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Research of American Badgers in Western San Diego County, 2014

Prepared for:
California Department of Fish and Wildlife and San Diego Association of Governments

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Western Ecological Research Center

Research Results of American Badgers in Western San Diego County, 2014

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

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WESTERN ECOLOGICAL RESEARCH CENTER

Prepared for:

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Cover photo: B. Heath Smith and Pips (Conservation Canines, University of Washington) and Stacie Hathaway (USGS), surveying for badger scat and sign in Marron Valley, California. (C. Brehme 2014)

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Abstract

Badgers (*Taxidea taxus*) are wide-ranging mid-sized predators known to inhabit San Diego County. They are known to 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 as well as species considered to be at risk of loss from the SDMMP Management Strategic Plan Area (MSPA).

In 2014, we conducted a follow up study to the initial 2011 rapid assessment for the American badger. Our objectives were to identify target areas with potentially higher densities of badgers and to better assess the level of connectivity between known occupied areas. We conducted 30 canine scent surveys for badger scat (15 funded under Natural Community Conservation Plan (NCCP) Local Assistance Grant (LAG) Grant P1282109 and 15 funded by San Diego Association of Governments (SANDAG)) that included genetic testing of scat for species verification. We particularly focused on better characterizing badger activity at sites where fresh sign was found in 2011 and also surveyed suitable priority areas that had not been previously surveyed. From March 31 to May 9, 2014, we surveyed for badger scat and sign across 15 sites within San Diego County. We verified American badger at 8 of the sites (confirmed badger scat at 5 sites and badger burrows at 4 sites).

We also found that many target areas that contained fresh badger sign during our canine scent surveys in 2011 (scat and/or burrows) did not contain fresh badger sign in the spring of 2014. Also in areas where we did find an abundance of fresh sign in May of 2014, badger activity quickly ceased and no further activity was documented through the summer and fall. Therefore, badgers in San Diego County do not appear to have stable populations occupying specific reserve areas but are operating on a larger spatial scale. Although stable populations with smaller home ranges have been documented in some parts of their range, badger home ranges of 35 to 300 km^2 are common in other areas, with size largely determined by availability of dispersed prey, burrowing sites and mates. During our surveys, we noted that badger activity appeared to coincide with high ground squirrel activity.

We also established an outreach effort that included a poster and badger reporting hotline and email. This has been highly successful in providing 13 verified badger locations within the county.

Because of the wide ranging nature of the species, road mortality is a primary concern for their continued persistence within the county. Roadkill has been identified as the largest cause of badger mortality in other parts of their range. The regional management goals for the American badger include increasing connectivity (and reducing potential road mortality) between occupied and suitable habitat areas to allow expansion and movement of the occurrence and to ensure persistence in the MSPA over the long-term. We present an initial assessment of roads of concern within the study area where there may be opportunities to reduce the threat of road mortality and enhance badger connectivity.

We recommend continued sign and camera surveys to inform spatial and temporal use of San Diego habitats by the American badger. This includes greater discovery efforts as well as regularly timed field and camera surveys in areas of known badger occupation or use. This also includes continued outreach and involvement of other biologists, citizen scientists, and the public. Results from these studies should help to better our understanding of badger ecology in the county. They would also better inform the appropriate time(s) and location(s) for capturing badgers in order to conduct any radiotelemetry studies.

Radiotelemetry should allow us to better identify important upland movement corridors in the county and manage for upland connectivity. Because badgers are partly fossorial with thick necks, radios are typically internally implanted. Therefore, we recommend safe and effective methods of trapping and attaching transmitters to badgers be thoroughly reviewed and evaluated to best ensure the safety and success of any badger telemetry efforts prior to commencement of such a study.

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 the effectiveness of 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 as well as a species considered to be at risk of loss from the SDMMP Management Strategic Plan Area (MSPA) (SDMMP 2013)..

In fiscal year 2011-2012, the NCCP LAG program funded an initial study to determine if badgers persisted in the western portion of San Diego County (Brehme et al. 2012). Canine scent surveys were performed in grasslands within MSCP/Multiple Habitat Conservation Program (MHCP) boundaries and nearby areas. Badger presence was detected in Camp Pendleton, Fallbrook Naval Weapons Station, Daley Ranch (northern Escondido), Ramona Grasslands, Crestridge Ecological Reserve, Santa Ysabel Ecological Reserve, Hollenbeck Canyon Wildlife Area, and Marron Valley. Because badgers do persist within the western portion of the county, they are believed to be a suitable species for assessing upland connectivity by means of radio-telemetry.

In order to determine what areas to target badgers for future radiotelemetry studies, our objectives were to identify target areas with potentially higher densities of badgers and to better assess the level of connectivity between known occupied areas. We also were to survey some high priority areas that were not available for investigation during the initial study. In this follow-up study, surveys were not limited to grasslands and an effort was made to find burrow locations, if present, in surrounding scrublands. Fifteen of the 30 surveys, including genetic testing of all scat for species confirmation, were funded under NCCP LAG Grant P1282109 and 15 were funded by San Diego Association of Governments (SANDAG).

In addition, SANDAG funded; 1) an American badger expert, Richard Klafki, R.P. Bio, to consult in our field sign and burrow surveys, the set up and use of hair snares, and share ideas regarding

movement of badgers across our fragmented landscape, 2) deployment of hair snags and infrared cameras in areas where active badger sign was found, and 3) development of a microsatellite genetic assay for individual badgers will be developed by U.S. Geological Survey (USGS) and validated on known samples. This report covers all but the microsatellite assay development, which is still in process and will be presented in a separate report.

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 Wildlife (DFW) 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 DFW 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). To date there is little known about the ecology of the badger in coastal southern California.

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

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".

Once in San Diego, the canine scent detection team surveyed targeted sites from March 31 to May 9, 2014. The schedule was typically 3 days on with one day off as recommended by Conservation Canines. USGS biologists (Cheryl Brehme and Stacie Hathaway) assisted as orienteers and for data collection. On several days, we would survey more than one site in a day. 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.

Badger Sign Surveys

In addition to canine surveys for scat, we also surveyed the landscape for potential badger sign (burrows, digs, and tracks). The surveyor would walk the site while scanning for mounds and burrows. Burrows were measured and confirmed as badger if they were the correct size and shape (approximately 8-12 inches wide and 6-10 inches in height) and contained characteristic horizontal claw marks within the burrow (approximately one inch spacing between claws). Freshness was determined by evidence of loose soil at the entrance indicative of recent digging. Other evidence included body 'drags' and/or tracks observed at the burrow entrance. Older burrows were identified as such if they had new or substantial growth of grasses or forbs at the entrance, there was no evidence of recent digging, or contained evidence of recent squirrel use.

Scat DNA Testing

The goal of scat DNA testing 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 and tested all samples.

The surfaces of all samples were swabbed in duplicate to remove mucosal cells for DNA extraction. DNA on the swabs was extracted using a modified version of Qiagen's DNeasy Tissue DNA extraction kit. These DNA extracts were then PCR amplified three times on the duplicate extracts using two previously developed and validated badger-specific mitochondrial DNA markers, BGR1 and BGR3. Fragments were separated by size using capillary electrophoresis on an ABI 3730 and then visualized and scored using SoftGenetics' GeneMarker software. Negative controls were used throughout each step of the process, and positive controls of known badger DNA and various non-target species were amplified along with experimental samples. 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.

To test for the potential of another animal's urine or contamination of DNA on the exterior surface of the scats, a subset of samples was swabbed on both the interior and exterior of the scats. In addition to amplification with the badger-specific markers, both the interior and exterior swabs of these samples were PCR amplified and digested using primers that amplify mammalian mitochondrial DNA and differentiate numerous species based on a restriction digest enzyme that cuts the amplified DNA into species-specific fragment sizes (Foran et al 1997). A small subset of these samples were also PCR amplified using BGR1, BGR3, COI and ATP6 markers from the mitochondrial genome, and the amplified DNA was sequenced using an ABI 3730 and analyzed using MEGA software.

Hair Snags

When fresh badger burrows were identified at sites where repeat visits were possible, hair snags were placed within the burrow entrances. Hair snags were constructed according to protocol provided by American badger researcher, Richard Klafki (British Columbia), who travelled to San Diego and shared his expertise and methods with the USGS from May 1 to May 6, 2014.

Snags were made from 30 cm (12”) of 2-cm (3/4”) wide metal strapping formed into a ‘D’ (Figure 1). Two 3-inch nails were inserted through holes drilled at the base of the ‘D’ and were used to secure the snag inside the burrow. Three rivets were placed at each edge and middle to secure the strapping in its shape. Two squares (approximately 3-4 cm by 2 cm) of pinned-knaplock (used to anchor carpet in doorways) were riveted to the curved edge of the metal strapping. The teeth of the knaplock were slightly bent down to better force hair into the snag and prevent injury to an animal.

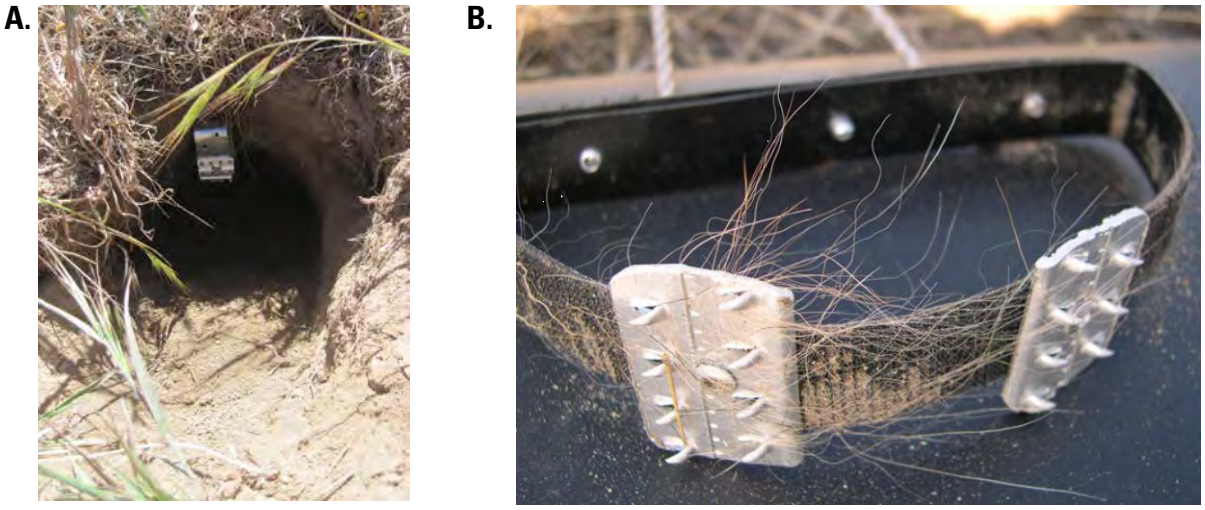

Figure 1. (A) Hair snag in burrow in Volcan Mountain, (B) Close-up of snag with hair provided by Richard Klafki.

Infrared Cameras

Infrared cameras were set near and facing areas with fresh burrows in attempts to document badger activity. Reconyx PC800 HyperFire Professional Semi-Covert IR were set to medium sensitivity for motion detection and automatic time-lapse photo captures every 1 minute.

Outreach Efforts

Outreach efforts to the public and other wildlife professionals are commonly used in order to gain information on badger localities and their spatial and temporal use of habitat (Ministry of Environment Ecosystems 2007). We created and distributed a poster for public and professional outreach for this information in July 2014 (Figure 2). The poster was modified from a version provided to us by Richard Klafki. We distributed the poster to wildlife professionals, land managers, and others, as well as posted to the Western Ecological Research Center and San Diego Monitoring and Management Program websites. Many people kindly forwarded this to others to further the outreach

efforts as well as posted in information kiosks (Figure 2). We also established a "San Diego Badger Hotline" (phone and email) to collect any sighting information.

Figure 2. Badger information outreach poster with hotline information (adapted from version provided by Richard Klafki). Example of poster in kiosk at Barnett Ranch Preserve.

Results

Field Surveys

From March 31 to May 9, 2014, we surveyed for badger scat and sign across 15 reserves/sites within San Diego County (Figure 3, Table 1). We verified American badger at 8 of the sites. We confirmed badger scat at 5 sites (Marron Valley, Otay Wilderness, Crestridge ER, Ramona Grasslands, and Volcan Mountain) and badger burrows at 4 sites (Barnett Ranch, Capitan Grande Reservation, Rancho Guejito, and Volcan Mountain; Table 1). Site-specific maps of survey routes and badger detections are presented in the Appendix.

We first focused on predefined focal areas and where fresh sign was found during our 2011 surveys in order to better characterize badger use of these areas and to locate denning and burrow areas. We extensively surveyed Marron Valley and nearby Otay Wilderness both in grasslands and adjacent scrublands (6 survey days). Although we verified badger scat at four locations in the southern Otay Wilderness and Marron Valley, the scats were largely old and dry and we found no evidence of fresh sign, digs or burrows. Similarly, extensive surveys of Ramona Grasslands (3+ surveys), Santa Ysabel Ecological Reserve (3 surveys), Rancho Jamul (3 surveys), and Hollenbeck Canyon (3 surveys), Crestridge Ecological Reserve, (2 surveys), failed to yield any evidence of fresh sign, although 1-2 older scat were verified as badger in Ramona Grasslands and Crestridge ER.

Therefore, we expanded our surveys in the north to include grassland and adjacent scrubland habitat in Barnett Ranch, Boulder Oaks, Cañada de San Vicente, Rancho Guejito (private land), Capitan Grande Reservation (El Capitan Reservoir), and Volcan Mountain. We found evidence of fresh or recent badger scat and burrows at Barnett Ranch, Rancho Guejito (north), Capitan Grande Reservation (El Capitan Reservoir), and Volcan Mountain. The most sign was found at Volcan Mountain with over 37 badger burrow digs and 12 confirmed badger scat. We installed hair snags in all fresh burrows at Volcan Mountain, Capitan Grande Reservation, and Barnett Ranch as well as infrared cameras at 3 locations in Volcan Mountain and 3 locations in Capitan Grande Reservation (with permission and escort from Barona Tribal Council). Repeat visits (without the canine scent team) were conducted from 1-4 week intervals through late August/early September at these sites to check and reset snags and cameras and to survey for fresh burrows (Table 2). Badger activity ceased in Volcan Mountain and Barnett Ranch by early May. At Capitan Grande Reservation (above El Capitan Reservoir), we found fresh burrows at each visit and recovered a badger hair in one of the snags before ending surveys on

August 28, 2014. No badger photos were recovered at the three locations. Representative photos of badger sign are presented in Figures 4 and 5.

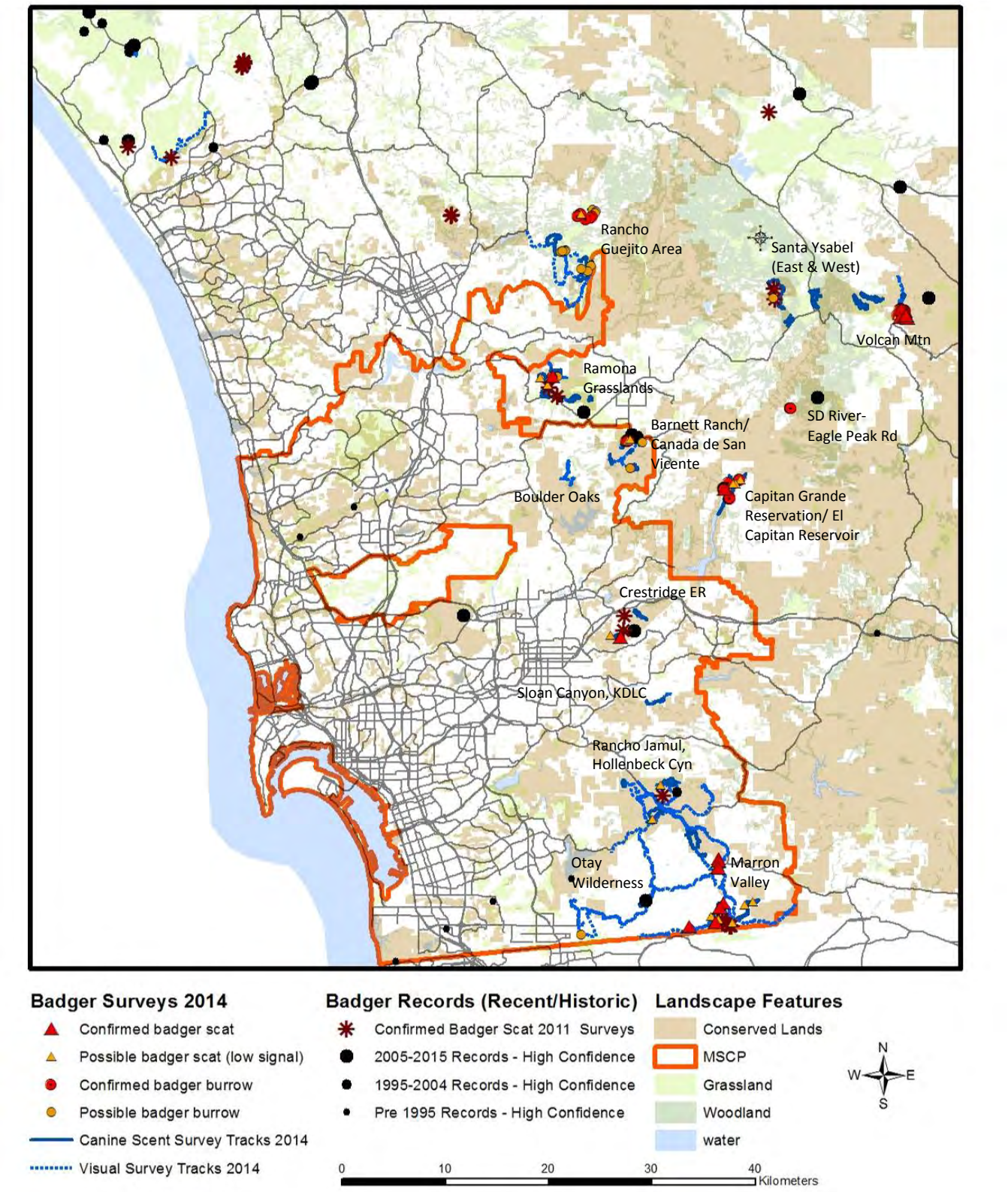

Figure 3. Badger Survey Locations and Detections.

TABLE 1: SUMMARY OF AMERICAN BADGER SURVEY EFFORTS WITH CANINE SCENT TEAM 2014

Date	Survey Day	Contract	Inside MSCP?	Location	Map(s)	Sign Type	Confirmed Badger Burrows	Unconfirmed Burrows	No. "hits"- Scat collected & analyzed	Confirmed Badger Scat- DNA test	Potential Badger Scat- DNA test	Notes
3/31/2014	1	LAG	Y	Marron Valley Cornerstone Lands (central)	A-14/17	S	0	0	10	2	2	Old scat
4/1/2014	2	LAG	Y	Marron Valley Cornerstone Lands	A-14/17	S	0	0	6	0	2	Old scat
			Y	Otay Mountain Wilderness Area	A-14	-						none
4/3/2014	3	LAG	Y	Marron Valley Cornerstone Lands (west)	A-14/17	S	0	0	8	2	2	Old Scat
4/4/2014	4	LAG	Y	Rancho Jamul Ecological Reserve (northeast)	A-14/15	-						none
			Y	Hollenbeck Canyon Wildlife Area	A-14/15	S	0	0	1	0	1	
4/5/2014	5	LAG	Y	Otay Mountain Wilderness Area (Marron Valley Rd)	A-14/16/17	S	0	0	14	5	6	Old & Fresh scat- no other sign
4/7/2014	6	LAG	Y	Marron Valley Cornerstone Lands (east)	A-14/17	S	0	0	6	1	2	Old & Fresh scat- no other sign
4/8/2014	7	LAG	Y	Rancho Jamul Ecological Reserve (southeast)	A-14/15	S	0	0	6	0	1	Old Scat
			Y	Hollenbeck Canyon Wildlife Area	A-14/15	-						none
4/10/2014	8	LAG	Y	Rancho Jamul Ecological Reserve (central)	A-14/15	S	0	0	18	0	5	Old scat
4/11/2014	9	LAG	Y	Marron Valley Cornerstone Lands (east)	A-14/17	S, B	0	1	4	0	1	Old scat
4/12/2014	10	LAG	Y	Crestridge Ecological Reserve	A-13	S, D	0	0	13	2	4	Old scat
4/13/2014	11	LAG	Y	Crestridge Ecological Reserve	A-13	S	0	0	1	0	0	Old scat
			Y	Hollenbeck Canyon Wildlife Area	A-14/15	-						none
4/15/2014	NA	SANDAG	N	Santa Rosa Plateau (Training)	na	-						Pips got sprayed by skunk
4/16/2014	12	LAG	N	Ramona Grasslands Preserve (southwest)	A-5	S	0	0	2	0	1	Old scat
4/17/2014	13	SANDAG	N	Santa Ysabel Ecological Reserve- West	A-8/9	S, D	0	0	2	0	0	Old scat
4/18/2014	14	SANDAG	N	Santa Ysabel Ecological Reserve- East	A-8/10	S	0	0	1	0	0	Old scat-low confidence
			N	Volcan Mountain Preserve	A-8/11	S, D, B	3	0	11	2	2	Burrows and fresh scat
4/19/2014	15	LAG	N	Ramona Grasslands Preserve (northeast)	A-5	S, D	0	0	4	1	1	Some digs and fresh scat
4/22/2014	16	SANDAG	N	Upper San Diego River: Capitan Grande Reservation/ El Capitan Reservoir	A-12	S, D, B	6	0	13	0	4	older digs/burrows and scat
4/23/2014	17	SANDAG	N	Volcan Mountain Preserve	A-8/11	S, D, B	22	0	21	5	5	Many burrows and scat- Simmons flat (some old, mostly fresh)
4/25/2014	18	SANDAG	N	Santa Ysabel Ecological Reserve- West	A-8/9	S	0	0	5	0	0	Old scat
4/26/2014	19	SANDAG	N	Ramona Grasslands Preserve (south)	A-5	S	0	1	9	0	1	Old scat
4/28/2014	20	LAG	Y	Boulder Oaks Preserve	A-7	-						none
			Y	Barnett Ranch Preserve	A-6	S, B	3	3	7	0	2	Old scat
4/29/2014	21	LAG	Y	Cañada de San Vicente	A-6	S, D	0	0	5	0	0	Old scat
5/2/2014		SANDAG		*Badger Workshop Presentations/ Snag construction*		NA						none
5/3/2014	23	SANDAG	N	Volcan Mountain Preserve	A-8/11	-						Revisit- No recent activity, installed snags (2), cam (1), RK confirmed sign
			N	Ramona Grasslands Preserve	A-5	-						Revisit- No recent activity
5/4/2014	24	SANDAG	Y	Barnett Ranch Preserve	A-6	-						snags (4), RK confirmed sign
5/5/2014	25	SANDAG	N	Rancho Guejito (south)	A-4	PB	0	5	0	0	0	Old burrows only- recently grazed
5/6/2014	26	SANDAG	N	Rancho Guejito (north)	A-4	B, D, S	9	7	6	0	1	Burrows/scat in north grasslands- not recently grazed, RK confirmed sign
5/8/2014	27	SANDAG	N	Volcan Mountain Preserve	A-8/11	B, S	12	0	18	5	3	fresh burrows- south side of mountain
5/9/2014	28	SANDAG	Y	Sloan Canyon, Kumeyaay Diegueño Land Conservancy		-						none
5/10/2014	29	LAG		Pips sick		NA						
5/11/2014	30	SANDAG		Pips sick		NA						

B= Burrow, S= Scat, D= Digs, PB= Possible Burrow

Red Font= Confirmed Badger Sign

Figure 4. Badger Scat from (A) Ramona Grasslands (with Pips), (B) Crestridge Ecological Preserve, (C) Otay Wilderness (piece with gopher skull), (D) Marron Valley (between 2 large rocks), (E&F) Volcan Mountain Preserve.

A.

B.

C.

D.

E.

F.

Figure 5. Badger burrows at (A&B) Volcan Mountain Preserve, (C) Barnett Ranch, (D) Rancho Guejito, (E) Definitive claw marks in burrow, (F) Badger hair captured in snag in Capitan Grande Reservation

TABLE 2: SUMMARY OF BADGER REPEAT SURVEY EFFORTS (WITHOUT CANINE SCENT TEAM) 2014

Upper San Diego River: Capitan Grande Reservation/ El Capitan Reservoir	7/15/2014	Fresh burrows	Added Snags/ Cams
	8/5/2014	Fresh burrows	Added/Checked Snags/ Cams
	8/28/2014	Fresh burrows	Checked/ Removed Snags/ Cams- Recovered Badger Hair from Snag
Volcan Mountain	4/23/2014	Fresh burrows	
	5/3/2014	Fresh burrows	Added Snags/ Cams
	5/8/2014	Fresh burrows	Added/Checked Snags/ Cams
	5/23/2014	No fresh sign	Checked Snags/ Cams
	6/20/2014	No fresh sign	Checked Snags/ Cams
	7/17/2014	No fresh sign	Checked Snags/ Cams
	9/5/2014	No fresh sign	Checked Snags/ Cams
Barnett Ranch	4/28/2014	Recent burrows/not fresh	
	5/8/2014	No fresh sign	Added Snags
	5/23/2014	No fresh sign	Checked Snags
	6/20/2014	No fresh sign	Checked Snags
	7/17/2014	No fresh sign	Checked Snags
	9/5/2014	No fresh sign	Checked Snags
Eagle Peak Road	9/5/2014	Recent burrows/not fresh	Added Snags (follow up monitoring SD River Park Foundation)

funded by SANDAG

Genetic Testing of Scat for Species Identification

Out of the 203 potential badger scats that were collected and analyzed over the surveys, 26 of them were confirmed as badger with medium or high confidence~~,~~ and 46 additional samples were identified as potential badger. The samples identified as potential badger remain unconfirmed due to low signal. The remaining samples did not yield DNA fragments specific to badger, either because of low DNA quantity or quality or because the sample was from a non-target species.

The majority of samples that amplified as badger with the badger-specific markers also amplified as badger with the PCR-RFLP method and/or sequencing results. However, there were some instances of mixed species results where the inside or outside swabs amplified for both badger and coyote or skunk as an example. These results combined with the notes taken in the field and physical characteristics of the scats indicate that there is territorial urination or "marking") occurring in the field where other species may mark on top of badger scat or vice

versa. In instances where badger DNA is present along with another species' DNA, we can only conclude that badger was on the sample, but not that the scat itself is of badger origin.

Outreach Efforts

Since distribution of the poster and establishment of the hotline in July 2014, we have received over 20 phone reports and 34 email reports from biologists and citizens in San Diego County and adjacent Orange and Riverside Counties. Many reports included photos or very specific descriptions. Although we were not able to verify many reports or confirm they were of other species, we verified 13 of these records as badger with high confidence. Within San Diego County, these included records from Daley Ranch, I 76, Upper San Diego River (Eagle Peak Area), Wildcat Canyon Road (roadkill), McCain Valley, and the Anza Borrego desert. Along with the SDMMP, we continue to maintain a database of badger records that is much larger and more comprehensive than what was known prior to the onset of our badger research program.

Discussion and Recommendations

In 2011-12, we established that the American badger occupied some conserved lands within MSCP and MHCP, as well as other portions of the county. This suggested that the American badger is a viable species for assessing connectivity of grasslands and uplands.

As a priority for research, telemetry is a preferred method to assess how these animals move among upland habitats and identify significant movement corridors between upland habitats. Live-trapping badgers for telemetry is typically conducted by placing a snare or other live-trap in front of an active burrow and capturing the animals upon exiting (i.e. Ministry of Environment Ecosystems 2007, Quinn 2008, Klafki 2014). Baited traps are reported to be ineffective in luring the American badger and have not been adopted by badger researchers due to the potential of attracting other carnivores that may compete or harass badgers (Ministry of Environment Ecosystems 2007, Richard Klafki pers. comm). Our goal was to identify and characterize targeted areas with higher badger density or activity and gather necessary information to support future capture efforts. This included estimating relative abundance in specific areas and characterizing badger use of the landscape for foraging and denning among target population sites.

We did not find core population sites for badgers in San Diego County. We found that many target areas that contained fresh badger sign during our canine scent surveys in 2011 (scat and/or burrows) did not contain fresh badger sign in the spring of 2014. In areas where we did find an abundance of fresh sign in May of 2014 (i.e. Volcan Mountain, Barnett Ranch), we found that badger activity quickly ceased and no further activity was documented through the summer and fall of 2014. Therefore, badgers in San Diego County are operating on a larger spatial scale and do not appear to have stable populations occupying specific reserve areas. Although stable populations with smaller home ranges have been documented in some parts of their range, badger home ranges of 35 to 300 km^2 are common in other areas, with size largely determined by availability of dispersed prey, burrowing sites and mates (i.e. Lindzey 1978, Minta 1993, Hoodicoff 2003, Klafki 2014). However, we did find variable but sustained badger activity from May to August within five square kilometers of the Capitan Grande Reservation (based upon 4 visits).

During our surveys, it appeared that badger activity coincided with high squirrel activity. This was particularly evident at Volcan Mountain. During our initial visits when there was fresh badger activity, we also noted abundant squirrel burrows and above ground activity. When badger activity ceased by mid-May, there was a marked and notable decrease in squirrel burrows and activity to almost nothing. This is consistent with the hypothesis that the badgers' home ranges in the study area are dependent upon spatially and temporally variable prey resources (i.e. Hoodicoff 2003). It is currently unknown whether badgers may consistently frequent individual reserve areas during specific times of the year or if specific areas may be preferred for birthing and raising kits.

Abundance of badgers cannot be determined based upon the number of burrows, digs, or scat because a single badger can dig many burrows in a single day (Ministry of Environment Ecosystems 2007). Therefore, abundance must be determined based upon genetic methods, identification of individuals from infrared camera surveys or night survey transects. The USGS is currently investigating the use of microsatellite markers to identify individuals from hair and scat. These results will be presented in a separate upcoming report in 2015. The collection of badger hair samples has proven to be difficult due to low capture probabilities. This is because it is necessary to identify and snag burrows that are *currently occupied* by badgers to collect hair samples. Although hairs may be occasionally found at burrow entrances, we did not find loose hairs at entrances during our study. Finding occupied burrows is challenging as badgers can dig

many burrows in a single day and may not stay within a single burrow for long. Canine scent detection is superior in detecting badger scat because of its' increased sensitivity, the fact that most scat is not easily identifiable by biologists due to highly variable size and shape, and that badger scat is often located away from identifiable digs and burrows (also see Brehme et al 2012). However, there is a lag between collection of scat and genetic confirmation of scat as badger. In 2014, the lag was 10 months due to troubleshooting and refinement of the assay. Since these methods have been optimized by the Center for Conservation Biology (UW), future efforts should have a shorter lag time. Regular searches for badger burrows and camera monitoring along with badger siting reports may be a better method for establishing real-time use of any area for any future live-trapping efforts, while canine scent surveys are an important tool for discovery of badger use areas and collection of scat for genetic testing. Canine surveys for live animals (vs. scat) and use of bait for attracting badgers may also be worthy of investigation (although baiting is not recommended for use in badger studies as previously noted).

We are starting to get a clearer picture of badger use and use areas within the western portion of the county, although there is much to be learned about badger ecology in this region. This includes investigation into if there are annual patterns in badger spatial and temporal use of these habitats, if squirrel (or other small mammal) activity is a predictor of badger use patterns, if there are prime denning areas used for birthing and raising kits, and if the denning areas are more likely to be located in grasslands or thicker scrub and chaparral habitats. Our searches of scrub and chaparral habitats adjacent to grasslands in Marron Valley, Otay Wilderness, and Crestridge Ecological Reserve failed to yield badger burrow locations. More thorough field searches may be fruitful, although live-capture with radiotelemetry may better allow us to answer these questions.

Prior to our surveys in 2011, most badger records in this region 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. Roadkill has been identified as the largest cause of badger mortality in other parts of their range (i.e. Hoodicoff 2007, Klafki 2014). The regional management goals for the American badger include increasing connectivity (and reducing potential road mortality) between occupied and suitable habitat areas to allow expansion and movement of the occurrence and to ensure persistence in the MSPA over the long-term (SDMMP 2012). The growing badger location data within the county has given us a preliminary idea of areas of concern for badger connectivity (Figure 6). For instance, the connection between the upper San Diego River valley and Crestridge Ecological Reserve to the

south is dependent upon crossing the I8 at Peutz Valley Road, a major wildlife choke point previously (and more recently) identified to require extensive improvement in order to be a functional linkage (Figure 7; Rochester et al. 2011). The connection between the upper San Diego River valley and the Barnett Ranch/ Canada de San Vicente areas to the west would require successful crossing of Wildcat Canyon Road of which there was also a recent badger roadkill report (Karen Miner, pers comm.; Figure 7). The connection between the upper San Diego River valley and Santa Ysabel and Volcan Mountain to the north would require successful crossing of I78 and I79 (Figure 8). Other preliminary roads of concern for badgers in the study area are I 76, San Vicente Road, I94, Otay Lakes and Honey Springs Roads, and Basilone Road. This is a very preliminary badger connectivity assessment and requires further study, however, suggested improvements of these wildlife linkage areas would benefit many wildlife species.

We recommend continued studies to inform spatial and temporal use of San Diego habitats by the American badger. This includes greater discovery efforts as well as regularly timed field and camera surveys in areas of known badger occupation or use (Ministry of Environment Ecosystems 2007). This also includes continued outreach and involvement of other biologists, citizen scientists, and the public. Results from these studies should help to better our understanding of badger ecology in the county. They would also better inform the appropriate time(s) and location(s) for capturing badgers in order to conduct any radiotelemetry studies.

As discussed in our previous report (Brehme et al 2012), radiotelemetry would help us to understand 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 better 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 (Messick & Hornocker 1981, Minta 1993, Hoodicoff 2003, Quinn 2008). However, mortality has been reported in some animals due to rupturing at the surgical site (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 safe and effective methods of trapping and attaching transmitters badgers be very thoroughly reviewed and evaluated to best ensure the safety and success of any badger telemetry efforts prior to commencement of such a study.

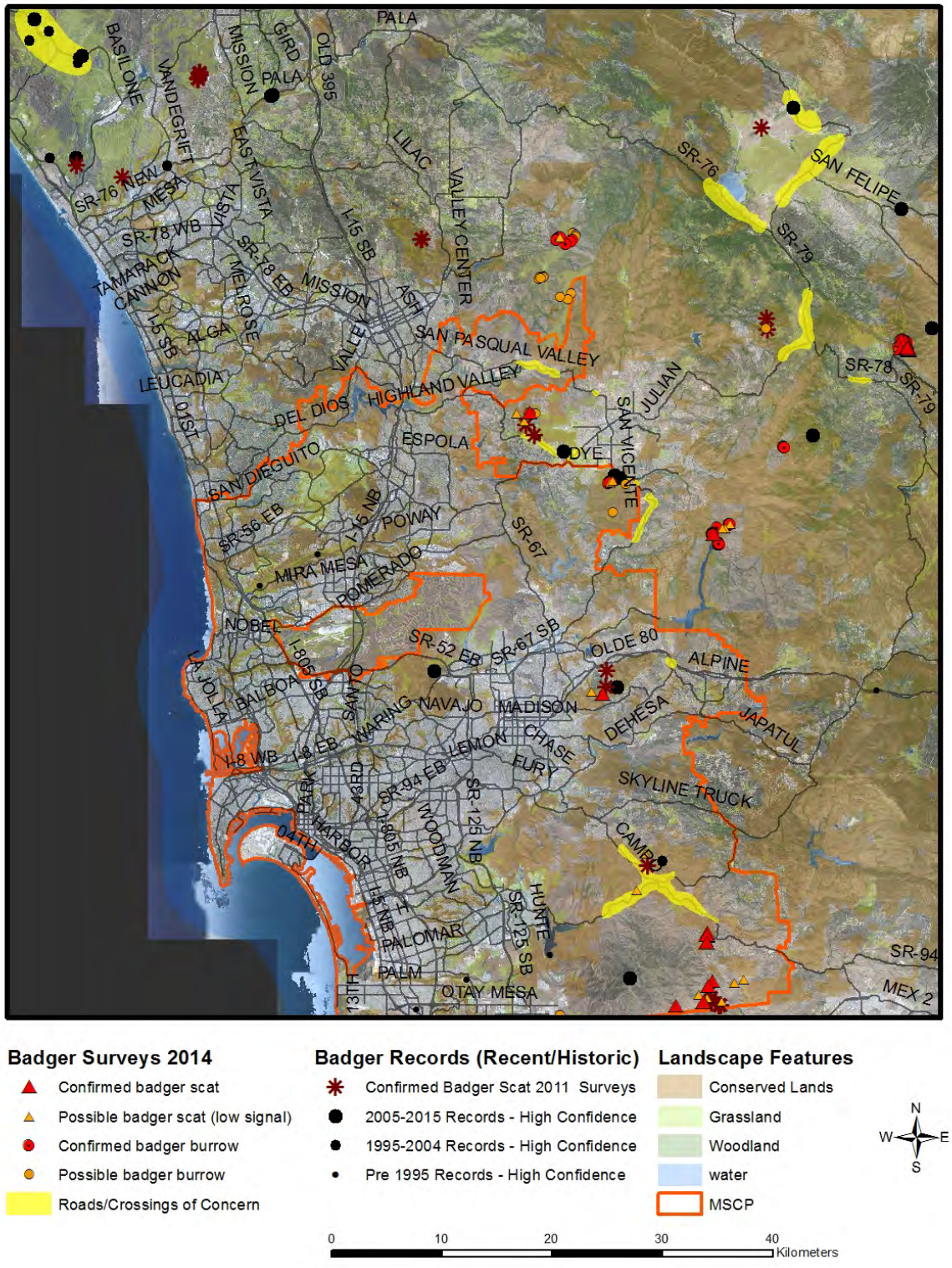

Figure 6. Preliminary Road Crossing Areas of Concern to Maintain Badger Connectivity-Western San Diego County

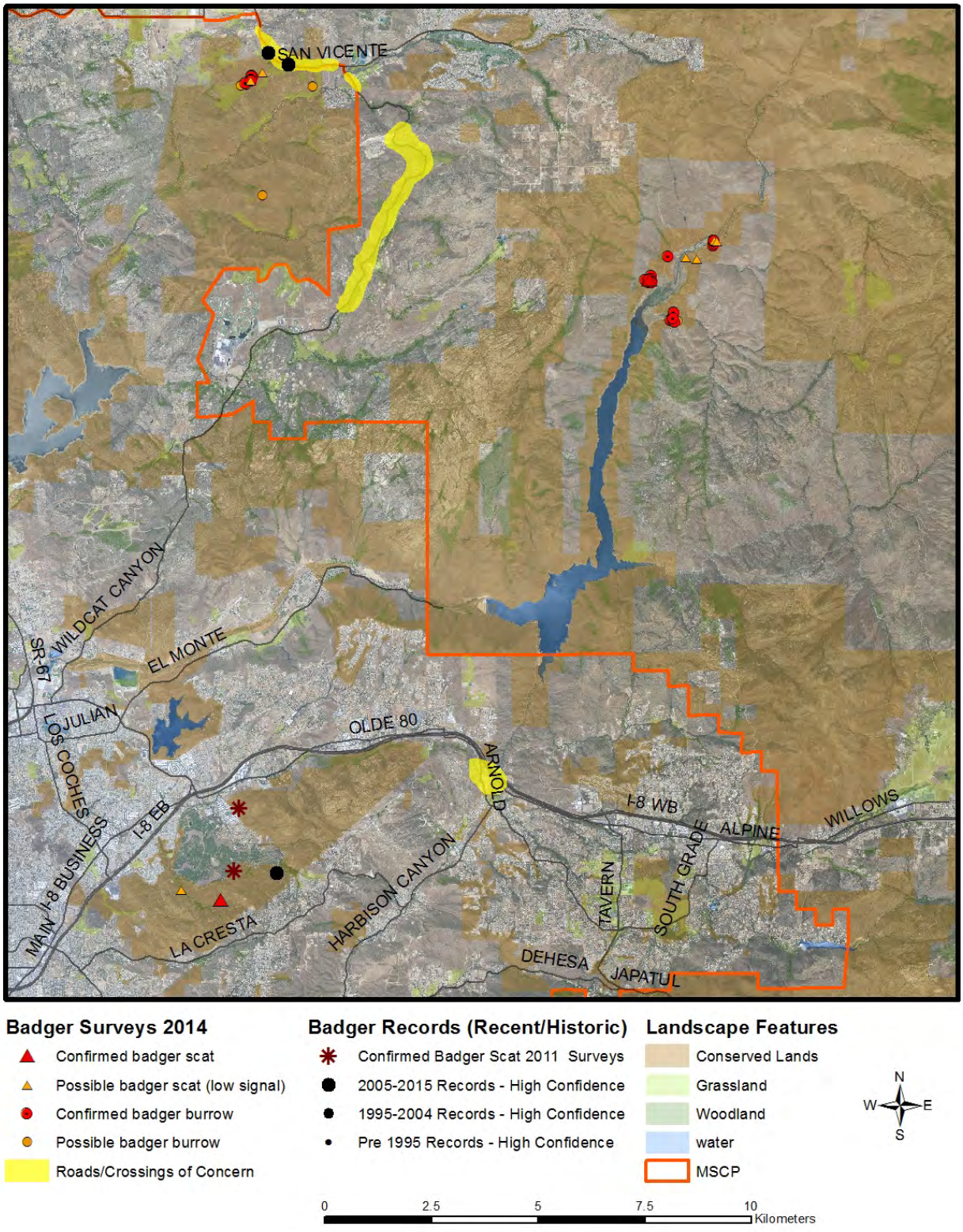

Figure 7. Preliminary Road Crossing Areas of Concern to Maintain Badger Connectivity-I8 and Wildcat Canyon Road

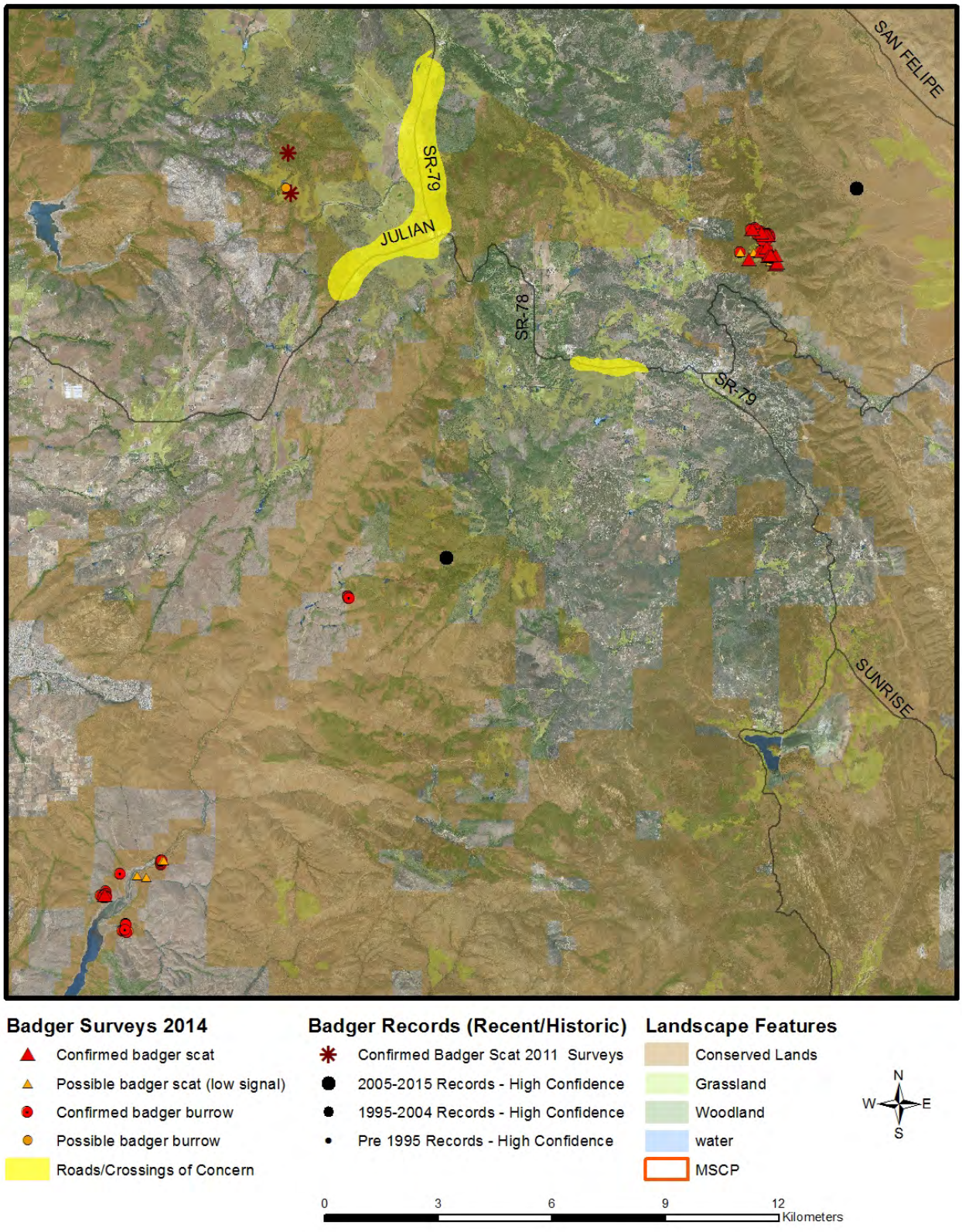

Figure 8. Preliminary Road Crossing Areas of Concern to Maintain Badger Connectivity-I78 and I79.

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