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Golden Eagle predation on endangered San Joaquin kit foxes

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Abstract.—Golden Eagles (*Aquila chrysaetos*) have been identified as a potential predator of endangered San Joaquin kit foxes (*Vulpes macrotis mutica*), but only one case of such predation has been confirmed. In a recent study on San Joaquin kit foxes, we documented 6 cases of putative predation by Golden Eagles on kit foxes and provided our evidence for each. Golden Eagle predation on kit foxes is most likely to occur in the spring when kit foxes and their pups are frequently aboveground during the day. Such predation is more likely to occur around the margins of the San Joaquin kit fox range, where suitable kit fox habitat abuts suitable nesting habitat for Golden Eagles.

Resumen.—El águila real (*Aquila chrysaetos*) ha sido identificada como el posible depredador de la zorra del desierto de San Joaquín (*Vulpes macrotis mutica*), aunque únicamente se ha confirmado un caso de dicha depredación. En un estudio reciente acerca de la zorra del desierto de San Joaquín, documentamos 6 casos de supuesta depredación por parte del águila real y proporcionamos evidencias sobre cada uno. Presumiblemente dicha depredación sucede durante la primavera, cuando la zorra del desierto y sus cachorros permanecen en la superficie durante el día, por períodos prolongados con mayor frecuencia. Además, es probable que la depredación ocurra alrededor de los márgenes de distribución de la zorra del desierto de San Joaquín, donde su hábitat colinda con el hábitat apropiado para la anidación de las águilas reales.

The San Joaquin kit fox (*Vulpes macrotis mutica*) occurs in arid shrublands and grasslands in central California (Cypher et al. 2013). Although hunting, trapping, and predator control programs may have contributed to declining numbers in the past, the primary threat to kit foxes has been and continues to be profound habitat fragmentation, degradation, and loss, largely resulting from agricultural, industrial, and urban development. Consequently, the San Joaquin kit fox was listed as Federally Endangered in 1967 and is also listed as California Threatened (USFWS 1998).

Due to the San Joaquin kit fox's status as an at-risk species, various investigations have been conducted to collect demographic and ecological data that will contribute to its conservation and recovery. Of particular interest is information on sources of mortality for San Joaquin kit foxes. In most locations, predators (Cypher 2003) have been identified as the primary cause of death, particularly coyotes (*Canis latrans*) and bobcats (*Lynx rufus*), and infrequently, red foxes (*Vulpes vulpes*) and badgers (*Taxidea taxus*).

Golden Eagles (*Aquila chrysaetos*) have been conjectured to prey on kit foxes as well (Grinnell et al. 1937, Clark 2009). However, to our knowledge, only one occurrence of confirmed Golden Eagle predation on a free-ranging San Joaquin kit fox has been documented. In a study of San Joaquin kit fox ecology in western Merced County, Briden et al. (1992) reported that a radio-collared kit fox was killed by a Golden Eagle. In a recent ecological study on kit foxes in San Luis Obispo County, we documented multiple occurrences of suspected Golden Eagle predation on San Joaquin kit foxes (hereafter, kit foxes or foxes).

The observations reported here were documented during an investigation of the demographic and ecological responses by kit foxes to the construction of a solar-powered energy generation facility (Cypher et al. 2018). The investigation was conducted during December 2014–November 2017 on the northern end of

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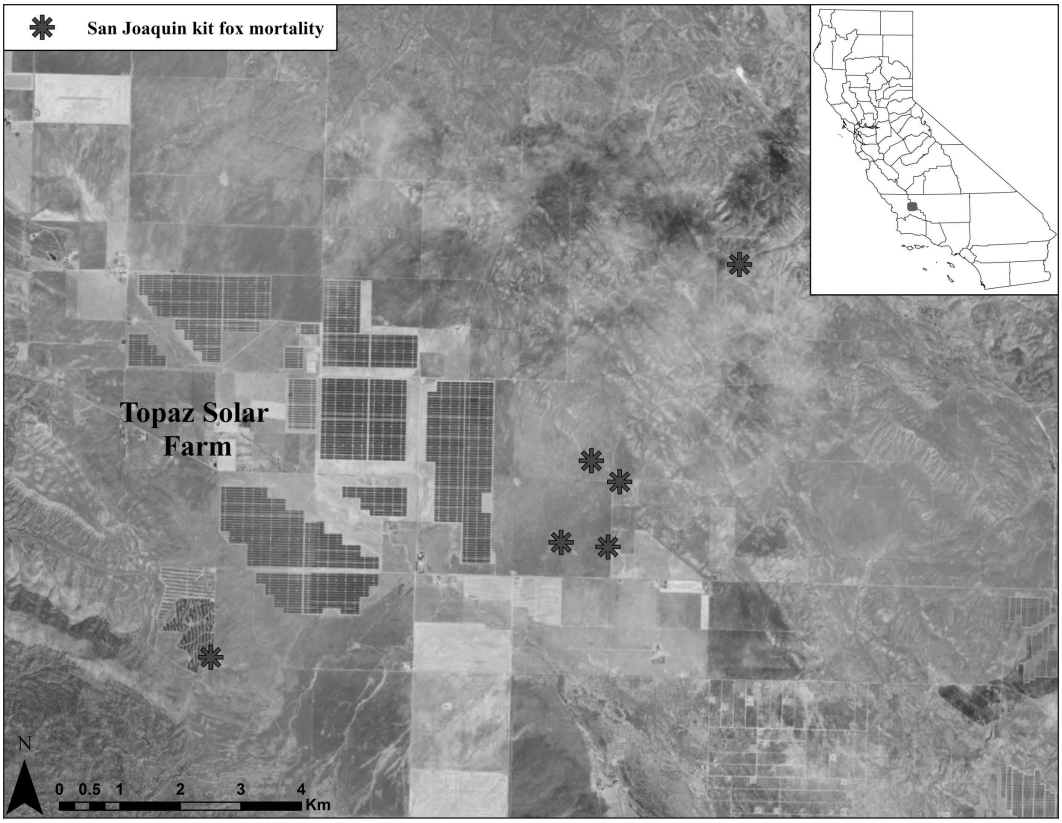

Fig. 1. Study area and locations of San Joaquin kit foxes putatively killed by Golden Eagles.

the Carrizo Plain in eastern San Luis Obispo County, California (Fig. 1). The topography in the study area ranged from flat to gently rolling with elevation ranging from 580 m to 680 m. The Mediterranean-type climate was characterized by hot summers and cool winters with most precipitation occurring as rain in winter. Annual precipitation averaged approximately 25 cm, and daily high temperatures were between 35 °C and 38 °C in summer and between 17 °C and 20 °C in winter (NOAA 2018). Most of the land in this area had been or still was being tilled for dryland farming of wheat and barley. Previously tilled lands were in various states of ecological recovery. Vegetation in the area consisted primarily of red brome (*Bromus madritensis*), wild oats (*Avena* sp.), wild barley (*Hordeum* sp.), red-stemmed filaree (*Erodium cicutarium*), fiddleneck (*Amsinkia* sp.), and Russian thistle (*Salsola* sp.). Shrubs were absent over much of the area and, where present, were very sparse and consisted primarily of goldenbush (*Isocoma acradenia*).

For the solar farm effects study, 52 kit foxes were captured and radio-collared (see Cypher et al. [2018] for methods and additional study details). Collars were only placed on foxes that were >6 months old. The radio collars included a mortality function whereby the signal pulse rate doubled if the unit remained motionless for 8 h. We attempted to monitor all foxes at least 3 times per week to assess survival and identify sources of mortality. If a mortality signal was detected, it was tracked to the source on foot as soon as possible to locate and recover the carcass. All carcasses were located within 48 h, and most within 24 h of the mortality signal being detected. Once located, the carcass and surrounding area were examined for clues to the cause of death. Cause of death was determined based upon physical evidence at the recovery site (e.g., tracks of larger predators,

Fig. 2. Remains of kit fox 6702 (adult male). Bones of the left hind leg and tail are intact but stripped of flesh. Clumps of hair are present around the remains.

carcass caching, location on or near a road) and on the carcass (e.g., evidence of mass trauma, puncture wounds, consumption of portions of the carcass).

During the study, carcasses or remains of 29 kit foxes were found; 24 of these were foxes with radio collars and 5 were uncollared foxes whose remains were found opportunistically. The sources of mortality identified included coyotes, bobcats, Golden Eagles, and vehicles. Carcasses of foxes killed by coyotes usually had bite wounds and significant internal trauma but were otherwise intact (coyotes killing kit foxes is considered interference competition, and the carcasses are rarely consumed; Cypher 2003). Carcasses of foxes killed by bobcats usually were partially consumed, and the remains were covered with debris or dirt. Carcasses of foxes struck by vehicles were intact and located along roadsides. Golden Eagle predation on kit foxes was identified based on a suite of diagnostic characteristics (Wade and Bowns 1985, Roemer et al. 2001, Coonan et al. 2010; P. Collins, Santa Barbara Museum of Natural History, personal communication). These characteristics include the following: talon puncture holes, particularly along the spine; skin peeled back, particularly along

Fig. 3. Carcass of kit fox 6706 (adult female). The carcass has been eviscerated. The bones of the left hind leg are intact but stripped of flesh.

limbs (aka "degloving"); evisceration; clumps of plucked hair near carcass; peck holes in the skull; skin not consumed; and eagle feathers present.

We documented 6 cases of suspected Golden Eagle predation on San Joaquin kit foxes. Details of each case are as follows.

The remains of adult male 6702 were found on 25 April 2016. Most of the front half of the fox was missing. The hind half was present and consisted primarily of skin and bones with most flesh missing (Fig. 2). The skin had been peeled away from the left hind leg and tail, and both had been stripped of flesh. Similarly, a foreleg and a portion of the spine were present and the bones were intact but stripped of flesh. Clumps of fur were present around the carcass.

The carcass of adult female 6706 was found on 25 April 2016. A Golden Eagle was perched on the carcass and flew away at the approach of a biologist tracking the collar signal. The fox appeared to have been recently killed (<6 h) and the body cavity had been opened. Most of the internal organs and considerable muscle was missing (Fig. 3). The

Fig. 4. Hole pecked into the cranium of kit fox 6706 (adult female).

stomach of the fox was lying near the carcass. Flesh had been stripped from the left hind leg, but the bones were intact. Punctures, presumably made by the talons of the eagle, were present on the carcass. A large hole had been pecked in the top of the cranium (Fig. 4).

The carcass of adult female 6852 was found on 26 April 2016. The skin of the fox was present, but most flesh was missing. The skin on the right foreleg and the left hind leg had been peeled back and stripped clean of flesh, but the bones were intact.

The remains of an untagged pup (sex could not be determined) were found on 24 April 2017. The remains were found lying at the base of a t-post. The head was missing and most of the flesh had been stripped from the rest of the carcass. A segment of the spine was near the carcass and stripped clean of flesh.

The remains of adult female 6655 were found on 27 April 2017. The skin and most bones were present, but most of the flesh was missing. The spine on the fox had been severed. Clumps of fur were present near the carcass.

The carcass of adult male 6792 was found on 23 May 2017. The remains consisted primarily of skin and bones with most of the flesh missing. Skin and flesh had been stripped from the left fore and hind legs, but all of the bones were intact. A hole appeared to have been pecked in the base of the cranium. Clumps of fur were present near the carcass. A feather from a Golden Eagle was also present near the carcass.

Based on the evidence found in each of the cases described above, we concluded that a raptor had clearly fed on each of the fox carcasses. We cannot state with absolute certainty that the foxes were killed by a Golden Eagle versus another raptor, such as a Red-tailed Hawk (*Buteo jamaicensis*) or Great Horned Owl (*Bubo virginianus*). Both of these species are potentially large enough and strong enough to kill a kit fox, and both were observed on or near the study site. We also cannot state with absolute certainty that the foxes were not killed by some other cause and that Golden Eagles just scavenged the carcasses. Many of the diagnostic characteristics we used to identify potential eagle predation also could have resulted from scavenging on a fresh carcass. However, we feel that the evidence is sufficiently compelling to conclude that the likelihood is very high that all of the foxes described above were killed by Golden Eagles. Certainty is particularly high in the case of adult female 6706, where a Golden Eagle was flushed off her freshly killed carcass. Furthermore, we sent representative photographs of the kit fox remains to 3 individuals who had examined numerous carcasses of island foxes (*Urocyon littoralis*) that had been killed by Golden Eagles, and all 3 concluded that the conditions of the kit fox carcasses and the sign present at kill sites were consistent with predation by Golden Eagles. The individuals were Timothy Coonan (Channel Islands National Park, Ventura, CA), David Garcelon (Institute for Wildlife Studies, Arcata, CA), and Paul Collins (Santa Barbara Museum of Natural History, Santa Barbara, CA).

All cases of putative Golden Eagle predation on kit foxes that we documented occurred in spring: 5 cases in April and 1 case in May. At this time, Golden Eagles may be foraging more intensely to feed rapidly growing nestlings. In a survey conducted in 2010 (Latta 2010), 22 Golden Eagle nests, 9 of which were active with nestlings present, were located within 28.2 km (17.7 mi) of the area that became our eventual study site. Seven of the nests (4 active) were located within 16 km (10 mi) of the site. Also, 24 Golden Eagles were observed perched or flying during the survey. Nest surveys were not conducted during our project, but active nests likely were present based on the previous documentation of nests in the region.

The spring timing has further significance because kit foxes exhibit increased diurnal aboveground activity at this time. From late March into May, growing pups are present aboveground at natal dens at various times of day, and adult foxes are typically present aboveground as well to guard the pups. As the pups become older, their movements away from den entrances increase, which increases their vulnerability to predation; also, the vigor of their play intensifies, and this activity may alert predators to the presence of the pups. This heightened activity is common in April and May. An example of the potential for this activity to attract Golden Eagles was captured on an automated camera station set to monitor a natal den during another kit fox study on the nearby Carrizo Plain National Monument (Fig. 5). In a sequence of photographs, a Golden Eagle was observed attempting to capture kit fox pups playing outside of the natal den.

The impact of Golden Eagle predation on kit fox populations is unknown. As stated previously, only one confirmed occurrence of such predation has been reported prior to our study. Fox pups may be particularly vulnerable as they are less experienced and wary, and are commonly distracted by play. However, predation on pups in the spring would be extremely difficult to detect because radio collars are rarely, if ever, placed on pups of this age (primarily because there is no certainty of recapture and the collars would become dangerously tight as the pups grow). Also, because they are lighter in weight than adults, pups killed by eagles might be more easily transported to nests to feed nestlings. Thus, carcasses of pups would be more difficult to find. Among adult foxes, those rearing pups may be at greatest risk. As stated above, Golden Eagles may be attracted to natal dens by pup activity, and adults rearing pups are more likely to be aboveground during the day when eagles are foraging. The 5 adults suspected to have been killed by Golden Eagles in our study were all associated with litters of pups.

A factor enhancing the risk of Golden Eagle predation on our study site may have been proximity to suitable eagle nesting sites. Of the 22 nests found during the survey in 2010, 10 were in trees, 7 were on power line transmission towers, and 5 were in cliffs (Latta 2010). Trees and cliffs are not present throughout

Fig. 5. Sequence of photos from a kit fox natal den on the Carrizo Plain National Monument showing (top) pups playing outside the den, (middle) cloud of dust from pups scrambling into the den, and (bottom) Golden Eagle perched on the den.

most San Joaquin kit fox habitat, which typically is quite arid and flat (Cypher et al. 2013). This may explain the lack of eagle kills in most studies. Consequently, Golden Eagles generally may not be a significant source of mortality for San Joaquin kit foxes. However, the study site where we documented the putative Golden Eagle predation is on the margin of suitable kit fox habitat and adjacent to habitats with an abundance of trees and cliffs. In Fig. 1, rugged terrain that provides potential nesting sites for Golden Eagles is visible immediately to the northeast and southwest of the Topaz Solar Farm.

The apparent predation by Golden Eagles on kit foxes that we documented is not surprising in that such predation has been documented on other fox species as well. Ellis et al. (1999) documented carcasses of corsac foxes (*V. corsac*) in Golden Eagle nests in Mongolia. Moehrenschlager et al. (2007) reported that 13 radio-collared swift foxes (*V. velox*) were killed by Golden Eagles over a 3-year period on their study site in Canada. In a more dramatic situation, Golden Eagles nearly caused the extirpation of island foxes (*U. littoralis*) on 3 of the 6 islands inhabited by the foxes off the coast of southern California (Roemer et al. 2001, Coonan et al. 2005, 2010). Only the extreme actions of captive breeding of foxes and removal of the eagles prevented the extinctions of the 3 island fox populations, each of which constituted a distinct subspecies. As with San Joaquin kit foxes, corsac foxes, swift foxes, and island foxes all are considered species of conservation concern. Finally, Golden Eagles have been traditionally used to hunt red foxes (*V. vulpes*) in Mongolia (Soma 2014).

In summary, we documented multiple San Joaquin kit foxes that apparently were killed by Golden Eagles. This is a nontypical source of mortality for which researchers should be vigilant in any future studies conducted along the margins of the San Joaquin kit fox range or where power line corridors cross the range.

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