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Rapid Assessment of the Distribution of American Badgers Within Western San Diego County.

Prepared for:
California Department of Fish and Game

U.S. Department of the Interior
U.S. Geological Survey
Western Ecological Research Center

Rapid Assessment of the Distribution of American Badgers Within Western San Diego County.

By C.S. Brehme, C.J. Rochester, S.A. Hathaway, B.H. Smith and R.N. Fisher

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Cover photo: B. Heath Smith and Pips of Conservation Canines (University of Washington) inspecting a badger burrow in Warner Springs Ranch, California. (C. Brehme 2011)

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Abstract

Badgers (*Taxidea taxus*) are wide-ranging mid-sized predators known to inhabit San Diego County. They prefer grassland habitats with sandy loam soils and naturally occur in low densities. Because of their large home ranges and low fecundity, they are highly vulnerable to habitat fragmentation and road mortality. Badgers are a covered species under the San Diego Multiple Species Conservation Plan (MSCP) and have been identified by the San Diego Monitoring and Management Program (SDMMP) Connectivity Monitoring Strategic Plan as a target species for monitoring regional-scale functional connectivity of upland and grassland habitats. However, we have little information on badger distribution, movement or habitat use within San Diego County.

In FY 2011, the California Department of Fish and Game (DFG) funded this initial study by a Natural Community Conservation Plan (NCCP) Local Assistance Grant (LAG) to determine if badgers still persist in the western portion of San Diego County. Survey sites were prioritized according to three criteria; 1) areas with historical and/or recent badger records, 2) conserved lands with priority given to MSCP and Multiple Habitat Conservation Plan (MHCP) lands, and 3) areas containing moderate to abundant grassland habitat.

We conducted canine scent surveys for American badger scat using a specially trained canine scent team from Conservation Canines (Heath Smith and Pips; University of Washington) from November 14 to December 14, 2011. We surveyed for badger scat across 32 sites within San Diego County and two sites in southern Riverside County. Pips had positive behavioral responses to scat at 13 sites. Using a badger specific DNA test, we were able to verify the scat collected to be that of the American badger at twelve sites: Marine Corps Base Camp Pendleton (Juliett and Oscar One), Fallbrook Naval Weapons Station, Daley Ranch in Escondido, Ramona Grasslands, Warner Springs Ranch, Whelan Lake, Crestridge Ecological Reserve, Santa Ysabel Ecological Reserve, Hollenbeck Canyon Wildlife Area, Marron Valley, and the Santa Rosa Plateau.

Because badgers are present within the western portion of the County, they are a suitable species for assessing upland connectivity by means of radio-telemetry. As a priority for research, we recommend follow-up focused surveys to identify target areas for future live-trapping and telemetry and to better define any areas with higher densities of badgers. We recommend development of a microsatellite DNA test to identify individual animals from scat. This would allow for estimation of minimum population sizes in areas with multiple scats. Finally, we recommend that a workshop be

held to evaluate safe and effective methods of trapping badgers, evaluate methods for attaching transmitters to badgers, assess safety issues regarding the use of internal transmitters, and produce field and laboratory protocols that best ensure the safety and success of badger telemetry.

Introduction

Badgers (*Taxidea taxus*) are wide-ranging mid-sized predators than are known to inhabit San Diego County. Similar to the mountain lion, they are known to range over wide areas, often making movements of 10km or more per day. Therefore, they are a suitable focus species for monitoring regional-scale connectivity. Unlike mountain lions that prefer to move within riparian areas (Dickson et al. 2005), badgers prefer open or grassy areas and thus are likely better indicators for upland connectivity and represent a different suite of species. Badgers are a covered species under the San Diego Multiple Species Conservation Plan (MSCP) and have been identified by the San Diego Monitoring and Management Program (SDMMP) Connectivity Monitoring Strategic Plan as a target species for monitoring regional-scale functional connectivity of upland and grassland habitats. However, we have little information on badger distribution, movement or habitat use within for San Diego County.

The objective of this study was to identify current locations of badgers in western San Diego County using canine scent detection. This method is advantageous in that large areas can be surveyed in relatively little time for badger scat, giving us a rapid assessment of the status of the American badger within the County. The results will be used to determine if badgers are a suitable focal species within the County to monitor upland connectivity. If badgers still persist within San Diego County, particularly within existing NCCP plan boundaries in the western portion of the County (e.g. MSCP, MHCP), we plan to build upon this information in future years by analyzing badger movement using radio-telemetry techniques.

American Badger

The American badger (*Taxidea taxus*) is a nocturnal medium-sized fossorial carnivore of the Mustelid family that includes weasels and wolverines. Badgers are stocky with very powerful forearms and claws for digging. Their primary prey are small mammals such as ground squirrels, gophers, ground hogs, prairie dogs, voles, mice, woodrats, and kangaroo rats, but they also eat birds,

herpetofauna, invertebrates, and plants (Grinnell 1937, Long 1972, Messick 1987, Quinn 2008). Their home ranges and densities have been associated to density of prey, particularly ground squirrels (i.e. Owing and Borchert 1975, Lay 2008). Badger densities are typically low, ranging from 0.2 to 5 individuals per km^2, while their home ranges are large, ranging from 2 to 50 km^2 and sometimes up to 450 km^2 (Messick and Hornocker 1981; Hoodicoff 2003, Minta 1993, Quinn 2008). Except for mothers with their young, adults are largely solitary moving an average of 0.5 km per night in search of prey (Lindzey 1978, Hoodicoff 2003). Badgers mate July through September and with delayed implantation, females give birth the following spring to an average litter size of 2 to 3 young. Their lifespan is 9 to 10 years in the wild (Long 1972).

Badgers range across much of North America, from southern Mexico to central Canada and from the west coast of California to the Great Lakes region. Within the range of the species, they are known to prefer sandy loam soils and open grasslands, although they are found in open scrublands, open woodlands, and open chaparral (Grinnell 1937, Long 1972, Messick and Hornocker 1981, Hoodicoff 2003, Quinn 2008). In Quinn's (2008) study of badger habitat and movement in Monterey County, California, she found they spent 91% of their time in grassland habitats.

Because of their large home ranges, habitat preferences, and low fecundity, badgers are especially vulnerable to the negative effects of habitat loss, habitat fragmentation, and road mortality. Significant declines of badger populations and distribution have been documented in California and British Columbia (Williams 1986, Adams and Kinley 2004). In a habitat fragmentation study of southern California, badgers were only found in very large unfragmented sites (Crooks 2002). In the San Francisco Bay Area., badgers were negatively associated with suburban land use and road lengths (Lay 2008). In 1986, the American badger was listed as a California Department of Fish and Game Species of Special Concern due to a substantial reduction of their distribution and abundance.

Badgers were extensively hunted for their pelts in 1930's and 1970's, and are still reportedly being trapped in high numbers (Williams 1986, Quinn 2008). Currently, a California DFG Trapping License is required for any for-profit trapping or hunting of badgers with no limits to the number of individuals. Depredation and predator control that is not for-profit does not require a permit or reporting. This species has long been considered a pest species for agriculture. It is hypothesized that there are many more badgers killed for depredation and it is unknown how much this has contributed to their decline (Williams 1986, Quinn 2008). The ecology of the badger in coastal southern California has not been studied.

Primary stressors to the American badger in southern California include:

1. Road mortality
2. Habitat loss
3. Habitat fragmentation: Lack of open habitat and/or corridors for movement and dispersal.
4. Hunting and trapping: Predator control/ sport shooting/ fur trapping
5. Consumption of pesticides through small mammal prey

Methods

Defining Target Survey Locations

We obtained historical badger records as a map (pdf) from the San Diego Natural History Museum with verified historical locations and from museum records accessed from the Global Diversity Information Facility Data Portal (*http://data.gbif.org*) and the California Natural Diversity Database (CNDDB; California DFG http://www.dfg.ca.gov/biogeodata/cnddb/). To obtain more information, we collaborated with San Diego Monitoring and Management Program (SDMMP: Yvonne Moore) to send out a general call for any San Diego County badger sighting information to wildlife agencies, consultants, and land managers. Many individuals responded by sending locations and descriptions of badger sightings or sign to USGS. After individual interviews and reviews of evidence, we assigned confidence levels to each record. We created a target survey map in ArcGIS by overlaying historical and recent badger records (high and medium-high confidence only), San Diego conserved lands (2010; SANDAG) and Vegetation (1995; SANDAG).

We then created a target survey site list (Appendix 1) based upon

1. Areas with historical and/or recent badger records (2 points);
2. Conserved lands with priority given to MSCP and MHCP lands (2 points); and
3. Areas containing moderate to abundant grassland habitat (1 point).

Access permits were acquired from the County of San Diego, City of San Diego, City of Escondido, California Department of Fish and Game (San Diego and Riverside), Bureau of Land Management, Sweetwater Authority, U.S. Fish and Wildlife Service, San Diego City Water Authority, Vista Irrigation District, Marine Corps Base (MCB), Camp Pendleton, Fallbrook Naval Weapons Station (NWS), Army Corps of Engineers, and California State Parks.

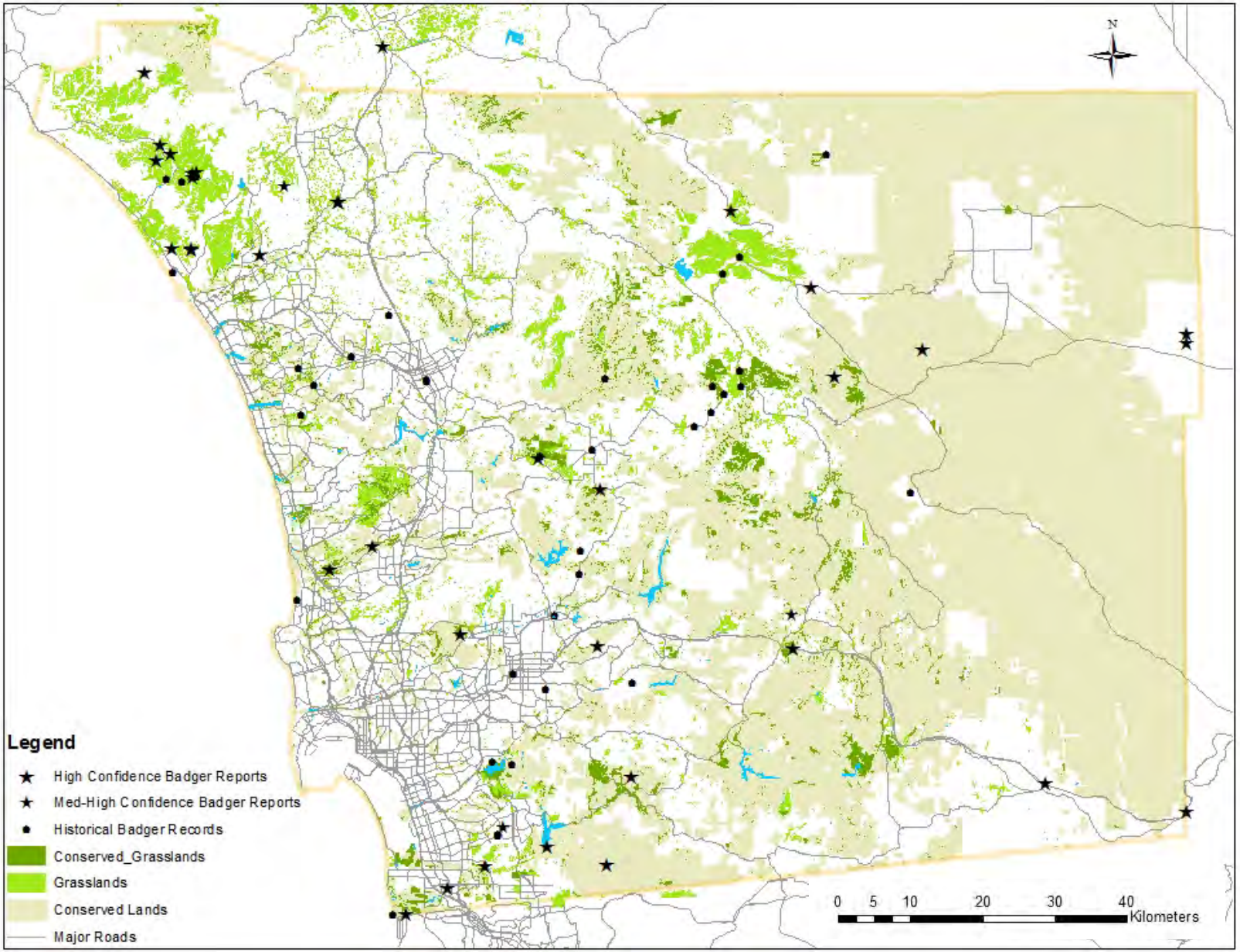

Figure 1. Overlay Map of Badger Records, Conserved Lands, and Grassland Habitat in San Diego County

Preliminary Sign Surveys

It is optimal to have local areas of known occupied badger habitat to reinforce the canine scent detection training, both prior to and during the overall canine scent survey period. Therefore, we contracted Barry Martin of the Western Tracking Institute (WTI) to conduct preliminary surveys for badger sign (i.e. tracks, scat, digs, burrows, trails) in historically occupied areas to identify potential training areas in or near San Diego County. Mr. Martin focused surveys on the Santa Rosa Plateau, which historically had abundant badger sign (C. Brehme pers. observation, Carol Bell pers. comm.). and also conducted rapid surveys of the Ramona grasslands, Mission Trails Regional Park, and Crestridge Ecological Reserve. The only badger sign found during the preliminary surveys were some tracks and digs on Burro Mesa in the Santa Rosa Plateau Ecological Reserve. No badger sign was found in other areas. Mr. Martin also provided training in badger sign identification.

Canine Scent Surveys

The Center for Conservation Biology (CCB, University of Washington) obtained American badger scat from the Washington Zoo. With this scat, CCB initially trained one detection dog "Pips" at their training facility in Eatonville, Washington, following the methods outlined in Wasser et al 2004.

> "Dogs selected for the program were initially introduced to target species odor (scat) utilizing a scent box. The scent box is a 2 m × 30 cm × 30 cm hinged rectangle with five compartments open to the outside by a 5-cm hole. Scat is placed in one of the five compartments. The search is initiated by the verbal command "find it". The dog is guided to investigate each compartment of the scent box and encouraged to smell at the hole openings. Initially, the "find it" command is verbalized between each hole. Upon sniffing the hole containing the sample, the dog is immediately rewarded with a well-timed toss of a tennis ball across its visual field followed by verbal praise and ~90 s of play. The dog quickly learns to associate sample detection with the reinforcement of the reward. This maintains a strong motivation level for these high play drive dogs to locate the source of target odors throughout the day. Samples are next hidden at multiple indoor locations, varying height, and degrees of detection difficulty. After 1–2 days, the scent box is again briefly used to teach the dog to sit at the sample prior to receiving the reward. This keeps the dog focused on the scat until the handler can confirm its presence. Scat samples are then gradually hidden over a progressively larger, defined area in the field. Samples are set out in the training area at least several hours prior to any given training session. This allows the scat scent to percolate into the environment and any human scent trail to dissipate. Dogs are introduced to scat from many different individuals of each target species".

After the initial training in Eatonville, the handler (Heath Smith) travelled to the Snake River Birds of Prey area, outside of Kuna, Idaho to reinforce the scat scent training with Pips in natural conditions of high density badger habitat (10 animals per square mile). This training was done for three consecutive days (November 10-12, 2011). Once in San Diego, the canine scent detection team surveyed targeted sites from November 14 to December 14, 2011. The schedule was typically 3 days on with one day off as recommended by Conservation Canines. USGS biologists assisted as orienteers and for data collection. The schedule was based upon the priority level of the site (Appendix 1), ability to obtain access permits, and proximity of locations to each other. On several days, we would survey more than one site in a day, so nearby priority locations were chosen. All routes and detection locations were recorded using a GPS unit attached to the dog. GPS coordinates were taken and pin flags were placed at locations where the dog indicated a scent detection (behavior change, "hit"). After a dog "hit", the handler would state the confidence level in the dog's response as well as the handler's confidence in the dog's response. All scat was collected with gloved hands, placed into a plastic bag, and stored frozen until DNA testing. The orienteer also recorded information on the condition of the scat (color, freshness, and contents), vegetation type, dominant soil type, and took photos of the scat and representative habitat.

Scat DNA Testing

The goal was to identify if scat samples collected in the field were from the American badger. CCB developed a badger specific identification assay that amplifies two American badger specific DNA markers. Four extractions were performed from each scat sample using a modified version of Qiagen DNeasy Tissue kit and performed PCR reactions using the designed primers. The amplified strands were analyzed using a highly sensitive ABI DNA fragment analyzer that measures the alleles precisely using a laser to read fluorescently labeled product against a known DNA standard. Because of the specificity of the assay, all positive results can be interpreted as DNA from the American badger. Negative results should be interpreted as either being from another species or from the scat of an American badger where the DNA was too degraded to amplify in the PCR's.

Results

We surveyed for badger scat across 32 sites within San Diego County and two sites in southern Riverside County (Figure 2, Table 1). Pips had positive behavioral responses to scat at 13 sites. We verified the scat collected to be that of the American badger at twelve sites (Table 1). Site specific maps of survey routes and badger detections are presented in Appendix 2. While we observed potential badger digs at many of the locations, most of the digs were not distinguishable as badger (i.e. no clear badger prints, claw marks, or wide oval shape that is characteristic of badger). We observed badger burrows at only four of the sites (MCB, Camp Pendleton: Juliett and Oscar One, Santa Ysabel Ecological Reserve West, and Warner Springs Ranch. Barry Martin (WTI) also identified an old badger burrow at Santa Ysabel Ecological Reserve East.

The scat DNA assay tested for two badger specific DNA markers. Of the four extractions performed on each of the 46 scat samples, 94% of the verified badger scat tested positive for both markers. For the 30 verified badger scats, the average rate of positive results for each extraction was 55% for Marker #1 and 64% for Marker# 2. Two scat samples tested positive for only one marker, one scat from Marron Valley and the scat from Hollenbeck Canyon. The scat from Hollenbeck Canyon tested positive for Marker #2 for two of the four extractions. Because of the specificity of the assay, a false negative is not possible (unless contaminated).

Badger scats were found on sand/sandy loam soils (MCB, Camp Pendleton, Fallbrook NWS, Santa Rosa Plateau, Santa Ysabel, Daley Ranch, Warner Springs, Crestridge, Marron Valley) and clay loam soils (MCB, Camp Pendleton, Fallbrook NWS, Santa Rosa Plateau, Ramona grasslands, Whelan Lake, Hollenbeck Canyon). Consistent with our search efforts, habitats included floodplains, grasslands, open sage scrub, and oak woodland. The age of badger scats were difficult to determine due to variation in habitat and climate, however, most appeared to be older than several days (dry, crumbly, or moldy). Fresh scat was found in the Santa Rosa Plateau (3 @ Burro Mesa), Fallbrook NWS (1) and Crestridge (1). Potential mammalian prey items recorded from nearby small mammal burrow observations included squirrels, gophers, and kangaroo rats. Most verified badger scats contained a mixture of bone and hair. However, a badger scat containing avocado and grasshoppers was found near an avocado grove in the Crestridge Ecological Reserve and a scat containing insects was found in Marron Valley. One verified badger scat in MCB, Camp Pendleton (Juliett) was found next to a dig with dug out comb structure from a wasp nest. Representative photos of badger sign are presented in Figures 3 to 5. Specific data for all verified badger scats are presented in Appendix 3

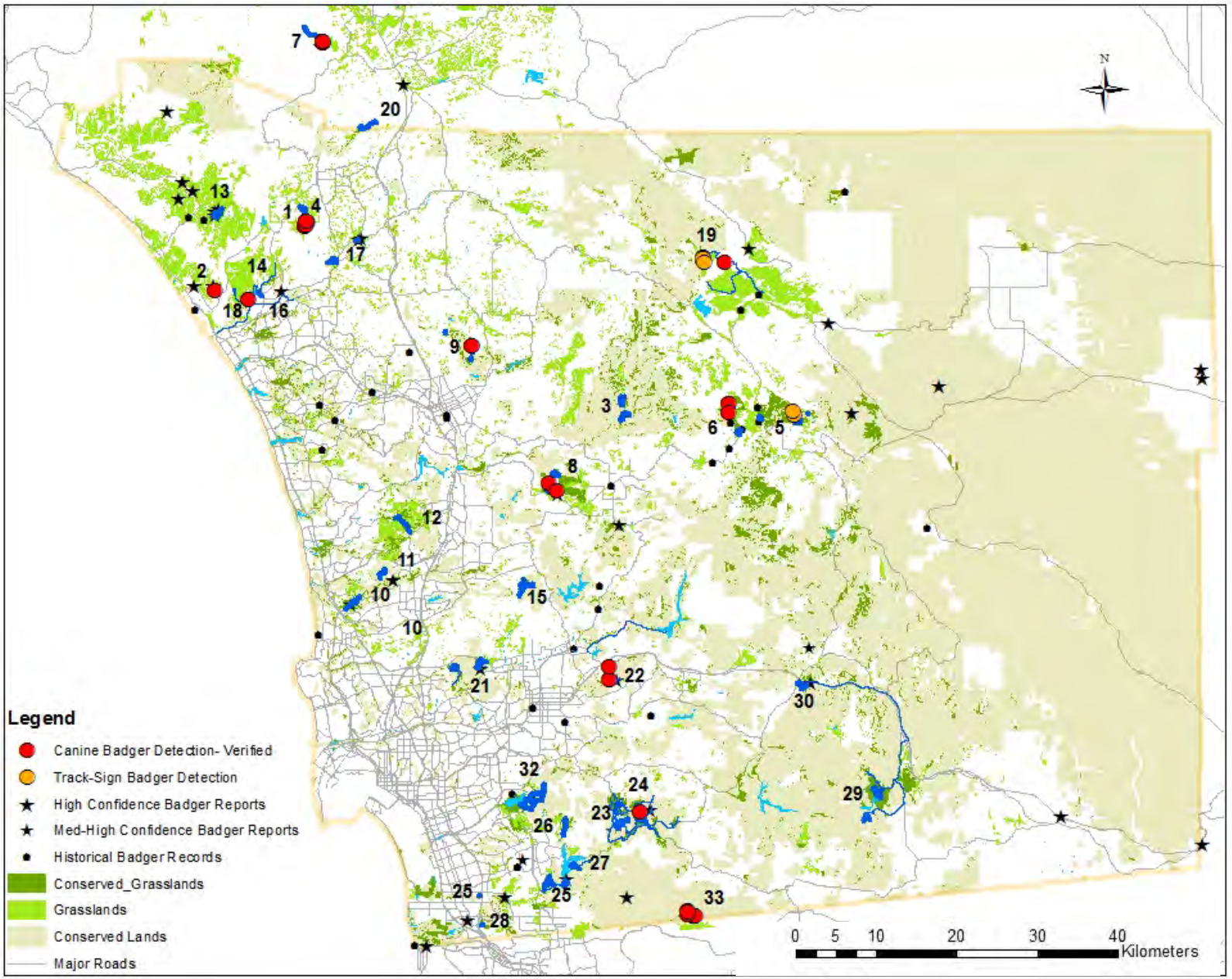

Figure 2. Badger Survey Locations and Detections

Numbers correspond to Site Numbers on Table 1.

TABLE 1: SUMMARY OF AMERICAN BADGER SURVEY EFFORTS

Site	Date	Day	Location	Map	page	Sign Present?	No. "hits"- Scat collected	Positive Badger-DNA test
1	15-Nov	Tuesday	MCB Camp Pendleton: Juliett	A-1,2	p. 19, 20	B, D	8	6
2			MCB Camp Pendleton: Oscar 1	A-1,4	p. 19, 22	B, D	4	1
3	16-Nov	Wednesday	Paumo Valley	A-6	p. 24	-	0	-
4	17-Nov	Thursday	Fallbrook NWS- South	A-1,2	p. 19, 20	D	4	2
5	18-Nov	Friday	Santa Ysabel Ecological Reserve- East	A-7	p. 25	B	0	-
6	20-Nov	Sunday	Santa Ysabel Ecological Reserve-West	A-7	p. 25	B, D	2	2
7	21-Nov	Monday	Santa Rosa Plateau	A-8	p. 26	D	5	3
8	22-Nov	Tuesday	Ramona Grasslands Open Space Preserve	A-9	p. 27	D	5	1
9	23-Nov	Wednesday	Daley Ranch Open Space Preserve- Escondido	A-10	p. 28	D	2	2
10	25-Nov	Friday	Los Penasquitos Canyon Preserve	A-11	p. 29	-	0	-
11			Del Mar Mesa	A-11	p. 29	-	0	-
12			Black Mountain Ranch	A-11	p. 29	-	0	-
13	26-Nov	Saturday	MCB Camp Pendleton: Range 116/117	A-1,3	p. 19, 21	-	0	-
14			MCB Camp Pendleton: Lima/November	A-1,5	p. 19, 23	-	0	-
15	28-Nov	Monday	Sycamore Canyon Open Space Preserve	A-12	p. 30	-	0	-
16	29-Nov	Tuesday	Lower San Luis Rey River	A-1,5	p. 19, 23	-	0	-
17			San Luis Rey River Park	A-1	p. 19	-	0	-
18			Whelan Lake/ Ranch	A-1,5	p. 19, 23	-	1	1
19	30-Nov	Wednesday	Warner Ranch	A-13	p. 31	B, D	1	1
20	1-Dec	Thursday	Santa Margarita Ecological Reserve	A-14	p. 32	-	0	-
21	2-Dec	Friday	Mission Trails Regional Park	A-15	p. 33	-	0	-
22	4-Dec	Sunday	Crestridge Ecological Reserve	A-16	p. 34	D	2	2
23	5-Dec	Monday	Rancho Jamul Ecological Reserve	A-17	p. 35	-	0	-
24	6-Dec	Tuesday	Hollenbeck Canyon Wildlife Area	A-17	p. 35	-	1	1
25	8-Dec	Thursday	Otay Valley / Otay Ranch Preserve	A-18	p. 36	-	0	-
26			Proctor Valley	A-18	p. 36	-	0	-
27	9-Dec	Friday	Otay Lakes Regional Park	A-19	p. 37	-	0	-
28			Furby North Property	A-19	p. 37	B	0	0*
29	11-Dec	Sunday	Lake Morena	A-20	p. 38	D	1	0
30			Roberts Ranch	A-21	p. 39	-	0	-
31	12-Dec	Monday	~~Marron Valley~~ *cancelled Rain*			-	0	-
32	13-Dec	Tuesday	Sweetwater Reservoir	A-22	p. 40	-	0	-
33	14-Dec	Wednesday	Marron Valley	A-23	p. 41	D, Bone	10	8**
							46	30

*scat in front of dug out squirrel burrow collected

**7 scat and 1 bone

B= Burrow

D= Digging

Red font= verified detection

A.

B.

Figure 3. (A) "Old" Badger Scat from MCB, Camp Pendleton; Oscar One and (B) "Medium Age" Badger Scat from Fallbrook NWS.

A.

B.

C.

Figure 4.
(A) "Fresh" Badger Scat from Daley Ranch Containing Hair and Bone;
(B) "Fresh" Badger Scat from Crestridge Ecological Reserve Containing Avocado and Grasshoppers, and
(C) Badger Scat in Marron Valley Next to Dug Out Small Mammal Burrows.

Figure 5. Badger Burrows at (A) MCB, Camp Pendleton; Oscar One with Claw Marks, (B) Warner Springs Ranch, (C&D)“ Santa Ysabel West, (E) Badger Bone Found in Marron Valley, and (F) Dig with Wasp Nest at MCB, Camp Pendleton; Juliett (with badger scat found nearby).

Discussion and Recommendations

In 2011-12, we established that the American badger currently persists within MSCP and MHCP conserved lands, as well as in Department of Defense (DOD) lands in the northern portion of the San Diego County and in Vista Irrigation Lands in the northeastern portion of the County. This suggests that the American badger is a viable species for assessing connectivity of grasslands and uplands. Prior to our surveys, most badger records were recorded from roadkill observations. Because of the wide ranging nature of the species, road mortality is a primary concern for their continued persistence within the County.

With the exception of Marron Valley and Warner Springs Ranch, we did not find significant amounts of identifiable sign (tracks, burrows, digs) in the survey areas. In most cases, the badger scat was not visibly distinguishable from that of other larger carnivores, such as coyote. This reinforced the use of canine scent detection with DNA confirmation as a sensitive and viable method for a countywide survey for the species. However, the lack of sign and age of many of the scat samples also indicated that badgers were not abundant at most sites and that we likely found scat from individuals that had traversed through the sites. This may be due to a reduction of badger activity during the winter months. The lack of burrow observations may also indicate that badgers burrow in other habitats than grasslands within the County. Positive identification of scat at Santa Rosa Plateau and Crestridge were both in scrub and chaparral habitats. In addition, we received a positive sighting of a badger on Otay Mountain in chaparral habitat, while no sign was found during extensive surveys of grassland and sandy soil habitats in Otay Valley.

The badger specific genetic assay was successful in verifying the presence of badger at most of the sites with positive canine scent detections. We recommend that at least three extractions be performed for each scat in order to best ensure that badger scat is identified if present. If the DNA is too degraded, it may result in a false negative. Lake Morena was the only site where Pips had a positive response (to a single scat) that was not verified by the badger DNA assay. Therefore, it is not known if the scat at this site was that of a badger or another species.

We were able to survey all the highest priority sites and many other targeted sites within the short time frame of having the canine scent team. However, there are still a number of sites that we were unable to survey during this period (Appendix 1). These include but are not limited to San Pasqual Valley, Boulder Oaks Ecological Reserve, Marine Corps Air Station (MCAS) Miramar, Kimball Valley, the upper San Diego River Valley, and areas of Otay Mountain.

As a priority for research, telemetry would be used to assess how these animals move among upland habitats and identify significant movement corridors between upland habitats. To identify target areas for future live-trapping and telemetry, we recommend follow-up focused canine scent surveys within several kilometers of badger scat locations identified in 2011, as well as any other verified locations within the County. Specifically, target areas could include grasslands and adjacent natural areas (within 10 kilometers) around the Ramona grasslands, Marron Valley, Crestridge Ecological Reserve, Hollenbeck Canyon Wildlife Area, Santa Ysabel Ecological Reserve, MCB, Camp Pendleton and adjacent Fallbrook NWS, and Warner Springs basin. Focused surveys could be prioritized for NCCP conservation lands within the western portion of the County.

We recommend development of a microsatellite DNA test to further analyze scat to identify individual animals. This would allow us to determine if sign in neighboring natural areas belong to a single animal or multiple animals and would allow for estimation of minimum population sizes in areas with multiple scats.

Radiotelemetry would allow us to learn how badgers move through upland habitats, how they move among habitat patches and where they may frequently need to cross primary roadways. This information should allow us to identify important upland movement corridors in the County and manage for upland connectivity. Because badgers are partly fossorial and have loose skin and a wide neck circumference compared to their head, external transmitters (collars and harnesses) are easily shed and thus radios are typically internally implanted (e.g. Messick & Hornocker 1981, Minta 1993, Hoodicoff 2003, Quinn 2008). However, mortality has been reported in some animals due to rupturing at the surgical site (e.g. Minta 1990) or internal adhesions, abscesses, and bleeding (Quinn 2008). Although this is rare, any telemetry study of badgers should require a thorough review and consideration of available methods and associated risks to minimize the chance of any harm to the study animals.

Therefore, we recommend that a workshop be held to 1) evaluate safe and effective methods of trapping badgers, 2) evaluate methods for attaching transmitters to badgers, 3) assess safety issues regarding the use of internal transmitters, and 4) produce field and laboratory protocols that best ensure the safety and success of badger telemetry.

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