survey methods for the presence of foxes in arid habitats. While initial investment is required to purchase cameras and memory cards, the materials required for camera deployment (e.g. mounting posts, bait, lure, batteries) are inexpensive and cameras can be used for multiple surveys. The labour required to deploy cameras is also relatively low compared to other, more invasive, techniques. Two, or even one, biologist can deploy anywhere from 10-15 cameras in a standard work day and camera collection takes even less time than deployment. Cameras are also easy to use with little training or technical expertise required. For surveys to determine presence, data interpretation is relatively simple as well. Because the bait is secured in front of the cameras, detections usually result in multiple images providing ample angles and views upon which to base identifications. Digital images of species detections make it easy to share images and verify questionable detections, as well as providing a permanent record for future reference or training materials.

Providing presence and likely absence data for kit foxes is not the only benefit to using remote cameras. Images can also provide ecological and demographic information. Detection of lactating females or pups can supply evidence of reproduction and images of previously marked animals (e.g. ear tags, collars, dye marks) could help with relative abundance estimates. Important biological information about the health of a population can be gathered when a disease is visually evident, as is the case for sarcoptic mange. Not only is information provided about kit foxes, but the presence of other species can also be recorded. Camera stations can detect other species of conservation concern (e.g. San Joaquin antelope squirrel, badger, burrowing owl), kit fox competitors (e.g. coyotes, red foxes, badgers, bobcats), or even potential prey in the area. Kit foxes also use defecation to mark their territory and prefer to defecate on or near visually conspicuous objects within their territory (Murdoch 2004). Many times kit fox presence could be determined, not only by camera detection, but by kit fox scat on or near the bait at a camera station (Figure 3). Scat left behind at camera stations can be collected and used for genetic analyses (e.g. confirmation of species identification, individual and population attributes), food habit analysis, and hormone and parasite samples.

Management implications

We highly recommend the use of automated camera stations to survey for presence of kit foxes. The average size of a kit fox home range in high quality habitat is approximately 5.9km^2 (Nelson et al. 2007). Therefore, we recommend that at least one camera be deployed per 2.9 km^2 when attempting to detect kit foxes. This will generally result in approximately two cameras per average home range of a kit fox (Cypher 2003). In our analysis, over 94% of cameras visited had a detection after two weeks, even at sites where kit fox numbers were low. Cameras should be deployed for a minimum of 14 nights to maximise the probability of detecting a kit fox. This technique will be useful for surveying for kit foxes prior to anthropogenic activities causing habitat disturbance (common within the range of kit foxes), long-term population monitoring and occupancy studies. This technique is also effective in detecting closely related swift foxes (Stratman and Apker 2014; D. Schwalm, Oregon State University, personal communication). Applicability to other fox species is likely and should be investigated.

Figure 3 Desert kit fox scats at a staked cat food can from a Mojave Desert remote camera station in 2011.

Acknowledgements

We would like to thank C. Fiehler, E. Kelly, A. Madrid and C. Van Horn Job for their field efforts deploying cameras on the various projects. Financial support for the original projects was provided by the U.S. Bureau of Land Management, U.S. Fish and Wildlife Service, California Department of Fish and Wildlife, and Kern County Waste Management Department. Two anonymous reviewers provided comments that helped improve the manuscript.

References

Balme, G.A., Hunter, L.T.B. and Slotow, R. 2009. Evaluating methods for counting cryptic carnivores. *Journal of Wildlife Management* 73: 433-441.

Brawata, R.L., Raupach, T.H. and Neeman, T. 2013. Techniques for monitoring carnivore behavior using automatic thermal video. *Wildlife Society Bulletin* 37: 862-871.

Clark, H.O. Jr., Warrick, G.D., Cypher, B.L., Kelly, P.A., Williams, D.F. and Grubbs, D.E. 2005. Competitive interactions between endangered kit foxes and non-native red foxes. *Western North American Naturalist* 65: 153-163.

Constable, J.L., Cypher, B.L., Phillips, S.E. and Kelly, P.A. 2009. *Conservation of San Joaquin kit foxes in western Merced County, California*. California State University-Stanislaus, Endangered Species Recovery Program, Fresno, California, USA.

Crooks, K.R., Grigione, M., Scoville, A. and Scoville, G. 2008. Exploratory use of track and camera surveys of mammalian carnivores in the Peloncillo and Chiricahua Mountains of southeastern Arizona. *Southwestern Naturalist* 53: 510-517.

Cypher, B.L. 2003. Foxes. Pp. 511-546 in G.A. Feldhamer, B.C. Thompson and J.A. Chapman (eds.), *Wild Mammals of North America: Biology,* *Management, and Conservation*. Second edition. Johns Hopkins University Press, Baltimore, USA.

Cypher, B.L. 2010. Kit foxes (*Vulpes macrotis*). Pp. 49-60 in S.D. Gehrt, S.P. Riley and B.L. Cypher (eds.). *Urban Carnivores: Ecology, Conflict, and Conservation*. John Hopkins University Press, Baltimore, USA.

Cypher, B.L. and Brown, A.D. 2006. *Demography and ecology of endangered San Joaquin kit foxes at the Bena landfill, Kern County.* California. California State University-Stanislaus, Endangered Species Recovery Program, Turlock, California, USA.

Cypher, B.L., Clark Jr., H.O., Kelly, P.A., Van Horn Job, C., Warrick, G.D. and Williams, D.F. 2001. Interspecific interactions among wild canids: implications for the conservation of endangered San Joaquin kit foxes. *Endangered Species UPDATE* 18: 171-174.

Cypher, B.L., Westall, T.L., Van Horn Job, C. and Kelly, E.C. 2014a. *Coyote foraging patterns in the central Mojave Desert: implications for predation on desert tortoises.* California State University–Stanislaus, Endangered Species Recovery Program, Turlock, California, USA.

Cypher, B.L., Westall, T.L., Van Horn Job, C. and Kelly, E.C. 2014b. *San Joaquin kit fox conservation in a satellite habitat area.* California State University–Stanislaus, Endangered Species Recovery Program, Turlock, California, USA.

Fiehler, C.M., Cypher, B.L. and Sasla, L.R. 2017. Effects of oil and gas development on vertebrate community composition in the southern San Joaquin Valley, California. *Global Ecology and Conservation* 9: 121-141.

Gompper, M.E., Kays, R.W., Ray, J.C., Lapoint, S.D., Bogan, D.A. and Cryan, J.R. 2006. A comparison of noninvasive techniques to survey carnivore communities in northeastern North America. *Wildlife Society Bulletin* 34: 1142-1151.

Harrison, R.L., Barr, D.J. and Dragoo, J.W. 2002. A comparison of population survey techniques for swift foxes (*Vulpes velox*) in New Mexico. *American Midland Naturalist* 148: 320-337.

Heilbrun, R.D., Silvy, N.J., Peterson, M.J. and Tewes, M.E. 2006. Estimating bobcat abundance using automatically triggered cameras. *Wildlife Society Bulletin* 34: 69-73.

IUCN SCC Canid Specialist Group (North America Regional Section). 2008. *Vulpes macrotis*. *IUCN 2013. IUCN Red List of Threatened Species*. Version 2013.2. http://www.iucnredlist.org/details/41587/0 Accessed 02 Jun 2016.

Locke, S.L., Cline, M.D., Wetzel, D.L., Pittman, M.T., Brewer, C.E. and Harveson, L.A. 2005. From the field: a web-based digital camera for monitoring remote wildlife. *Wildlife Society Bulletin* 33: 761-765.

McGee, B.K., Butler, M.J., Wallace, M.C., Ballard, W.B. and Nicholson, K.L. 2005. From the field: a comparison of survey techniques for swift fox pups. *Wildlife Society Bulletin* 33: 1169-1173.

Murdoch, J.D. 2004. *Scent marking behavior of the San Joaquin kit fox (Vulpes macrotis mutica).* MSc. University of Denver, USA.

Nelson, J.L., Cypher, B.L., Bjurlin, C.D. and Creel, S. 2007. Effects of habitat on competition between kit foxes and coyotes. *Journal of Wildlife Management* 71: 1467-1475.

Nielsen, C.K. and McCollough, M.A. 2009. Considerations of the use of remote cameras to detect Canada lynx in northern Maine. *Northeastern Naturalist* 16: 153-157.

Stratman, M.R. and Apker, J.A. 2014. Using infrared cameras and skunk lure to monitor swift fox (*Vulpes velox*). *Southwestern Naturalist* 59: 502-510.

Swann, D.E., Hass, C.C., Dalton, D.C. and Wolf, S.A. 2004. Infrared-triggered cameras for detecting wildlife: an evaluation and review. *Wildlife Society Bulletin* 32: 357-365.

U.S. 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, Oregon, USA.

U.S. Fish and Wildlife Service (USFWS). 1999. *U.S. Fish and wildlife service San Joaquin kit fox survey protocol for the northern range.* U.S. Fish and Wildlife Service, Sacramento, California, USA.

Biographical sketch

Tory Westall is a Research Ecologist with the Endangered Species Recovery Program of California State University, Stanislaus. She has studied various sensitive species in the San Joaquin Desert and surrounding areas. She is interested in the ecology and conservation of endangered species and primarily studies the San Joaquin kit fox.

Brian Cypher is the Associate Director with the Endangered Species Recovery Program of California State University, Stanislaus. His primary research interest is the ecology and conservation of wild canids. Since 1990, he has been involved in research and conservation efforts for sensitive species in the San Joaquin Valley of California.