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Documentation of mountain lion occurrence and reproduction in the Sacramento Valley of California

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Little is currently known about mountain lion (*Puma concolor*) use of California's Sacramento Valley. Although mountain lions are occasionally reported adjacent to the floor of the Sacramento Valley at the base of the Sierra Nevada and Coast Ranges, habitat in this region has been considered unsuitable for mountain lion due to its extensive urban and agricultural development (Torres et al. 1996). However, relic riparian habitats persist in conjunction with restored and managed wetlands thanks to the efforts of local residents, waterfowl hunters, non-governmental organizations (NGOs) and State and Federal Agencies. These relic riparian and associated habitats provide essential habitat components for resident deer (*Odocoileus hemionus*). Thus with adequate prey, and sufficient habitat connectivity, these same areas might also allow for the presence of mountain lions.

The Butte Sink is a depression in the Sacramento Valley located immediately northwest of the Sutter Buttes, a small mountain range that rises out of the valley floor. The Butte Sink is approximately 24,500 ha containing a complex of riparian and wetland habitats at the conjunction of Butte, Colusa, Glenn, and Sutter counties east of the Sacramento River, north of the town of Colusa, California (Figure 1). Habitat types include valley riparian, seasonal emergent wetlands, permanent wetlands, and agricultural crops including rice, corn, walnuts, and olives. The Butte Sink regularly floods for several weeks at a time during winter months. Land ownership in the Butte Sink is composed of private commerical agricultural production interspersed with state and federal wildlife management areas, and private duck clubs which are managed for the benefit of the extensive numbers of waterfowl that seasonally inhabit the area.

Historic and recent information from bounty records, museum records, and depredation permits suggest that mountain lion occurrence in the area has been historically low since records began in 1907. Sutter County is the only county in the study area to be entirely contained in the Sacramento Valley, and accounted for only one depredation permit issued since the depredation program's inception in 1972. Similarly, Long and Sweitzer (2001) surveyed museums and found only four out of the 280 mountain lions collected in the state came from the California's Central Valley (composed of the Sacramento Valley and the much larger San Joaquin Valley). All four specimens were collected prior to

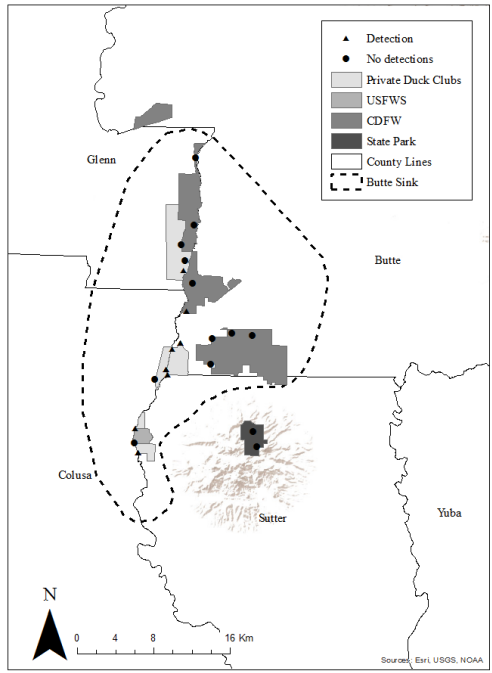

FIGURE 1.—Land ownership and camera-trap locations in the Butte Sink, Sacramento Valley, California. Cameras were deployed from March to November 2016.

1921. As part of an effort to document mountain lion populations across the state, and due to recent anecdotal reports by local residents of mountain lion presence in the Butte Sink, we wanted to document mountain lion presence in the Butte Sink and surrounding areas within the Sacramento Valley. Data gathered from this study was deposited into a statewide mountain lion habitat assessment and population estimate database.

We placed 20 un-baited Reconyx PC900 HyperFire Professional covert IR cameras throughout the Butte Sink and surrounding areas. Camera-traps were placed on private duck clubs, and state and federal lands (Figure 1). Potential locations were established either through the use of aerial imagery (Google Earth, accessed 15 February, 2016); or reliance on local knowledge of wildlife game trail occurrence. The final decision for selecting sites was based on on-the-ground evaluation of the physiognomic and topographical features that would naturally facilitate mountain lion movement in and around the Butte Sink. These included infrequently traveled dirt roads, levees, and game trails; particularly those with adequate vegetation for cover, which mountain lions select when moving through their home range (Dickson et al. 2005). Twenty cameras were placed opportunistically to meet our objective of documenting presence of mountain lions, rather than in a grid design used in modeling occupancy. We set camera-traps from 01 March 2016 through 10

November 2016, for a total of 5,165 camera-trap nights. We also received opportunistic images from cooperating individuals or land managers when mountain lions were detected on their cameras. Camera-traps were checked weekly at which time photos from the previous week were viewed on a portable tablet. We also replaced media storage cards and batteries as needed.

Mountain lions were detected on 15 occasions for a detection rate of 0.29 detections per 100 camera-trap nights. The first detection occurred on 12 April 2016, 39 days after deployment of the camera-traps. The mean occurrence interval of mountain lion detections was every 11 days over the period from receiving the first image to the last on 20 September 2016. The shortest inter-detection interval was 2.6 hrs on 15 April 2016, between two cameras spaced approximately 3,150 m apart. As only the rear of the lion was captured on the first camera, and only the head at the second location, we could not confirm whether or not it was the same animal. The longest inter-detection interval was 48 days from 10 June to 28 July 2016. Although mountain lion detection rates (number of detections per day) lessened during the summer months with a mean of 25 days between sightings from 27 April to 31 August 2016, we continued to detect them throughout the study period.

At least two distinct adults were identified in our images: a male who was distinguished by a missing right front foot (Figure 2), and a female who was accompanied by three kittens (Figure 3A). We also detected an adult with no kittens or foot abnormalities, but it is unclear if this is a third individual or the mother without her kittens. In addition to these five known unique mountain lions detected during this study period, we were given images of a female and litter taken in 2012 (Figure 3B) at a duck club in the study area. We cannot however determine whether this is the same female we detected in 2016.

The presence of multiple litters observed in the area indicates the Butte Sink is suitable for foraging reproductive females. A female with kittens requires substantially more calories than a non-reproductive adult mountain lion. Energetic models have demonstrated that over the length of time required to carry, birth, and raise dependent young to independence, females with dependent young require at least twice the amount of deer compared to a lone individual (Laundrè 2005). This time period of increased caloric need is generally 21-24 months long with 3 months for gestation and 18-21 months for raising young (Logan and Sweanor 2001).

Although the majority of the Sacramento Valley is either open agriculture or urban development, our study area may represent a pocket of suitable mountain lion habitat within the Sacramento Valley. Mountain lions have been documented preferentially selecting riparian habitat and avoiding agriculture and urban areas in Southern California (Dickson and Beier 2002) and Arizona (Nicholson et al. 2014). Furthermore, mountain lions living in landscapes dominated by human disturbance appeared less sensitive to anthropogenic features, suggesting that some may differentially select habitats (Wilmers et al. 2013) and may become accustomed to more regular human activity (Benson et al. 2016). However, animals living in closer proximity to human activity are at greater risk of mortality (Burdett et al. 2010).

It is conceivable that mountain lions living in riparian islands like the Butte Sink would likely have adequate prey throughout the year. In mountainous areas, mountain lions generally follow seasonal ungulate movement patterns (Robinson et al. 2002), but mountain lions in general are known to have very flexible foraging patterns (Smith et al. 2016).

FIGURE 2.—Camera-trap image of an adult male mountain lion with a missing right front foot (date 12 April, 2016). The camera-trap was located adjacent to a tributary of Butte Creek within the Butte Sink study area.

FIGURE 3A.—Camera-trap image of an adult female mountain lion with two kittens (date 19 April 2016).

FIGURE 3B.—Camera trap image of an adult female mountain lion with two kittens (date 6 November 2012). Image courtesy of JP Stover and Wild Goose Club.

In addtion to the deer detected on nearly every camera-trap each week, the Butte Sink is also known to support dense populations of American beavers (*Castor candensis*), turkeys (*Meleagris gallopavo*), lagomorphs (*Sylvilagus* spp.), striped skunk (*Mephitis mephitis*), raccoon (*Procyon lotor*), and various species of waterfowl (e.g., *Areidae* and *Anatidae*), and fish (e.g., *Cyprinidae*; CDFW 2015), all potential mountain lion prey (Iriarte et al. 1990; Murphy and Ruth 2009). Further, deer are likely year-round residents because of the extensive agricultural development that now surrounds, and is a part of, the Butte Sink (Ingles 1965; Loft and Bleich 2014). The combination of resident deer and the diversity of secondary prey available lead us to believe that mountain lions likely persist year-round in the Butte Sink. However, further study is needed to determine mountain lion movements during large-scale flood events, which can inundate the Butte Sink area for multiple weeks at a time.

The Butte Sink is a remnant of native habitats that once covered much of the Sacramento Valley. Using California GAP vegetation data (Davis et al. 1995) we attempted to visually identify additional aggregate blocks of relic riparian habitat that remained in the Central Valley (Figure 4). These aggregate blocks were identified by selecting riparian habitat ≥1,500 ha in size and ≤2 km from similar habitat of greater than or equal size. These thresholds were derived from research on mountain lions in the Santa Monica National Recreation Area and surrounding areas wherein some animals were found to inhabit, at least temporarily, habitat blocks ≥1,500 ha in size and ≤2 km from similar habitat (Benson

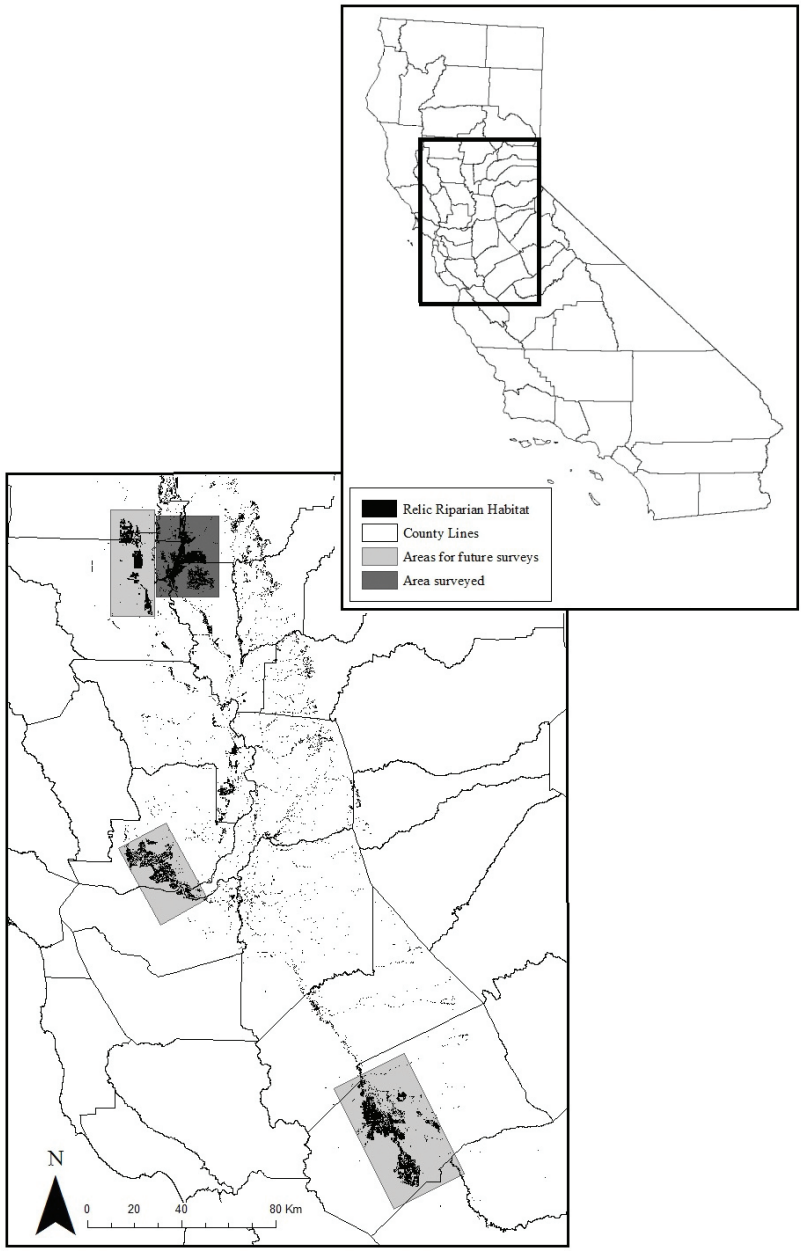

FIGURE 4.—Location of Butte Sink survey area relative to the locations of additional areas of relic riparian habitat in the Central Valley of California. These areas could be surveyed for mountain lion activity.

et al. 2016). Based on this analysis, we found that blocks of relic riparian habitat occur in and around the Sacramento River National Wildlife Refuge Complex (~11,800 ha), Grizzly Island Wildlife Area (~17,200 ha), and San Luis National Wildlife Refuge (~31,900 ha). It is possible that mountain lions are present, at least periodically, in these additional blocks of relic riparian habitat. Future camera work in these areas might help increase our understanding of mountain lion distribution in the Central Valley of California.

We suggest that mountain lions are occupying and reproducing within the Sacramento Valley's Butte Sink, an area heavily impacted by humans, and are capable of utilizing habitat islands within agricultural lands that have adequate connectivity with larger habitat blocks. Such information should be carefully considered when designating suitable habitat for mountain lions in California, in that some habitat of this type may not have been considered viable for mountain lions in the past. However, adequate connectivity between remnant islands of habitat and larger habitat areas is critical if these remnants are to remain viable over time.

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