



JOURNAL OF
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THE *Journal of Wildlife Rehabilitation* is designed to provide useful information to wildlife rehabilitators and others involved in the care and treatment of native wild species with the ultimate purpose of returning them to the wild. The journal is published by the International Wildlife Rehabilitation Council (IWRC), which invites your comments on this issue. Through this publication, rehabilitation courses offered online and on-site in numerous locations, and its outreach to those in the profession, the IWRC works to disseminate information and improve the quality of the care provided to wildlife.



LEFT:

Mitred conure (*Psittacara mitratus*). Native to Chile, Bolivia, Peru. Naturalized flocks are found in California, Florida, and Hawaii.

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ON THE COVER:

Chinese leopard cat (*Prionailurus bengalensis chinensis*), one of the 42 subspecies widely distributed throughout Southeast Asia.

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Providing evidence-based education and resources on wildlife rehabilitation to move the field of wildlife rehabilitation forward; to promote wildlife conservation and welfare; and to mitigate human-wildlife conflicts worldwide, through better understanding of wild animal ecology, behavior, and welfare.

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Human–Wildlife Coexistence

Human and wildlife interactions are never far from my mind. This year I've found myself considering our intricate relationships whether I'm perusing a local social media site or traveling to distant continents.

At home in Oregon, I've been watching the conversations on the social media platform NextDoor around black bears (*Ursus americanus*) in the Eugene South Hills. We've reached the time in the year where bears, recently out of hibernation, are looking to replenish calories, finding easy pickings in unsecured garbage cans. Fortunately, for each person who asks "I saw a black bear, who do I call?", there are fifteen people responding with helpful tricks to keep bears and humans safe without the need to call any external agency. I've been encouraged by this peer level human–wildlife interaction education.

In March, I was lucky enough to attend the first International Conference on Human–Wildlife Conflict and Coexistence. Human–wildlife interaction happens in all sorts of places and with all sorts of species, but some interactions seemed to get more attention than others at the conference, especially elephants and large cats. There is no doubt these high impact interactions need attention, but practitioners were keen to discuss wider-ranging interactions, from reptiles and small rodents to ungulates. It was obvious that we need to identify the role of conflict mitigation for species and communities of all sizes. Wildlife rehabilitators have a critical role in this discussion.

In a second big travel event this year I visited New Zealand, a place where human–wildlife interactions can be infamous. I found it disconcerting to be walking in the remote Fjordlands and encounter poison warning signs and bait stations for introduced possums, ferrets, and weasels. But just as condors seem to rebound in the southwest US when lead is limited, so in New Zealand do birds like takahē

(*Porphyrio hochstetteri*) and hihi (*Notiomystis cincta*) thrive where cats, rats, and other predators have been excluded via physical or chemical means. It is quite something to visit a 500-acre (200-hectare) native species reserve completely enclosed with predator exclusion fencing and double door access.

Unfortunately, humans intentionally introduced most of these problem species, although some like rats and mice were unintentionally brought to the island, coming ashore via docked ships. Possums were brought from Australia for fur production, rabbits for food and "to remind British settlers of home," weasels and ferrets to predate the rabbits run amok, and so forth. Now citizens are trying to rectify the situation yet again.

We often see human–wildlife interactions as one-way events: cars injuring squirrels at a busy city intersection, elephants eating a human's corn field. But in reality these instances are part of a tangle of interactions stretching in time and space. So it is in New Zealand. As a short term tourist I see the poison warning signs, the campsites filled with rabbits, cats, ferrets, and mallards, and the well-guarded native species reserves. But the full story is only experienced by the humans and wildlife of New Zealand, both working to persist in their environment over the course of centuries.

Before we can make pronouncements, we need to understand that full story along with the conservation, welfare, and OneHealth implications of actions and inaction. Wildlife rehabilitators navigate the tricky patterns of human–wildlife conflict every day, weaving together the needs of the entire community with all the tools in their kits. The world owes wildlife rehabilitators a great deal of gratitude for this constant and often fruitful effort to improve the welfare of the wildlife and humans within our communities.

—Kai Williams
Executive Director

Case study: Cross-fostering an endangered San Joaquin kit fox pup (*Vulpes macrotis mutica*) orphaned due to sarcoptic mange

Nicole A. Deatherage,¹ Erica C. Kelly,¹ Tory L. Westall,¹ Sharon Adams,² Jaime L. Rudd,³ Deana L. Clifford,³ and Brian L. Cypher¹

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Introduction

The San Joaquin kit fox (*Vulpes macrotis mutica*) is a small canid endemic to the Central Valley of California, USA. It is a federally-listed endangered and state-listed threatened species primarily due to habitat loss and degradation as a result of anthropogenic development, thus concerted efforts are made to protect as many remaining individuals as possible.¹ San Joaquin kit foxes (hereafter, “kit foxes”) are born altricial in January to March and depend on maternal care until they are fully weaned at around 8 wk.^{2,3} Kit fox pups remain dependent on adult provisions until they are about 4 mo old when they are capable of hunting on their own and foraging for prey, which primarily includes rodents and insects.^{4,5} Kit fox pups become fully independent and disperse from their natal range when they are about 5 mo old.⁶ Dependent kit fox pups that do not have the care of an adult family member will likely perish without human intervention, which often involves raising them individually in captivity.⁴ Raising wildlife in captivity may be less than ideal as facilities must have adequate space, proper permits,

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ABSTRACT: The San Joaquin kit fox (*Vulpes macrotis mutica*) is an endangered canid endemic to Central California, USA. San Joaquin kit foxes living in urban areas are susceptible to a fatal skin disease called sarcoptic mange. Advanced cases require hospitalization until the individuals recover and can be released. In spring 2022, a young San Joaquin kit fox pup was hospitalized for sarcoptic mange. The pup was determined to be orphaned and fated for a life in captivity due to his young age and lack of conspecific caretakers. Concurrently, a family group consisting of an adult female San Joaquin kit fox and three pups was also hospitalized for sarcoptic mange. Cross-fostering was successfully implemented in captivity by introducing the orphaned pup into the family group, and all were released together after recovery. Following releases, the orphan and his foster family appeared healthy and demonstrated natural behaviors, at least till the pups reached independence, implying successful cross-fostering and reintroduction. This case study constitutes the third instance of cross-fostering San Joaquin kit fox pups.

KEYWORDS: California, canids, captive rearing, husbandry, orphaned wildlife, sarcoptic mange, urban wildlife, veterinary medicine, wildlife conservation.

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and financial means to house animals, which is particularly involved for endangered species.^{7,8} Rehabilitated wildlife also tends to have varying post-release survival rates between 11% and 53%.^{7,8} Post-release survival rates for inexperienced orphans are likely lower due to the inopportunity to learn proper social skills from their family group, which could result in an increased risk of habituation to humans and inappropriate responses to conspecifics and predators.⁹

Cross-fostering is an option occasionally employed to rear orphaned young in the wild with unrelated conspecifics, which allows them to learn natural behaviors that increase their chances of survival and eventual reproduction.^{10,11} Cross-fostering has proven successful in other canid species, including red foxes (*Vulpes vulpes*), coyotes (*Canis latrans*), and red wolves (*Canis rufus*).^{11,12,13} Canids are generally behaviorally adaptable, and females of many species will allonurse or even adopt young of related or unrelated individuals of the same social group to assist kin, spread energetic costs of rearing across more individuals, and maximize survivorship of young.^{2,7,14,15,16} In kit foxes, related adult females have been documented allonursing and co-rearing pups in the same den.^{16,17} Additionally, young female kit foxes that have not dispersed from their natal range have been known to adopt and raise the subsequent litter after the mother died.¹⁸

Two successful instances of kit fox pup reintegration and cross-fostering from a single litter are described in Cypher et al.⁷ In this case, six pups whose mother had died when they were 3 wk old were captured and reared together in captivity until they were 10 wk old. Four of these pups were successfully released into a den with the biological father and an unrelated female, and the remaining two pups were integrated into an unrelated family group that consisted of a mated pair with their two pups of similar age. The survival rate for all six pups was higher than the estimated survival rate for wild kit fox pups raised normally, and the orphaned pups demonstrated natural behaviors, including the ability to find food and shelter. Here we present the third documented attempt at cross-fostering kit foxes in Bakersfield, California.

Background

The city of Bakersfield is located in the southeastern San Joaquin Valley of Central California. Bakersfield is a heavily developed city with a population of nearly 380,000 people and is surrounded primarily by agriculture, with natural habitat including saltbush scrub (*Atriplex* spp.), grassland, and riparian areas on 25–30% of its boundary.¹⁹ Bakersfield has historically supported a stable population of kit foxes that have been studied extensively for their value as successful urban-adapted yet endangered canids. Urban kit foxes occur in higher densities than non-urban kit foxes and are observed in many urban land uses, though they prefer undeveloped lots or open, landscaped lots such as school campuses; and dens may be constructed in culverts, pipes, rubble piles, or under infrastructure.^{10,19,20} Many Bakersfield residents who observe kit foxes have a greater knowledge and appreciation for them and express support for their conservation.²¹

Since 2013 the Bakersfield kit fox population has been severely afflicted by sarcoptic mange, a skin disease caused by an infestation of the parasitic mite *Sarcoptes scabiei*, which is fatal for kit foxes.^{22,23} Since the start of the sarcoptic mange epizootic, kit fox abundance in Bakersfield has declined by nearly 70%.²⁴ Transmission occurs via direct contact with infectious mites on another fox or possibly by environmental transmission in dens.^{15,25} Affected kit foxes exhibit degradation of the epidermis as mites burrow into the skin, causing pruritus, dermatitis, erythema, lichenification, crusting, darkened skin, alopecia, and eventual death unless medical intervention is provided.²² Affected kit foxes may also present with lethargy and emaciation, often appearing outside of dens during daylight in exposed locations, and may not respond to human presence.²² A majority of sarcoptic mange cases in kit foxes are reported by concerned members of the public, allowing affected individuals a chance at treatment. A single dose of the topical acaricide selamectin (Revolution[®], Zoetis, Florham Park, NJ, USA) can effectively treat mild infestations (i.e., initial infection where <25% of an individual's body demonstrates hair loss and crusted skin) and provide protection from infestation for up to 28 days, and an acaricidal flumethrin collar (Seresto[®], Bayer, Shawnee Mission, KS, USA) can provide protection for up to 5 mo for individuals of appropriate body condition to wear a collar.^{22,26,27} If a kit fox exhibits moderate to severe signs of sarcoptic mange (i.e., hair loss and crusted skin over >25–50% of its body, emaciation, dehydration, lethargy, open wounds), it is transported to the California Living Museum Zoo wildlife rehabilitation center (CALM). At CALM, kit foxes receive extensive treatment over the course of at least 4 wk, including multiple doses of selamectin, antibiotics for secondary infections, subcutaneous fluids to address dehydration, and any other necessary care.²² Kit foxes are released at their original capture site once their appropriate treatment courses have been completed. All kit fox trapping, handling, and collaring procedures follow guidelines for the use of wild animals in research described by the American Society of Mammalogists and are conducted in accordance with conditions and protocols established in permits from the US Fish and Wildlife Service and Memoranda of Understanding from the California Department of Fish and Wildlife.¹⁸

A kit fox pup is orphaned due to sarcoptic mange.

On 12 April 2022, a concerned business manager at Bakersfield Renewable Fuels, a large industrial refinery, reported two distressed kit fox pups to the Endangered Species Recovery Program (ESRP). The pups were without an adult and approaching employees and heavy equipment during daylight hours. On the day of the initial report, we placed a trail camera (Black Flash digital cameras, Cuddeback, Green Bay, WI, USA) at either entrance of the suspected natal den that was within a 70 m culvert adjacent to a railroad. We baited one of the cameras with a punctured can of cat food and several drops of scent lure (Carman's Canine Call, Minnesota Trapline Products Inc., Pennock, MN, USA). We collected the cameras and reviewed the images the following

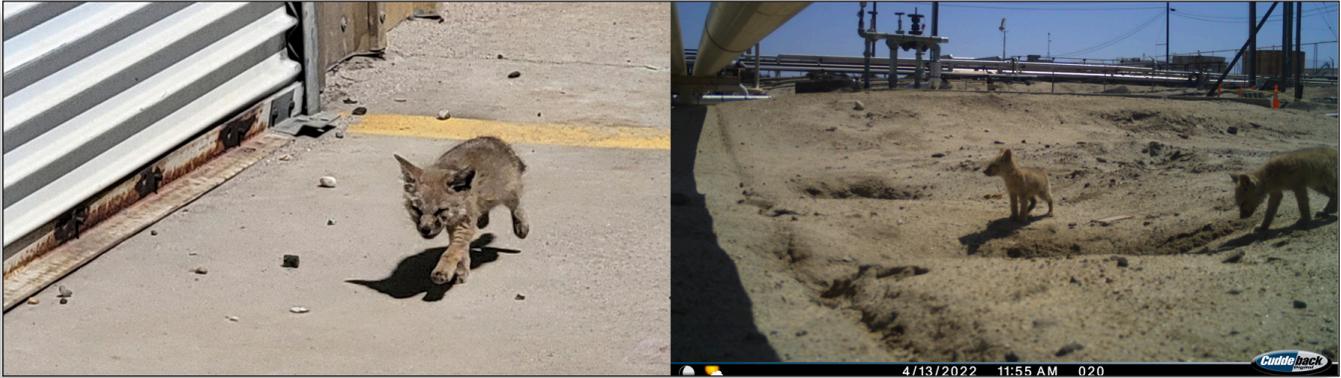


FIGURE 1. San Joaquin kit fox (*Vulpes macrotis mutica*) pups were observed with sarcoptic mange at a local business in Bakersfield, California,

USA in April 2022. The left image was captured by the reporting party, and the right image was captured by a trail camera on 13 April 2022.

day along with images provided by the reporting party and determined the pups had advanced sarcoptic mange and that there was at least one adult kit fox in the area (Fig. 1). We left cameras in place to determine if any other kit foxes were visiting the natal den and placed live-traps (wire-mesh box, double-door collapsible traps, 25.4 x 25.4 x 121.9 cm, Tomahawk Live Trap, Hazelhurst, WI, USA) in the vicinity to be monitored during business hours. Traps were baited with a bowl of water and a mixture of wet cat food, hot dogs, and sardines and covered with canvas tarps for camouflage and protection. One of the pups was captured in a trap near the natal den the following morning and the other was observed drinking from a nearby water source and was opportunistically hand-captured. Both pups were immediately transported to CALM for assessment and medical treatment (Fig. 2). The pups were both males, estimated to be 4–6 wk old, and exhibited severe signs of sarcoptic mange with darkened skin, eyes crusted shut, lesions, and crusting on face and legs. They were also dehydrated, cold, and lethargic. Despite supportive care and initiation of medical treatment, one pup died in care overnight.

We left the traps open one additional night in an attempt to capture other kit foxes still in the area that might need treatment for sarcoptic mange, particularly an adult caretaker for the pups. While an adult male was captured with mild signs of sarcoptic mange, there was insufficient evidence demonstrating that he was the biological father, and the pups did not appear fully weaned. Thus, we treated him with selamectin, fitted him with a flumethrin collar, and released him at his capture location. We collected the two cameras left at the natal den six days after they were originally deployed. Apart from the sick pups, four other kit foxes appeared in images: the adult male we had previously captured, a second adult, and a pup with an adult that we presumed was its parent. This pup was captured in only one image and appeared slightly larger and in better physical condition than the sick pups, so we concluded that they were likely from a neighboring litter as this area supports multiple kit fox family groups. We then set additional traps for four days in attempts to capture these other individuals, although no additional kit foxes were captured. Two baited cameras were then deployed for an



FIGURE 2. Two young kit fox pups with sarcoptic mange were captured on 14 April 2022.

additional 11 days at the natal den following this trapping effort. Other baited cameras were deployed nearby on 5 May 2022 for five days in continuing attempts to capture images of kit foxes that could be siblings or part of the family group. Kit fox activity on cameras decreased over time, and no other sightings were reported. We attempted one final trapping effort for two days starting 5 May 2022 at a location nearby the natal den, though no kit foxes were captured. Therefore, we deduced that the two pups likely did not have a definitive conspecific caretaker, and their mother either abandoned them because they were sick, or had recently died from sarcoptic mange.

The absence of a family group for the surviving pup had us

concerned for his post-release survival. While minimal human contact is routinely provided when kit foxes are in rehabilitation, due to his young age and poor condition this pup was hand-nursed for several days following admission into care. Caretakers also needed to ensure the pup was getting the proper nutrition, warmth, rehydration, and treatment needed to make a full recovery. Additionally, field cameras and other recent reports indicated that coyotes and bobcats (*Lynx rufus*), both of which are kit fox predators, frequented the area.¹ Because it seemed unlikely that this pup would be able to provision himself or avoid predators and other dangers on his own, the decision to place the pup into a permanent captive home was considered.

Another kit fox family is captured for sarcoptic mange treatment.

On 11 May 2022, four wk after the orphaned pup was captured, a concerned employee at Norris Elementary School reported a family of sick-looking kit foxes that consisted of an adult female and at least two pups. The school is in a quiet area of town surrounded by residential neighborhoods and is located 0.3 km from the urban edge of Bakersfield and about 8 km away from Bakersfield Renewable Fuels. The kit foxes were regularly observed on campus, particularly during and immediately after student mealtimes, and were known to be denning under a row of portable classrooms. The adult female had reportedly ventured into an occupied classroom before quickly running out, and this family of kit foxes did not seem to be afraid of humans. After reviewing photos taken by the reporting party, it was apparent that the adult kit fox had advanced sarcoptic mange and would need to be captured.

We surrounded the portable classrooms with traps, and two pups displaying early signs of sarcoptic mange were captured within one hr. The pups were estimated to be 12 wk old and presented with minimal flaking and crusted skin and they were transported to CALM. The traps were left open and monitored during the day to target the adult female and any additional pups, including one pup that was observed from a distance while processing the first two pups for transport to CALM. We set two unbaited cameras nearby to assist in the detection of additional littermates and adult family members.

The following morning a third pup was captured, exhibiting more severe signs of sarcoptic mange than the first two pups. This pup was also transported to CALM and united with its two presumed siblings following an examination and initial treatment. We rebaited traps with McDonald's fast food (hamburgers or chicken nuggets) in an attempt to entice the adult female to enter a trap; she was captured the following morning and transported to CALM. Anthropogenic food may be used as bait in the urban environment as a familiar food item for trap-shy animals where it is crucial we have the animal in hand.

Images from the cameras revealed no additional kit foxes had visited, so we collected the traps, though we left the cameras in place and added a scent lure to the ground below the cameras to attract any additional kit foxes that may be in the area. Cameras

were deployed for an additional three nights with no other kit foxes observed, and no additional reports of sick kit foxes were made from the school or surrounding neighborhood. We felt confident that all kit foxes in the immediate vicinity had been captured, so we collected the cameras accordingly.

Upon examination at CALM, the adult female was emaciated, dehydrated, and had extensive hair loss and thickened, crusted skin over her entire body. She had enlarged mammae, so we concluded that she was the mother of the three captured pups and gave her the unique number identifier F7416. In efforts to reduce the stress of being held in captivity and ensure socialization continued with reduced attention on humans, the three pups and the adult female were housed together in the same enclosure while they underwent treatment. As soon as F7416 was reunited with the three pups at CALM, the pups immediately became vocal, and F7416 sniffed each one individually. Despite her poor physical condition, F7416 proceeded to feed each of the pups out of the bowl of meat product provided to them. These behaviors reinforced our decision to have placed all four individuals together during the course of their treatment despite F7416's guarded prognosis of survival.

The orphaned kit fox pup is introduced to the family group.

F7416 and her pups showed improving conditions after one wk of treatment, so a meeting was arranged with representatives at the California Department of Fish and Wildlife (CDFW) and CALM to discuss the possibility of integrating the orphaned pup into F7416's litter while in captivity. After careful consideration, it was unanimously decided the orphaned pup should be allowed an opportunity to live its life in the wild, especially since the orphan continued to display an aversion to human presence despite being in care for four wk.

On 31 May 2022, nearly 7 wk after the orphan was captured and 3 wk after the family group was captured, the orphan and the family group were moved into adjacent outdoor enclosures. The enclosures were separated by chicken wire fencing (1.27 × 7.62 cm), allowing for safe contact that would provide a minimal risk of injury. The outdoor enclosures had the added benefit of minimal human activity where both groups could experience natural sounds and weather, and engage in natural behaviors such as digging and running. CALM personnel directly observed the initial introductions so that staff could intervene and separate the kit foxes if introductions went poorly (e.g., the kit foxes appeared to be in extreme duress, acted aggressively, attempted to get away, cowered, or became injured).

Positive behaviors were displayed immediately by the orphaned pup including squealing vocalizations and repeated attempts to get closer to the other kit foxes. Positive behaviors were also exhibited by the family group including curiously watching the orphaned pup and attempting to engage in play through the fence (Fig. 3). The kit foxes were left in their respective enclosures overnight to further acclimate, observe, and interact with each other.

Given the positive behaviors observed in both groups, the orphaned pup was allowed supervised access into the adjacent pen with F7416 and her three pups the following day. The orphaned pup quickly approached F7416, and she displayed similar dominant behavior as she did with her pups that included a gaping mouth and slight growl, though she was mostly indifferent towards the orphaned pup.

Within the first day, the pups were all playing together. The orphan became more confident when approaching F7416 for direct contact and she accepted him as she did her own pups (Fig. 4). After their integration, all the kit foxes were fed together, and no negative behaviors were observed. Considering this a success, the orphaned pup was left with the F7416 and her pups continu-

ously. The kit foxes were closely monitored for 1 wk following the introductions. During this time, all kit foxes continued to exhibit normal behaviors, with the only notable behavior being the orphaned pup seemed bolder and displayed more assertiveness towards food which may have been attributed to him being at CALM for the longest amount of time.

The cross-fostered pup was released with the family group following recovery from sarcoptic mange.

On 8 June 2022, 8 wk after the orphaned pup was captured, we prepared all five kit foxes for release at the site of F7416's natal den at Norris Elementary School where the family group was captured 4 wk earlier. Each kit fox received a final dose of selamectin, and all four pups had hair and tissue samples taken for genetics, received ear tags with unique number identifiers, and were uniquely marked with black nontoxic dye (Nyanzol-D; Albinal Dyestuff, Inc., Jersey City, NJ USA) to identify individuals on camera or from a distance. We also fitted a VHF/GPS radio collar (Advanced Telemetry Systems, Isanti, MN, USA) with a flumethrin insert onto F7416 for telemetry tracking. We placed each kit fox in individual travel kennels for safety while being transported from CALM to the release site.

Releasing kit foxes near or after dark is preferable as they are nocturnal, and it helps to diminish disorientation after being held in captivity for a period of time. The foxes were scheduled to be



FIGURE 3. Kit fox F7416 and one of her pups investigating the fence line of the adjacent pen containing an unrelated orphaned San Joaquin kit fox pup at the California Living Museum in Bakersfield, CA, USA on 31 May 2022.



FIGURE 4. Kit fox F7416 and an orphaned pup that was cross-fostered into her litter nestled together at the California Living Museum in Bakersfield, CA, USA on 1 June 2022, while receiving treatment for sarcoptic mange.

released at sunset.¹

We placed the kennels directly in front of the portable buildings under which the natal den was located. We opened the kennel holding F7416 first so that she might help orient the pups as they were released, and then simultaneously opened the doors to the other kennels shortly after. As the pups saw each other and F7416, they all rushed towards F7416 with their ears tucked back, bodies low to the ground, and tails wagging (Fig. 5). Despite his observed confidence in captivity, the orphaned pup, given unique number identifier M7470, was the most reluctant to leave the kennel and required the most encouragement, including tilting the kennel forward and gently tapping on the back. Once he saw the other kit foxes playfully running around the portables, he quickly joined



FIGURE 5. Adult female kit fox F7416 (far right, collared), one of her pups (far left), and an orphaned pup cross-fostered into her litter (center, lateral dye marking) were released on 8 June 2022 at the capture location of F7416 and her litter in Bakersfield, CA, USA, following their recovery from sarcoptic mange.



FIGURE 6. Cross-fostered kit fox pup M7470's last appearance on a trail camera on 13 July 2022 in Bakersfield, CA, USA.

them, though he was observed lingering outside the portables and sniffing the environment more so than the others, who had all eventually retreated under the portables. This was not unexpected behavior as the release site was a novel location for M7470.

Post-release monitoring

We tracked F7416 regularly and ran field cameras for a number of weeks following the release to monitor the family's survival and verify that M7470 had stayed with his foster family. We provided a total of 7.5 kg of dog kibble (Purina ONE SmartBlend Natural Dry Dog Food) over the course of six wk to assist F7416 in transitioning back to providing food for her pups, especially with the added burden of an additional pup. The family was provided food, and F7416 was tracked to underneath the portables or nearby on a biweekly basis until 28 June 2022, after which her collar signal was not heard again.

We placed two unbaited cameras on 24 June 2022 facing two entrances to underneath the portables that the kit foxes had been observed using. These cameras were deployed for one wk and regularly captured all five kit foxes. Kit fox activity was mostly limited to after dark, and both F7416 and two of the pups appeared with prey items or trash on at least one occasion. F7416 last appeared on camera on 29 June 2022. Another camera was placed on the more extensively used entrance under the portables on 8 July 2022 and was baited in hopes of locating F7416. The camera was deployed for 1 wk but captured significantly less kit fox activity though all four pups appeared on camera, as well as five raccoons (*Procyon lotor*) and two domestic cats (*Felis catus*).

During this time, we examined fresh kit fox scat at the site that contained numerous insect parts, indicating that the pups were at least successfully foraging for insect prey despite F7416's

absence. M7470 last appeared on camera on 13 July 2022, about 5 wk after his release, and appeared healthy (Fig. 6). Additionally, two baited field cameras were placed in locations surrounding the school on 27 July 2022 for one wk, to further assess sarcoptic mange occurrence in the area, and two of F7416's biological pups were detected. Neither F7416 nor M7470 visited these cameras.

Discussion

There is considerable evidence for successful cross-fostering in canids and other species particularly when it occurs at a very early age, such as within 2 wk of birth.^{9,11,28} As they become older, animal offspring become more recognizable to parents.¹¹ This may be due to developmental milestones that appear as juveniles age such as vocal cues and

scent glands.¹¹ The ability to recognize kin and the motivation to persecute unfamiliar conspecifics influences the success of cross-fostering in species.^{11,29} In this case study, the orphaned kit fox was nearly 11 wk old when he was accepted into the foster family. As compared to more social canids, kit foxes do not form hierarchical groups or partake in cooperative hunting, have low-to-no retention of adult offspring in the group, rarely interact with members of their group outside of breeding season, and exert dominance or territory maintenance mostly through indirect means such as scent marking as opposed to agonistic interactions.^{17,30,31} This lack of intensive social hierarchy may have facilitated the acceptance of an older pup into the family group.

Despite the stress of being held in captivity and recovering from disease, the foster family and the orphaned pup readily accepted each other. The urban setting in which these kit foxes lived may have further contributed to the acceptance of an additional pup by the mother kit fox, who was also presumably a single parent at the time of her capture. Urban environments offer plentiful cover in the form of anthropogenic structures as well as consistent and abundant kit fox prey.³² Kit foxes and other canid species may be more tolerant of additional group members if resources are abundant.^{16,26,33,34,35} The natal den of the foster family was on an elementary school campus where maintained green spaces support abundant prey such as rodents and insects, and anthropogenic food and food waste are frequently dropped or left out. The campus also includes a large sports field, a water catchment basin, and portable units, all of which are favored micro-landscapes for denning and foraging by kit foxes in the urban environment.

Post-release monitoring showed that all kit foxes had stayed at the natal den at least through June, when kit fox pups typically

become independent of their parents. All of the kit foxes appeared healthy and were exhibiting normal behaviors that included capturing prey and limiting most activity to after dark. Because the elementary school is fenced in, the natal den was protected from high-speed vehicles, the number one cause of mortality for kit foxes in urban areas, and kit fox predators such as coyotes, bobcats, and free-ranging dogs (*Canis familiaris*) were mostly excluded.¹⁹ Human activity after dark was also limited, allowing the kit foxes to engage in nightly activities without direct human interference. All pups further remained in the area at least through mid-July, which is the peak time of year for dispersal, despite the mother kit fox disappearing at the end of June. GPS data indicated F7416 was crossing a four-lane road and venturing into the urban fringe where predators such as coyotes and bobcats are more likely to reside.¹⁹ F7416 presumably died as a result of predation since no kit fox remains were observed in the roadway after extensive searching throughout her home range. It is encouraging that M7470 was documented alive and healthy 5 wk after his initial release with the foster family, demonstrating he had accepted his foster family and natal range, and the family had accepted him at least through dispersal age.

A number of behavioral traits should encourage the survival and future reproductive success of the kit foxes involved in this cross-fostering event including behavioral plasticity, tolerating some human handling and presence, lack of intense social hierarchy, access to abundant resources, and innate and learned behaviors in the urban environment alongside conspecifics. This case study demonstrates that cross-fostering kit foxes has the potential to be a successful management tool for rescuing orphaned pups as well as in increasing population numbers or genetic diversity. Observations from this case study suggest kit foxes can be successfully cross-fostered at least until they are 3 mo old, and mother kit foxes can be accepting of additional pups even under stressful circumstances. Additionally, only minimal provisioning and monitoring following a cross-fostering and release event may be required as individuals readily demonstrate the ability to find resources and survive. This is ideal as the less interaction the foxes have with humans, the less likely they are to become habituated to human presence. Because this is only the third cross-fostering event attempted for San Joaquin kit foxes, further observations would allow for a more defined cross-fostering protocol for future incidences.

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