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Scat Detection Dog Surveys for the San Joaquin Kit Fox on the Lawrence Livermore National Laboratory's Experimental Test Site (Site 300) and the Corral Hollow Ecological Reserve: 2020 Deployment

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Alameda and San Joaquin Counties, California

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Background

The San Joaquin kit fox (*Vulpes macrotis mutica*) historically occupied an extensive range in the San Joaquin Valley, California; however, their populations and habitat have since been significantly reduced by human impacts (United States Fish and Wildlife Service [USFWS] 1998). More than 95% of the potential habitat for kit foxes on the San Joaquin Valley floor has been converted to irrigated agriculture, urbanized, or industrialized lands. The San Joaquin kit fox was listed as endangered by the USFWS in 1967 and as threatened by the State of California in 1971.

Records from local surveys, research projects, and incidental sightings indicate the present distribution of kit foxes extends from 1) southern Kern County north to Contra Costa, Alameda, and San Joaquin counties on the west side of the valley and to Stanislaus County on the east side; 2) into some of the larger, uncultivated valley-floor land parcels in Kern, Tulare, Kings, Fresno, Madera, and Merced counties; and 3) westward within 5 counties in the interior coastal range (USFWS 1998). Kit foxes have been denoted to occur in 3 geographically distinct core and several satellite populations in a heavily fragmented landscape, with the largest extant populations concentrated in the southern part of the range and smaller populations and isolated sightings in the central and northern portions (USFWS 1998, 2010).

Specific to Alameda and San Joaquin counties, kit fox abundance appears to have declined in the last four decades (Orloff et al. 1986, Sproul and Flett 1993, Westlar 1987). From 1986 to 1992, the occurrence of kit foxes in these counties was re-confirmed (Orloff et al. 1986, Bell 1994). Subsequent work with the implementation of several survey methods (i.e., baited cameras, nocturnal spotlighting, scat-detection dogs) found no evidence of kit fox presence, even in areas where they had been documented earlier (H. Bell and K. Ralls unpubl. data, Smith et al. 2006, D. A. (Smith) Woollett unpubl. data).

Prior surveys to determine kit fox status have been conducted on and adjacent to Lawrence Livermore National Laboratory's (LLNL) Site 300 – an approximately 28 km^2 experimental test site on the border of Alameda and San Joaquin counties, operated by the Lawrence Livermore National Security, LLC, (LLNS) for the U.S. Department of Energy's National Nuclear Security Administration. Surveys in 1986 and 1990 were not able to find definitive evidence of kit foxes on the site, nor were they able to verify kit fox use of an adjoining study area and 24,000 acres of land immediately southeast of Site 300 (Orloff 1986, Taylor et al. 1986b, Garcia and Chamberlain 1990). In contrast, a separate survey in 1986 reported two confirmed sightings and a kit fox carcass approximately 1.5 and 2 miles north of Site 300 in the valley lands adjacent to Patterson Pass Road and the PG&E substation (Taylor et al. 1986a).

More recent mesocarnivore surveys, including scat detection dog, on Site 300 in 2002 confirmed presence of badger, bobcat, and coyote, but resulted in no kit fox findings (Clark et al. 2003). Similarly, scat dog surveys on Site 300 and the neighboring California Department of Fish and Wildlife's Corral Hollow Ecological Reserve in 2018 found no evidence of kit foxes (Woollett 2019). In 2020, Working Dogs for Conservation (WD4C) was contracted by LLNS to provide professional conservation detection dog teams and updated surveys for scats of San Joaquin kit fox on Site 300 and the Corral Hollow Ecological Reserve.

K9 Utah during surveys to detect kit fox scat at the Corral Hollow Ecological Reserve. Photo: Lisa Paterson

The method of using formally trained dogs to survey for scats of rare or endangered species – followed by DNA analysis of scats found – allows for rapid and accurate ways to determine the presence of target wildlife in an area (MacKay et al. 2008). To date, dogs have been deployed in natural environments to seek the scats of a multitude of species, including gray wolf (*Canis lupus*; Beckmann 2006), fisher (*Martes pennanti*; Long et al. 2007, Thompson et al. 2012), cougar (*Puma concolor*; Beckmann 2006), grizzly bear (*Ursus arctos;* Wasser et al. 2004, Beckmann 2006), black bear (*Ursus americanus*; Wasser et al. 2004, Beckmann 2006, Long et al. 2007), bobcat (*Lynx rufus*; Harrison 2006, Long et al. 2007), moose (*Alces alces*; Kretser & Glennon 2011), river otter (*Lontra canadensis*; Richards et al. 2018), black-footed ferret (*Mustela nigripes*; Reindl-Thompson et al. 2006) and North Atlantic right whale (*Eubalaena glacialis;* Rolland et al. 2006).

In particular for San Joaquin kit fox, where scats are generally small (~1-3 cm) and cryptic, conservation dog-handler teams have proven useful as a valuable scat detection tool, increasing both the potential for discovery as well as the number of samples recovered (Smith et al. 2003, Ralls and Smith 2004, Wilbert et al. 2015). This type of monitoring method was demonstrated to be successful in confirming the presence of kit fox in known core and satellite population areas in the San Joaquin Valley and with various fox densities and habitat types (Smith et al. 2005). Because dogs can detect both fresh and old scats, data on current presence as well as recent past in an area can be determined.

LLNL Site 300 surveys were conducted in November 2020. Follow-up genetic analysis of DNA extracted from scat collected during the survey effort was carried out by the Mammalian Ecology and Conservation Unit of the Veterinary Genetics Laboratory at the University of California, Davis to identify kit fox presence in the study areas. This report records the methods and results of these surveys.

Methods

Study area

Site 300 serves a variety of functions related to testing non-nuclear explosives and weapons subsystems. Surveys were conducted on Site 300, and the immediately adjacent California Department of Fish and Wildlife's (CDFW) Corral Hollow Ecological Reserve, in Alameda and San Joaquin Counties, California (Figure 1). This habitat expanse of rolling hills and canyons supports a diverse array of grassland communities typical of lowland central California. The Corral Hollow Ecological Reserve was deeded by the U.S. Department of Energy to the State in recognition of its biological significance, and is now managed by CDFW. The total area covered by the 2020 surveys was approximately 810 acres of grassland habitat with low, moderate, and steep slopes.

Scat survey

During 03 to 05 November 2020, surveys for scats of kit fox were systematically conducted on transect routes that were designed to thoroughly cover search areas on each property (Figure 1). Search areas were based on suitable kit fox habitat present on site. Transect routes were relatively similar to those surveyed in 2018, and several routes from the earlier year were merged together based on logistical considerations. To adequately obtain high scat capture probabilities, transects were established to purposely take advantage of fire roads and fence-lines, as these are common travel paths for kit fox and a place where they frequently deposit scats, similar to other carnivore species (MacDonald 1980, Kohn et al. 1999, Koopman et al. 2001, Smith et al. 2005, Ruell et al. 2009, D. A. (Smith) Woollett unpubl. data). Additionally, various transects (or legs) were in vegetative areas.

Linear scat detection transects established in the study areas totaled approximately 37.40 km. Transect legs are viewed as broad belts of survey activity; prior research shows that detection dogs have found kit fox scats at a mean distance of 4.8 $\pm$ 6.7 m from a transect line (range 0 - 38.40 m; Ralls and Smith 2004).

Two individual detection dog teams consisting of a dog and biologist/handler were used to locate scats along transects (refer to Figure 1). Teams were escorted by an LLNL representative familiar with Site 300 work control and off pavement travel procedures, as well as with the Corral Hollow Ecological Reserve boundaries.

Detection dogs

Each dog was trained using standard and established methods of conservation dog programs (Smith et al. 2003, MacKay et al. 2008, Hurt and Smith 2009, Hurt et al. 2016). For instance, dogs that locate the odor of kit fox scat give a trained alert to the handler at the source of the odor by sitting or lying down next to the scat. Field searches involve the handler walking the transect line while the dog ranges and quarters ahead of the handler to encounter the target's odor.

Canid verification

In the interest of not excluding any possible kit fox scat, some non-target canid scats (e.g., coyote (*Canis latrans*), red fox (*V. vulpes*), gray fox (*Urocyon cinereoargenteus*)) have the potential to also be collected during surveys. Although conservation dogs can detect more scats and with greater accuracy in identification of species than humans (Hurt and Smith 2009), a handler may inadvertently collect non-target scat when a dog correctly locates a latrine containing fresh scats from multiple canids (i.e., fox/coyote; Ralls and Smith 2004); when a dog errs in scent discrimination and keys on a similar (yet incorrect) target; or when a dog selects an incorrect target when few target scats are present in order to receive a reward (Schoon 1996, Smith et al. 2003). Therefore, any scat sample indicated by a dog is to be collected, stored in a plastic bag containing one teaspoon of silica gel for desiccation (Fisher Scientific, Pittsburgh, PA), and shipped to the genetics laboratory for DNA verification of species (Bozarth et al. 2010). Additionally, the location of each potential kit fox scat collected is to be geo-referenced with a global positioning system (GPS).

For supplemental information purposes, biologist/handlers also noted visual or auditory observations of any wild canid using the property.

Results

A total of 37.40 km of transect legs were searched on the approximately 810 acres of delineated search area on Site 300 and the Corral Hollow Ecological Reserve (Table 1; Figure 1). One scat was alerted to by a dog during surveys on Site 300, and collected for genetic analysis (Table 1; Figure 2).

Based on morphological characteristics of the scat, there was low confidence that it came from a kit fox; nonetheless, physical features suggested it was deposited by a carnivore (likely a non-target red or gray fox or smaller coyote) and therefore, under WD4C protocols, the scat was submitted for DNA identification. Correct identification of scat by human visual examination can be difficult, and expert naturalists have been known to consistently misidentify scats from sympatric species (Bulinski and McArthur 2000, Davison et al. 2002).

Subsequent DNA analysis indicated the scat was from a coyote. Both properties continue to support a viable population, and biologist-handlers observed numerous, visually-obvious coyote scats during surveys. The majority of transects had between 30 and 70 scats, with one transect possessed upwards of 160 scats. Although coyotes are a primary cause of kit fox mortality (Ralls and White 1995, Spiegel 1996, Cypher et al. 2000), in general, coyotes do not competitively exclude kit foxes, and both species that have co-evolved will occur together in most areas (Clark et al. 2005). The two species appear to partition resources adequately to allow for coexistence throughout the San Joaquin Valley (Nelson 2005).

Table 1. Summary of transects covered and scat collected during surveys on Site 300 and the Corral Hollow Ecological Reserve.

Date	Transect	# of scats located	Distance surveyed (km)	Species ID by DNA analysis
04 November 2020	1	0	6.10	--
04 November 2020	2	0	5.80	--
03 November 2020	3	1	9.50	coyote
03 November 2020	4	0	7.10	--
05 November 2020	5	0	3.50	--
05 November 2020	6	0	5.40	--

Discussion

In summary, results of the scat detection dog surveys, and subsequent DNA analysis, do not support the presence of kit foxes at Site 300 or the Corral Hollow Ecological Reserve. Studies within their range indicate kit foxes deposit scats singly, in pairs, and at latrines throughout their territories, and also commonly mark conspicuous objects (e.g., fence posts, carcasses, skulls, cement objects, trash litter, coyote scats) (Ralls and Smith 2004, D. A. (Smith) Woollett unpubl. data). Furthermore, dogs are capable of detecting scats that range from fresh to several weeks to several months old (Smith et al. 2003, D. A. (Smith) Woollett unpubl. data). The surveys resulted in no kit fox scats of any age found across the study areas on either property.

Previously scat collection in satellite and core populations with various kit fox densities found on average 18.65 ± 18.51 scats/km (range: 0.25 - 52.25 scats/km; Smith et al. 2005). If scats were available for detection on Site 300 and the Corral Hollow Ecological Reserve, it is highly likely that they would have been detected within the distance of each route and through the extensive transect system established.

Red and gray foxes were not observed during surveys, but have been documented previously on Site 300 (e.g., Garcia and Chamberlain 1990). The presence of nonnative red foxes is potentially detrimental to kit foxes. Red foxes have been known to kill kit foxes, displace kit foxes from their dens and habitat, compete for food resources, and potentially transmit diseases to kit foxes (Ralls and White 1995, Cypher et al. 2001, Clark et al. 2005). In the past ten years, two genetically confirmed red fox scats were detected on a private property close to Site 300 and the Corral Hollow Ecological Reserve (D. A. (Smith) Woollett unpubl. data), and three red fox road-fatalities/carcasses were documented on nearby Interstate 580 between Corral Hollow Rd. and Patterson Pass Rd. (J. Woollett pers. comm.). The presence of red foxes likely increases competitive pressure on kit foxes, and can reduce the suitability of an area for this endangered species.

Gray foxes are typically spatially segregated from kit foxes based on habitat preferences, with gray foxes favoring more mesic, agricultural, brushy, and forested communities and kit foxes favoring more arid scrublands and grasslands (Cypher 2003). Areas where occasional gray fox have been seen on Site 300 suggests that the habitat in those locations was probably not suitable for kit foxes.

Surveys with detection dogs have been recognized as an effective way to obtain canid species presence and range information for conservation management (MacKay et al. 2008, Woollett et al. 2014). Here, detection dog surveys yielded no sign of kit fox occurring on Site 300 or the Corral Hollow Ecological Reserve. These results appear to be consistent with previous detection dog (and additional survey method) findings in 2002 and 2018, as well as with conclusions from other researchers and managers working in this region.

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Figures

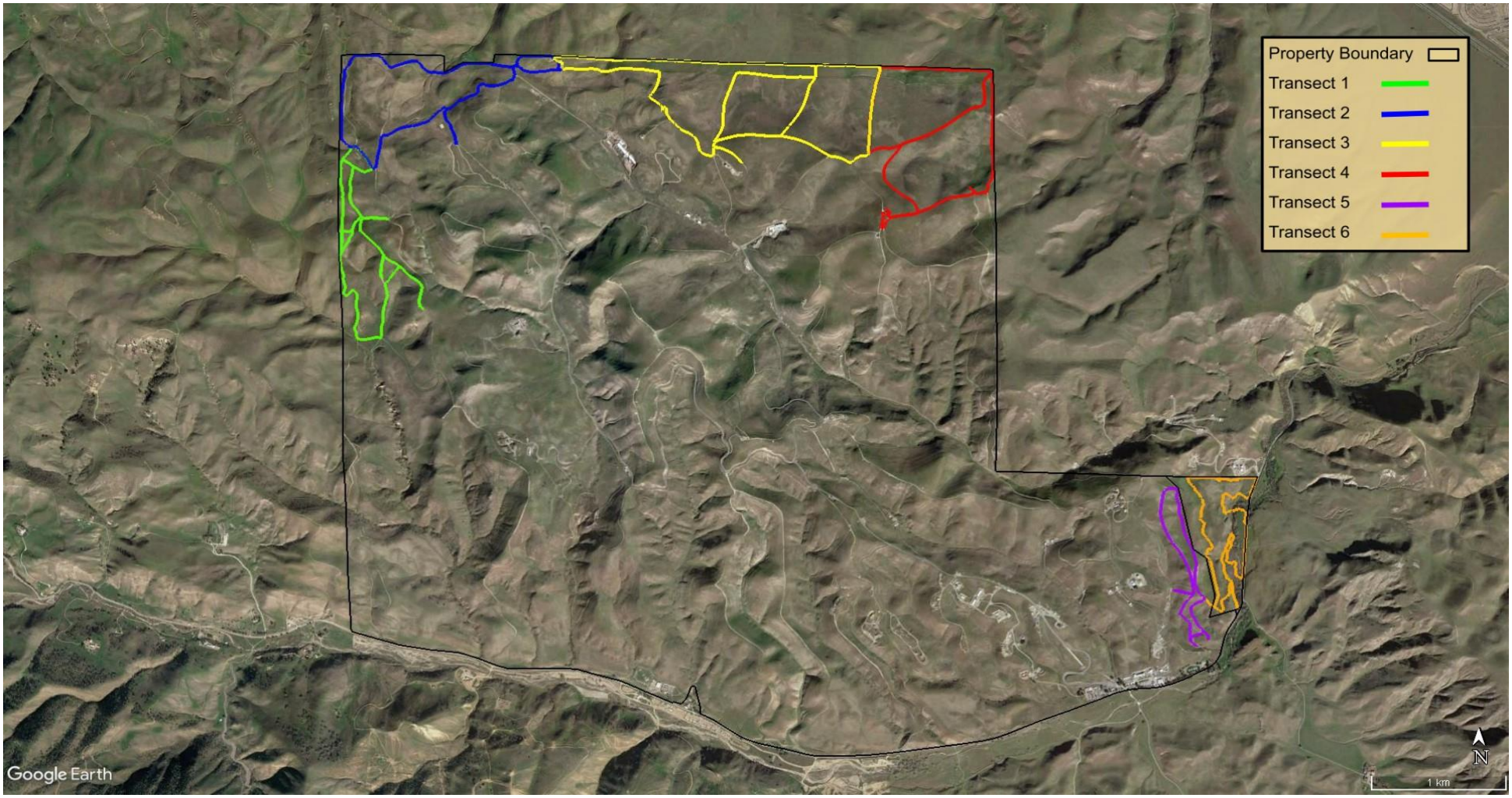

FIGURE 1. SURVEY AREA AND TRANSECTS ON SITE 300 AND THE CORRAL HOLLOW ECOLOGICAL RESERVE. The areas specified for surveys were situated along the northwest, north, and northeast borders of Site 300 and in the southeast corner adjacent to, and in, the Corral Hollow Ecological Reserve. All scat detection transects are overlaid. The Transect ID is provided, corresponding to Table 1.

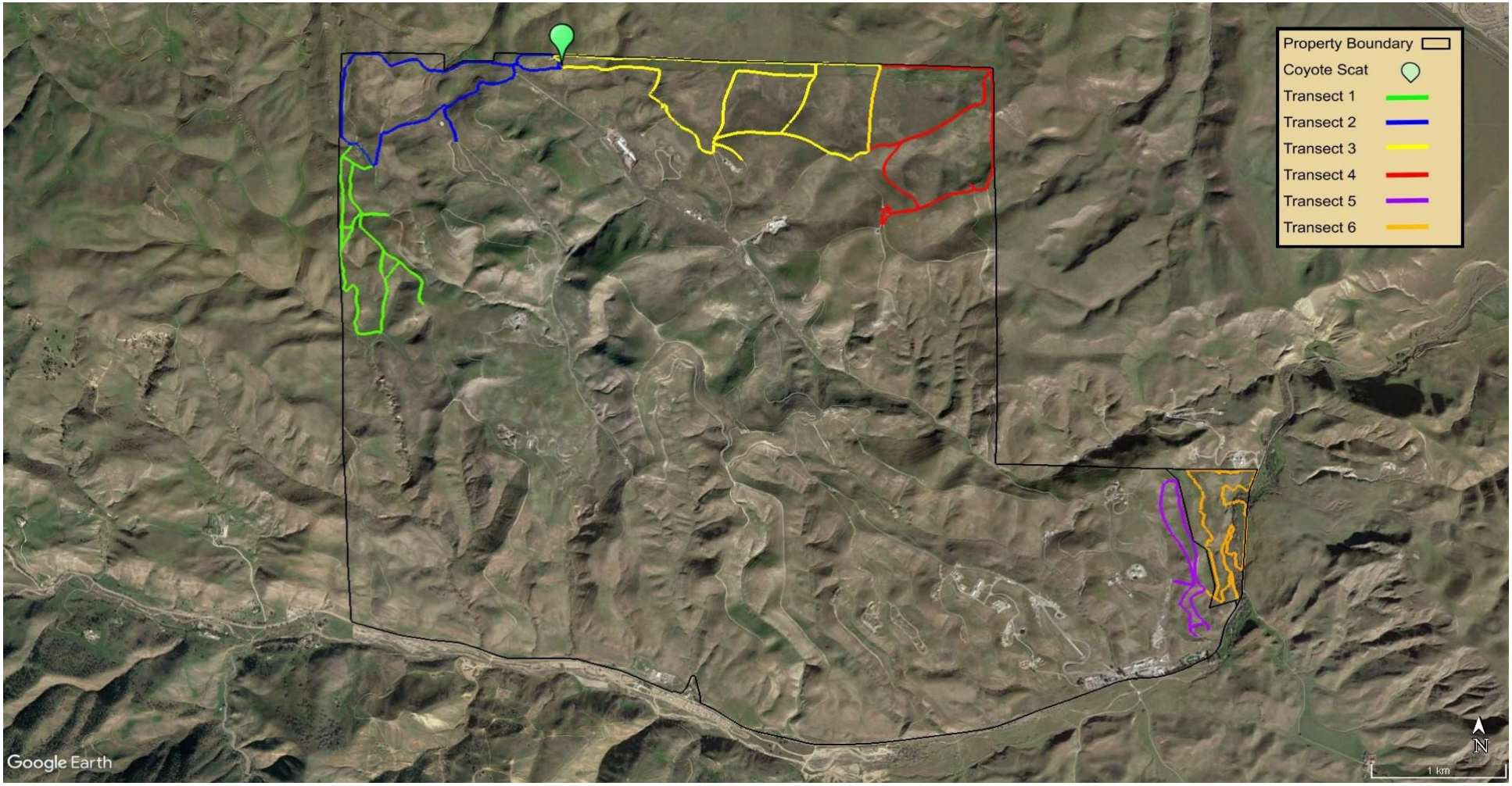

FIGURE 2. SCAT COLLECTION ON SITE 300. Location of the scat collected on Site 300 is indicated. The single scat was genetically analyzed to confirm species ID.