Western Riverside County
Multiple Species Habitat Conservation Plan (MSHCP)
Biological Monitoring Program

Carnivore Survey Report 2009

23 April 2010

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NOTE TO READER:

This report is an account of survey activities conducted by the Biological Monitoring Program for the Western Riverside County Multiple Species Habitat Conservation Plan (MSHCP). The MSHCP was permitted in June 2004. The Monitoring Program monitors the distribution and status of the 146 Covered Species within the Conservation Area to provide information to Permittees, land managers, the public, and the Wildlife Agencies (i.e., the California Department of Fish and Game and the U.S. Fish and Wildlife Service). Monitoring Program activities are guided by the MSHCP species objectives for each Covered Species, the information needs identified in MSHCP Section 5.3 or elsewhere in the document, and the information needs of the Permittees.

MSHCP reserve assembly is ongoing and it is expected to take 20 or more years to assemble the final Conservation Area. The Conservation Area includes lands acquired for conservation under the terms of the MSHCP and other lands that have conservation value in the Plan Area (called public or quasi-public lands in the MSHCP). In this report, the term "Conservation Area" refers to the Conservation Area as understood by the Monitoring Program at the time the surveys were planned and conducted.

We would like to thank and acknowledge the land managers in the MSHCP Plan Area, who in the interest of conservation and stewardship facilitate Monitoring Program activities on the lands for which they are responsible. A list of the lands where data collection activities were conducted in 2009 is included in Section 7.0 of the Western Riverside County Regional Conservation Authority (RCA) Annual Report to the Wildlife Agencies. Partnering organizations and individuals contributing data to our projects are acknowledged in the text of appropriate reports.

While we have made every effort to accurately represent our data and results, it should be recognized that data management and analysis are ongoing activities. Any reader wishing to make further use of the information or data provided in this report should contact the Monitoring Program to ensure that they have access to the best available or most current data.

The primary preparer of this report was the 2009, Lead Biologist, Bill Kronland. If there are any questions about the information provided in this report, please contact the Monitoring Program Administrator. If you have questions about the MSHCP, please contact the Executive Director of the RCA. Further information on the MSHCP and the RCA can be found at www.wrc-rca.org.

Contact Information:

Executive Director
Western Riverside County
Regional Conservation Authority
4080 Lemon Street, 12th Floor
P.O. Box 1667
Riverside, CA 92502-1667
Ph: (951) 955-9700

Western Riverside County MSHCP
Monitoring Program Administrator
c/o Adam Malisch
4500 Glenwood Drive, Bldg. C
Riverside, CA 92501
Ph: (951) 782-4238

INTRODUCTION

Species objectives for mammalian carnivores covered by the Western Riverside County Multiple Species Habitat Conservation Plan (MSHCP) call for the maintenance of habitat conservation cores and linkages that provide an effective means of dispersal (Dudek & Associates 2003) (Appendix A). Presence of covered carnivores, as measured once every 8 years, must be maintained on at least 75% of locations identified in individual species accounts as specified by Section 5.0 of the MSHCP (Dudek & Associates 2003). We began surveying for bobcat *(Felis rufus*), mountain lion *(Puma concolor*), coyote (*Canis latrans*), and long-tailed weasel (*Mustela frenata*) in 2008 using 3 methods of remote detection: scent-station, scat, and camera-station surveys. We used results from our 2008 effort to modify survey design in 2009.

Monitoring carnivore populations is difficult due to elusiveness and large home ranges of many species. Remote-detection surveys (e.g., scent stations) offer an inexpensive alternative to more invasive methods (e.g., radio collars), and can provide an effective means of measuring carnivore presence/absence (Roughton and Sweeney 1982, Gompper et al. 2006). These methods often record detections as track imprints (scent station) or digital images (camera station) of animals visiting individual stations that are often baited with a scent lure. Scat surveys are another means of detecting carnivore occurrence that does not require direct observation of the animal.

We implemented scent-station, scat, and camera-station surveys in 2008 to document occurrence of covered carnivore species in the northern portion of the MSHCP Plan Area. We conducted scent-station and scat surveys on transects placed along secondary roads and trails (2 to 10 stations per transect, 480-m spacing between stations), and targeted habitat linkages and freeway undercrossings with camera-station surveys. Scent stations were very effective at detecting coyote, with a cumulative detection probability that approached 1. In contrast, cumulative detection probability for bobcat was much lower than 1, and we could not infer species absence based on lack of detection. We were also unable to collect enough long-tailed weasel observations for meaningful analysis, and did not observe mountain lion sign along transects. Lack of detections for target species (except coyote) likely reflected our survey design rather than true absence because our efforts targeted roads and foot trails, and did not record animals that may have been present on game trails or in drainages. We also found that short transects (i.e., < 1 km) were more efficient than longer transects, and allowed for larger overall sample sizes.

Scat surveys added little to our understanding of carnivore presence/absence in 2008, and we detected only 2 of 4 Covered Species (bobcat and coyote) with this survey technique. We also did not record bobcat scat in the Santa Ana Mountains where the species was most often detected with scent stations. Moreover, scat was often difficult to identify and largely depended on what the animal had eaten, the size of the individual, and age of the sample.

Camera stations worked well in recording presence of bobcat and coyote in linkages targeted in 2008, but we only detected 1 mountain lion on a single occasion (Bogart County Park; 11 April 2008). We subjectively placed camera stations in portions of corridors that appeared most likely to be used by dispersing carnivores (e.g., drainages, game trails). Still, our coverage was by no means complete, and we could not imply absence from our lack of mountain lion detections. We were also unable to determine if target species were using freeway undercrossings because we did not have access to bridges and culverts. Moreover, our camera station survey design was effective at recording images, but failed to prevent the theft of 2 cameras.

We focused our 2009 transect-survey effort in the Anza-Cahuilla Valley and Vail Lake-Wilson Valley-Aguanga habitat blocks in a continued effort to determine if species-specific objectives for covered carnivores were being met. We modified our survey design to address weaknesses of our 2008 effort by shortening transects and expanding our area of inference to include off-road drainages as well as secondary roads. This allowed us to efficiently survey a greater proportion of the landscape than we had sampled in 2008. We did not conduct scat surveys, but did record presence of animal sign (e.g., tracks) from target species detected while traveling between scent stations within a transect. Our goals were to document presence/absence of covered carnivores, and to compare detection probabilities using scent stations versus walking transects, and along roads versus drainages.

We also distributed camera stations at undercrossings of the I-15 and I-10 freeways to confirm movement of target species across these potential dispersal barriers. We modified our camera-station design to better deter the theft by encasing each unit in a steel box and attaching them to fixed objects with chain. Moreover, we documented presence of covered carnivores by conducting opportunistic area searches in linkages too small for more rigorous transect-based presence/absence surveys. Specifically, our goals and objectives in 2009 were as follows:

Goals and Objectives

1. Document presence/absence of covered carnivores in Anza-Cahuilla Valley and Vail Lake-Wilson Valley-Aguanga habitat blocks.
    a. Record presence/absence of target species at scent stations and along transects
    b. Calculate encounter rates and detection probabilities for target species.

2. Compare survey methods for determining presence/absence of covered carnivores.
    a. Compare detection probabilities and encounter rates derived from transects placed along off-road drainages versus secondary roads for target species.
    b. Compare detection probabilities and encounter rates derived from scent stations and walking transects for target species.

3. Document use of freeway undercrossings by covered carnivore species where dispersal corridors are bisected.

   a. Install motion-triggered cameras (infrared flash) under bridges along the I-15 and I-10 freeways.
   b. Deter theft by encasing cameras in steel boxes and securing them with steel chain.

4. Document presence of covered carnivores at MSHCP-defined habitat linkages too small for rigorous presence/absence surveys.
   a. Record presence of animal sign from covered carnivore species.

METHODS

Transect Surveys

We conducted transect surveys (scent-station and walking surveys) across the Anza-Cahuilla Valley (Existing Core L and Proposed Core 6) and Vail Lake-Wilson Valley-Aguanga (Proposed Core 7) habitat blocks from 26 January to 19 March 2009. Surveys in the Anza-Cahuilla Valley were performed on lands managed by Bureau of Land Management (BLM), Anza-Borrego Desert State Park (ABDSP), and the Regional Conservation Authority (RCA). The Anza-Cahuilla Valley survey area (11,852 ha) spanned east-west from Table Mountain to Tule Creek, and north-south from Durasno Valley (i.e., Silverado Ranch) to the San Diego County line (Figure 1). Roughly 86% (10,154 ha) of vegetation within the survey area was composed of red-shank (*Adenostoma sparsifolium*) and mixed chaparral (*Cercocarpus betuloides*, *Adenostoma* spp., *Quercus* spp.), with approximately 13% (1582 ha) being a mix of annual grassland and coastal sage scrub. There were approximately 104 km of drainages and 70 km of secondary roads in the Anza-Cahuilla Valley survey area. Most drainages were composed of either chaparral (72.1 km) or coastal sage scrub (17.8 km), but riparian (5.9 km), grassland (3.6 km), and oak woodland (4.0 km) vegetation types were also present. Roads mostly passed through chaparral (54.6 km), coastal sage scrub (9.4 km), and annual grassland (5 km), with only about 1 km crossing or running through drainages. Roads were also either seldom-traveled unpaved routes, or jeep trails through remote areas, including the proposed Beauty Mountain Wilderness Area.

The Vail Lake-Wilson Valley-Aguanga habitat block was less remote than the Anza-Cahuilla Valley survey area, with 56.6 km of unpaved roads and 29.4 km of drainages. We defined a survey area (5570 ha) that extended east-west from CA-371 to Oak Mountain, and north-south from Tucalota Creek to Aguanga (Figure 2). Approximately 50% (2807 ha) of vegetation within the survey area was composed of red-shank and mixed chaparral, with coastal sage scrub accounting for 44% (2439 ha). Grassland, oak woodland, and riparian vegetation types were also present, and covered a combined 5% (262 ha) of the survey area. Most roads (38.8 km) were behind locked gates on lands managed by the RCA or Center for Natural Lands Management (CNLM), with the remaining routes being BLM or county roads that were open to the general public. Some RCA lands experienced occasional motor-vehicle traffic despite the presence of gates due to illegal trespass of off-highway vehicle users. Roads typically

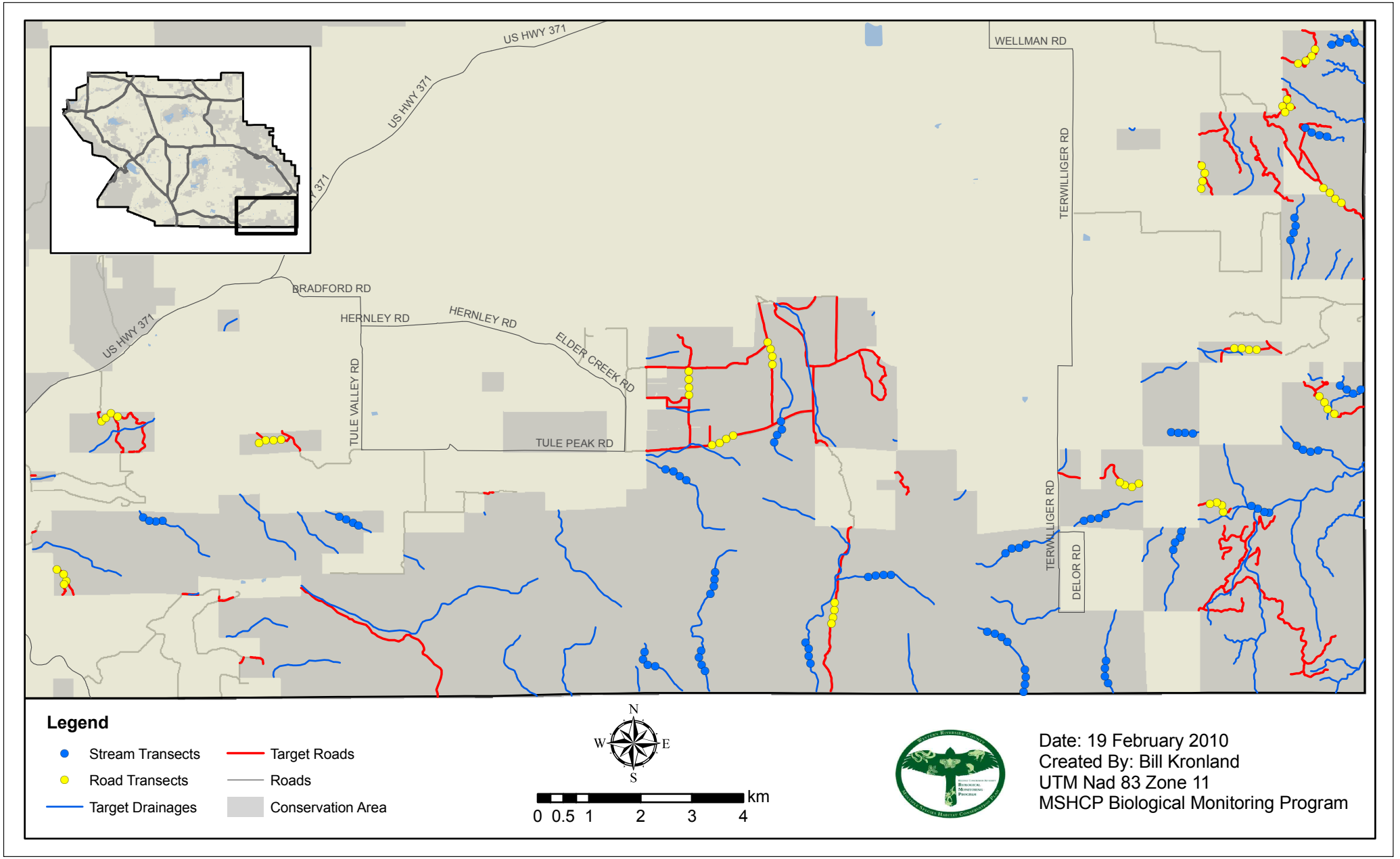

Figure 1. Location of scent-station transects distributed across roads and drainages in the Anza-Cahuilla Habitat Block (Existing Core L and Proposed Core 6).

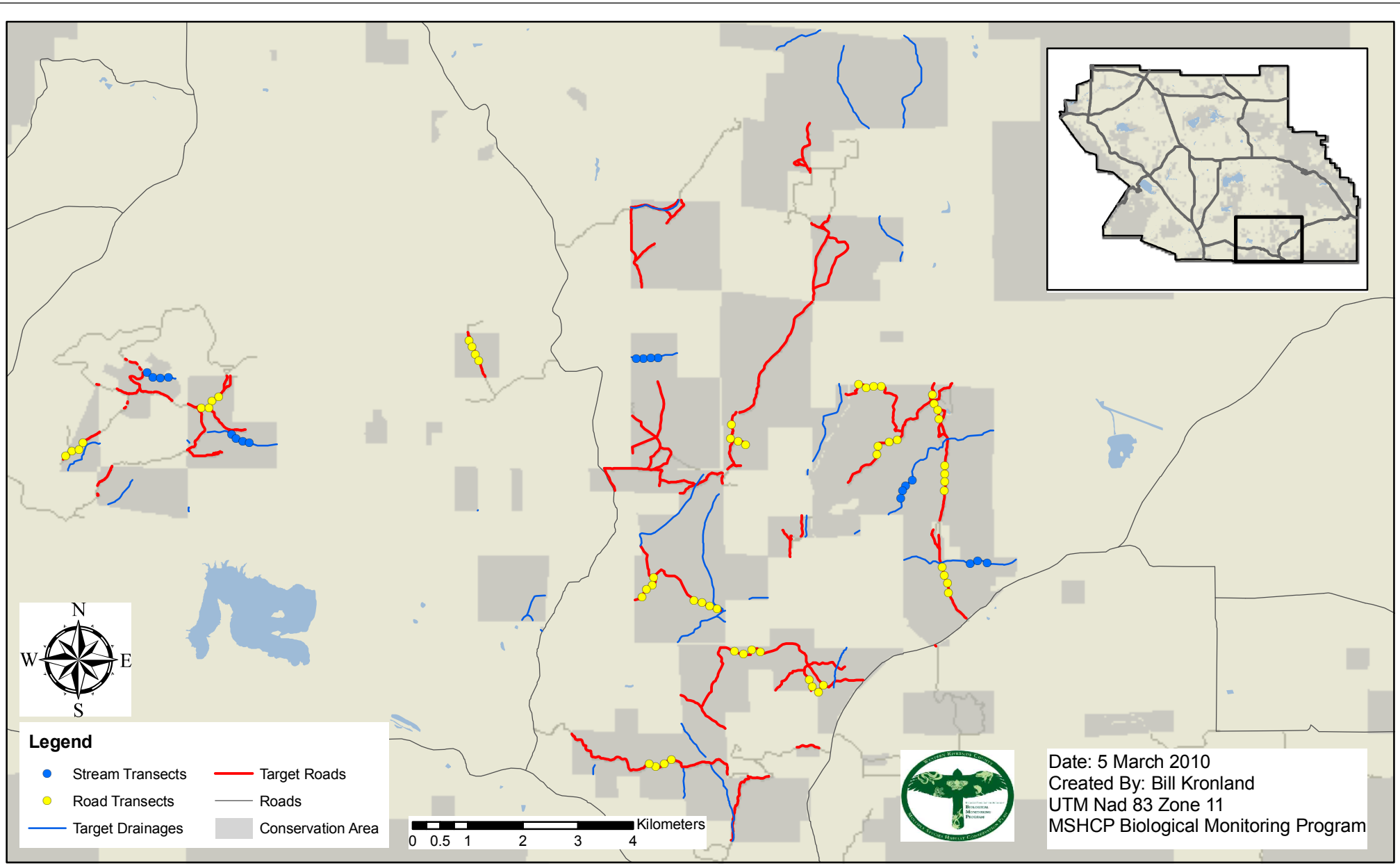

Figure 2. Location of scent-station transects distributed across roads and drainages in the Vail Lake-Wilson Valley-Aguanga Habitat Block (Proposed Core 7).

passed through coastal sage scrub (31.4 km), chaparral (21.9 km), and annual grassland (2.2 km), with < 1 km crossing or running through drainages. Most drainages flowed through coastal sage scrub (9.5 km), riparian (8.8 km), and chaparral (6.9 km) vegetation, but oak woodlands (3 km) also occurred.

Survey Design

We selected survey transects by first creating a 10-m buffer around drainages and secondary roads in each habitat block using Arc GIS v 9.1 Geographic Information System (GIS) software (ESRI 2006). We then distributed random points within the 10-m buffer using the Hawth's Tools extension (Beyer 2004), and maintained a minimum distance of 1000 m between points. We extended a 450-m transect from each point along the drainage or road, choosing direction based on a random coin toss (e.g., heads = north or east; tails = south or west) unless the result extended the transect outside of conserved lands. We also selectively maintained a minimum spacing of 500 m between transects to preserve sample independence and coverage across survey areas.

Roads and drainages occurred at different densities within and between habitat blocks. We initially maintained a sampling density of 1 transect per 3.5 km of roads and drainages, thus standardizing our effort between survey type (road vs. drainage) and habitat blocks. We were unable to sample a portion of off-road drainage transects because of their distance from roads, rough terrain, and the travel time between the survey area and our Riverside office. Our actual survey effort was 1 transect per 4 to 6 km of roads and drainages, with 37 transects at Anza-Cahuilla Valley (road: $n = 15$; drainage: $n = 22$) and 19 transects at Vail Lake-Wilson Valley-Aguanga (road: $n = 14$; drainage: $n = 5$).

Field Procedure

Availability of furloughed state vehicles limited our access to field sites in 2009, so we surveyed each transect daily over a 3-day period (Tuesday to Thursday) following their initial set-up on Monday. We also sampled each survey area over multiple weeks because we were unable to visit every transect during a single 3-day period. We surveyed the Anza-Cahuilla Valley area over 4 weeks from 26 January to 5 March, beginning in the east at Table Mountain and finishing near Tule Creek in the west. We surveyed the Vail Lake-Wilson Valley-Aguanga area over 3 weeks from 9 to 19 March, beginning near CA-371 in the east and working westward to Oak Mountain.

We placed 4 scent stations along each transect at 150-m intervals and 1 m off of roads or drainage channels, and marked them with flagging tape tied to vegetation no closer than 10 m from each station to avoid distracting animals from visiting the site. Scent stations consisted of a Fatty Acid Scent (FAS) lure (USDA Pocatello Supply Depot, Pocatello, Idaho) placed at the center of a 1-m-diameter track plate made of moistened sand (screened and washed, Paragon Building Products, Inc., Norco, California). Scent lures attracted carnivores in the immediate vicinity of scent stations, and their tracks were recorded in the moistened sand. We identified the species of origin for each print recorded, and assigned an ID certainty (1 = 100% certain, clean print; 2 =

85% certain, rough print; 3 = can not identify print with any certainty). We also recorded the length (cm) and width (cm) of tracks made by Covered Species or difficult-to-identify prints. We then reset stations after each check by smoothing remoistened sand with a plastering trowel and replacing FAS lures as needed. We removed scent lures and dispersed sand from each station on the final day of surveying (i.e., Thursday).

We also noted the presence of target species on transects by recording sign (e.g., tracks, scat) detected while walking between scent stations. Each animal sign was identified to species of origin and type, and assigned an ID certainty. We also recorded the length (cm) and width (cm) of tracks from each target species, and measured stride (cm) and straddle (cm) of mountain lion prints whenever possible. We recorded only the first sign detected on each transect per target species per visit, and removed all animal sign (e.g., rubbed out tracks, tossed scat) as we walked between stations.

Field personnel collected data after completing a 1-week training exercise led by experienced Biological Monitoring Program staff. The training included in-office presentations and field excursions that focused on recognizing animal sign and identifying species of origin. Trainings also covered protocol implementation and use of Global Positioning System (GPS) units. Crew members demonstrated proficiency in identifying animal sign through a quiz administered by Biological Monitoring Program staff, and were able to recognize sign from at least 13 mammal species (4 Covered Species) after completing training (Table 1).

Table 1. Biological Monitoring Program staff that conducted carnivore surveys in 2009.

Name	Funding Source	Position
Bill Kronland	Regional Conservation Authority	Lead Biologist
Ariana Malone	Regional Conservation Authority	Field Biologist
Betsy Dionne	Regional Conservation Authority	Field Biologist
Ana Hernandez	Regional Conservation Authority	Field Biologist
Conan Guard	Regional Conservation Authority	Field Biologist
Espie Sandoval	Regional Conservation Authority	Field Biologist
Jonathan Reinig	Regional Conservation Authority	Field Biologist
Mike Zerwekh	Regional Conservation Authority	Field Biologist
Ryann Loomis	Regional Conservation Authority	Field Biologist

Data Analysis

We estimated cumulative detection probabilities (P^*) that compared transect type (i.e., roads versus drainages) and method (i.e., scent stations versus walking transects) for each target species. We only included track detections with an ID certainty of 1 or 2, and discarded scat observations from our analysis because of their associated uncertainty of identification. We also pooled data across survey blocks because detections at Vail Lake-Wilson Valley-Aguanga habitat block were too few regardless of species to derive separate estimates.

We estimated the percent of transects used ($\hat{\psi}$) by coyote according to type (i.e., road vs. drainage), and analyzed datasets consisting of scent-station detections and

observations made while walking transects separately. We did not estimate $\hat{\psi}$ for other target species because detections were too few on 1 or both transect types and across methods to estimate this parameter. We derived estimates using Program MARK to construct a set of candidate models that examined the effect of survey type (e.g., road vs. drainage) on nightly detection probability (p) and $\hat{\psi}$ (White and Burnham 1999). The candidate set was based on a general closed-capture occupancy model that accounts for animals present, but not detected (MacKenzie et al. 2006). We then ranked candidate models according to Akaike's Information Criterion for small samples (AICc), calculated Akaike weights (w_i), and derived weighted-average estimates for p and ψ across the entire candidate set unless a single model showed clear support (i.e., $w_i > 0.9$) (Burnham and Anderson 2002). We calculated P^* using model-averaged estimates of p and the following formula where p_i is the detection probability on a given survey night: $P^* = 1 - \prod_{i=1}^{3} 1 - p_i$. Variances for P^* were calculated using the delta method (MacKenzie et al. 2006, Powell 2007).

Finally, we calculated an encounter rate for each species as a means of comparing the availability of animals on each transect type for a given method. We defined encounter rate as total detections divided by total observation days (product of transects surveyed and number of visits per transect).

Camera Stations

We operated 14 motion-triggered camera stations non-concurrently at 9 locations in 2009, and targeted carnivore corridors and potential dispersal barriers (e.g., freeway crossings) within corridors and cores (Figure 3). We conducted surveys year-round and continuous with our 2008 effort with some modifications in camera placement. We deployed new stations under the I-10 crossing of San Gorgonio Wash (n = 2), and under bridges along I-15 at Horsethief Wash (n = 1; Proposed Constrained Linkage 5, Proposed Linkage 1) and Pechanga/Temecula Creek (n = 1; Constrained Linkage 14). We repositioned stations midway through 2009 at Indian Wash (n = 1; Proposed Constrained Linkage 3) and Gavilan Wash (n = 1; Proposed Core 2) to sit directly under I-15 overcrossings of those drainages, and moved a camera near Calimesa (n = 1, Proposed Constrained Linkage 23) about 200 m to better monitor a water seep. We also removed a camera from Chino Hills State Park at Green River (n = 1, Proposed Constrained Linkage 2) because the U.S. Geological Survey (USGS) was concurrently conducting extensive surveys of carnivore dispersal in the area. We continued to operate cameras from 2008 along CA-79 in Lamb Canyon (n = 2; Proposed Core 3) and Walker Canyon near Gavilan Wash (n =1; Proposed Core 2).

We modified our 2008 camera-station design to address the increased threat of vandalism and theft of units placed under bridges. We encased each camera in a metal box (24 cm x 15 cm x 10.5 cm) made with 1/8-in steel, and with an opening cut into the front (Figure 4). We attached each box to a 4 in x 4 in wood post buried in the ground at

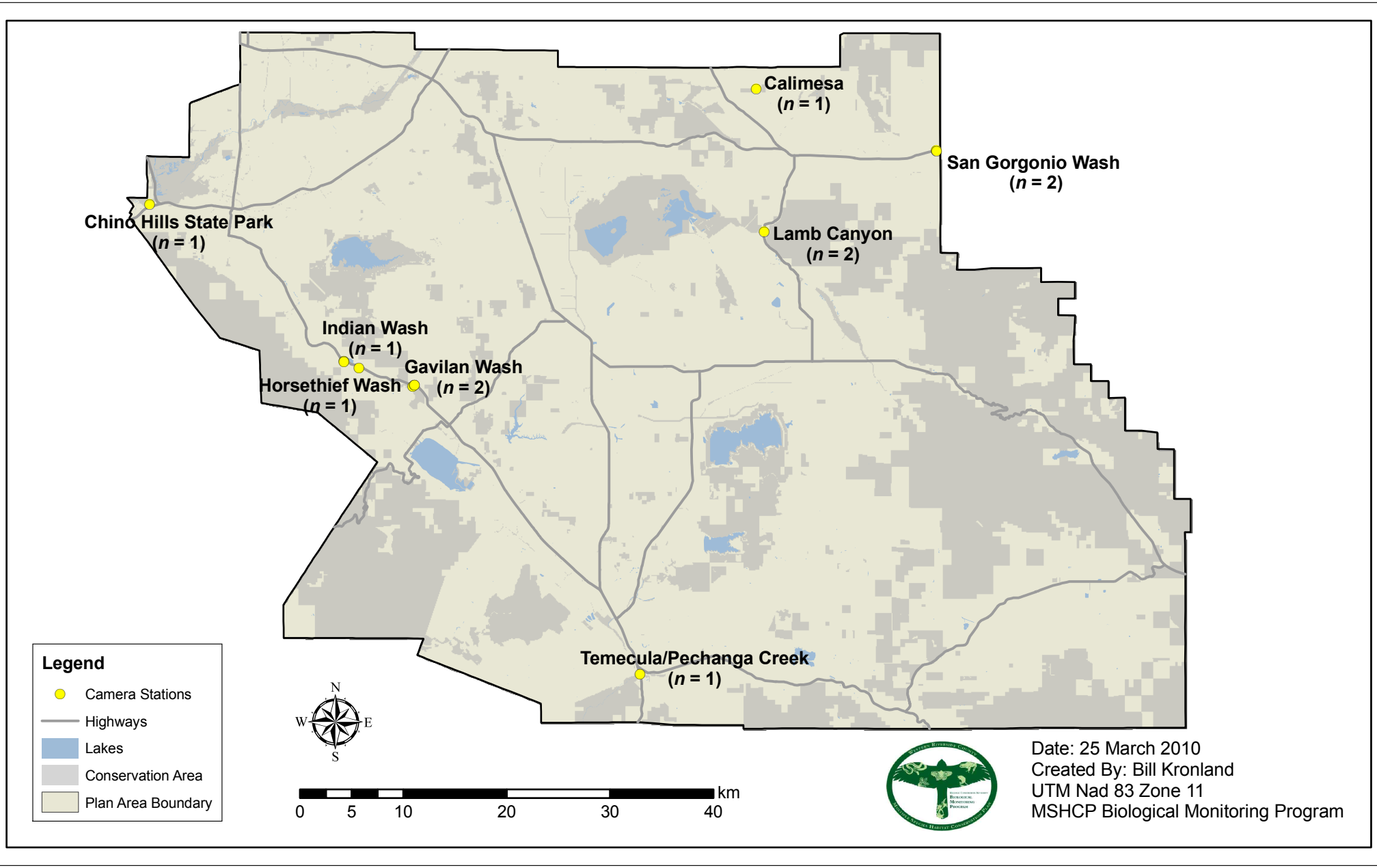

Figure 3. Sites monitored with camera stations and number of cameras (*n*) operated at each location.

least 60 cm deep, positioning cameras on wood posts so that motion/heat sensor sat 46 cm off the ground. We then secured the steel boxes and wood posts to fixed objects (e.g., boulder, tree) with padlocks and ¼-in steel chain. We did not use steel boxes or chain for camera stations deployed in areas other than bridges because of the associated material cost; rather, we secured cameras to fixed objects with 3/8-in coated cable and concealed them with burlap (Figure 4).

Figure 4. Camera station designs for units placed under bridges with steel box and chain(A), and cameras deployed without steel box and concealed with burlap (B).

We used Cuddeback Expert Digital Scouting cameras (Non Typical, Inc., Park Falls Wisconsin) equipped with either an infrared or incandescent flash for recording images at night. We used infrared flash on units placed under bridges to reduce the likelihood of distracting motorists or discouraging wildlife from using the corridor. We programmed cameras to operate 24 hours/day and to record a single high-resolution digital image (2048 x 1536 pixels) after being triggered. Each photo-capture event was followed by a 1-minute delay to avoid recording multiple images of a single visit, or repeated photos of non-target movement (e.g., shadows, vegetation movement). Each image included the date and time when it was recorded, and the camera station location.

We selectively installed cameras at locations that maximized coverage of bridge underpasses, or captured landscape features most likely to be used by carnivores (e.g., game trails, drainages). We allowed human users of bridge undercrossings to become accustomed to the presence of camera stations by initially installing empty steel boxes chained to fixed objects, then returning after 2 to 3 weeks to add camera units and began recording data. We did not use an initiation period for stations placed away from freeway undercrossings, and began recording data on the day of installation. Motion/heat sensor sensitivity on each camera, regardless of station placement, was initially set to 'high', then adjusted 2 to 4 days later to a lower setting if many blank or non-target images (e.g., movement of shadows, shifting vegetation) were being recorded. We checked cameras on a 21-day cycle once motion/heat sensor sensitivity was adjusted appropriately, thus allowing human scent to dissipate from the site between visits (Séquin et al. 2007). We switched out Compact Flash Cards (2 gigabyte), changed batteries when < 50% power,

cut back vegetation, and maintained the general condition of camera stations on each visit.

Habitat Linkage Surveys

A number of MSHCP-defined habitat linkages are too small or incomplete to survey with a rigorous presence/absence sampling design. We opportunistically conducted presence-only surveys in December 2009 in 9 of 15 habitat linkages defined by Species Objective 2 for coyote (Table 2). We visited as many conserved parcels within each linkage as possible, and searched trails, drainage channels, or any other landscape feature conducive to animal dispersal for covered carnivore sign. We searched each parcel for 15 to 90 minutes, depending on area and how quickly we detected sign. We recorded the species of origin and location (UTM waypoint) for covered-carnivore sign detected, and measured the length, width, and, when possible, stride and straddle of each track. Each parcel was visited once, and lack of detection should not be interpreted as evidence of absence.

Incidental Observations

We opportunistically recorded presence of covered-carnivore species throughout 2009 across the MSHCP Plan Area during non-target surveys. We also collaborated with regional biologists and land managers to collect reliable observations made across the Plan Area by non- Monitoring Program staff. Incidental observations represent evidence of presence only, and lack of detections in any given area should not be interpreted as evidence of absence.

Table 2. Parcels surveyed with area searches in 9 habitat linkages defined for coyote.

Linkage	Parcel
Arroyo Seco	Cleveland National Forest, in Arroyo Seco adjacent to Dripping Springs Campground
Murrieta Creek	Riverside County Flood Control, Murrietta Creek joins Santa Margarita River. Riverside Conty Flood Control, about 1 km north of Rancho California Road. Riverside County Flood Control, about 1 km north of Winchester Road.
Warm Springs Creek	Riverside County Parks, Winchester 700 parcel west of CA-79
Warm Springs Creek (French Valley Trib.)	Regional Conservation Authority, 600 m north of intersection of Thompson Road and Winchester Road.
San Jacinto River	Riverside County Parks, about 500 m southeast of Gilman Springs Road bridge.
Temecula Creek	City of Temecula, 1 km east of County Road 16
Tucalota Creek	Mitigation Lands, about 500m north of Murrieta Hot Springs Road.
Tule Creek	Regional Conservation Authority, just east of Happy Valley Road.
Wilson Creek	Regional Conservation Authority, about 500 m north of Cahuilla Creek tributary.

RESULTS

Transect Surveys

We distributed 224 scent stations across 25.2 km of secondary roads (29 transects) and off-road drainages (27 transects). Our total survey effort was 80 and 76 observation days for road and drainage transects respectively. Coyotes accounted for the greatest number of transects used by a target species (n = 39), followed by long-tailed weasel (n = 21), bobcat (n = 12), and mountain lion (n = 2). We detected coyote, long-tailed weasel, and bobcat on transects surveyed at both habitat blocks, but only recorded mountain lion at Anza-Cahuilla Valley (Table 3). We also detected gray fox (*Urocyon cinereoargenteus*), domestic dog (*Canis lupus familiaris*), cottontail (*Sylvilagus* spp.), hare (*Lepus* spp.), California ground squirrel (*Spermophilus beecheyi*), striped skunk (*Mephitis mephitis*), black-tailed deer (*Odocoileus hemionus*) and raccoon (*Procyon lotor*)(Appendix B).

Table 3. Number of transects used by 4 carnivore species surveyed on lands in the Anza-Cahuilla Valley and Vail Lake-Wilson Valley-Aguanga regions of western Riverside County.

	Bobcat	Coyote	Long-tailed Weasel	Mountain Lion
Anza-Cahuilla Valley				
Anza-Borrego Desert State Park (n = 15)	6	10	6	2
Bureau of Land Management (n = 15)	4	7	5	-
Regional Conservation Authority (n = 7)	-	7	5	-
Vail Lake-Wilson Valley-Aguanga				-
Bureau of Land Management (n = 4)	1	4	1	-
Center for Natural Lands Management (n = 2)	-	1	1	-
Regional Conservation Authority (n = 13)	1	10	3	-
TOTAL	12	39	21	2

We calculated encounter rates and P^* for all target species except mountain lion because sample size was too small for meaningful analysis of this species (Appendix C). Detections of bobcat at scent stations (n = 3) were also too few to calculate encounter rates or estimates of P^* based on this method. In general, detection probabilities and encounter rates were low for all target species regardless of survey method or transect placement (Table 4). We had the greatest success detecting coyote over any other target species (scent stations: P^* = 0.87), but still did not achieve a probability that approached 1. Coyotes were also the most common species encountered, especially while walking road transects (encounter rate = 0.36, SE = 0.05). There was no significant difference in coyote use of road versus drainage transects, and estimates varied slightly between those based on scent stations (road: $\hat{\psi}$ = 0.49, SE = 0.1; drainage: $\hat{\psi}$ = 0.41, SE = 0.09) and walking transects (road: $\hat{\psi}$ = 0.74, SE = 0.11; drainage: $\hat{\psi}$ = 0.71, SE = 0.12).

Long-tailed weasel was the only species that was encountered more often and had a greater probability of being detected with scent stations rather than by walking transects. In contrast, both mountain lion observations and all but 3 bobcat detections

were recorded when walking transects, and scent stations were largely ineffective in detecting these species. We also only detected mountain lion along drainage transects. Encounter rates and *P** did not differ significantly between methods for coyote, and did not differ significantly between transect type for any of the 4 target species.

Table 4. Number of transects(*n*), encounter rates (SE) and cumulative detection probabilities (SE) for bobcat, coyote, and long-tailed weasel detected on drainage and road transects using 2 survey methods (scent station vs. walking transects).

	Scent Stations		Walking Transects	
	Drainage	**Road**	**Drainage**	**Road**
Transects used[a]				
Bobcat (*n* = 12)	3	-	7	3
Coyote (*n* =39)	8	14	13	18
Long-tailed weasel (*n* =21)	8	13	-	-
Mountain lion	-	-	2	-
Encounter Rate[b]				
Bobcat	-	-	0.11 (0.04)	0.05 (0.02)
Coyote	0.2 (0.05)	0.28 (0.05)	0.22 (0.05)	0.36 (0.05)
Long-tailed weasel	0.11 (0.04)	0.19 (0.04)	-	-
Cumulative Detection				
Bobcat	-	-	0.44 (0.16)	0.38 (0.12)
Coyote	0.87 (0.05)	0.87 (0.04)	0.77 (0.09)	0.86 (0.06)
Long-tailed weasel	0.34 (0.07)	0.42 (0.7)	-	-

[a] animals were detected with both survey methods on some transects.
[b] encounter rate = number of detections / total survey days (number of transects * visits per transect).

Camera Stations

We surveyed 9 locations with 14 camera stations for a total of 2312 camera nights in 2009. Eight of the 14 stations were not in continuous operation during periods of intended use, and a total of 316 camera nights were not surveyed because of battery failure, scheduled checks being missed, or failure to turn cameras on after routine maintenance (Appendix D). We lost 1 camera to theft (Indian Wash), and another was burned in a wildfire east of CA-79 in Lamb Canyon. None of our cameras encased in steel boxes were stolen or vandalized.

Coyote was the most common species photo-captured in 2009 (*n* = 386), and we detected them at every surveyed location except the culvert opening east of CA-79 in Lamb Canyon (Table 5). We also regularly captured bobcat (*n* = 123), but did not detect the species at the I-10 crossings of San Gorgonio Wash, or the culvert opening east of CA-79 in Lamb Canyon. We did not detect bobcat at the I-15 crossing of Pechanga/Temecula Creek, but we only surveyed this site for 9 nights at the end of December. We did not photo-capture mountain lion or long-tailed weasel at any camera-station in 2009. Black-tailed deer were the most common non-target species detected (*n* = 94), followed by humans (*n* = 88). We were unable to identify 33 photo-captured animals because of image quality. None of the unidentifiable images were the size of mountain lion, and most were likely medium-sized canines.

Table 5. Images recorded per species with motion-heat triggered cameras at 9 locations.

		Species[a]					
Site	**Camera**	**CALA**	**LYRU**	**PRLO**	**MEME**	**URCI**	**VUVU**
I-15							
Indian Wash	1	17	3	-	-	-	-
	2[b]	40	4	-	-	-	-
Horsethief Wash	1[b]	29	7	11	1	-	1
Walker Canyon	1	118	66	1	-	-	-
Gavilan Wash	1	6	1	-	-	-	-
	2[b]	7	15	-	-	-	-
Pechanga/Temecula Creek	1[b]	7	-	-	-	-	-
CA-74							
Lamb Canyon	east	-	-	-	-	-	-
	west	8	18	-	2	7	-
I-10							
San Gorgonio Wash	1[b]	2	-	-	-	-	-
	2[b]	-	-	-	-	-	-
Constrained Linkage 23							
Calimesa	1	46	4		3	-	-
	2	9	3	-	-	-	-
Constrained Linkage 2							
Chino Hills State Park	1	97	2	5	-	-	-
	TOTAL	386	123	17	6	8	1

[a] CALA = coyote; LYRU = bobcat; PRLO = raccoon; MEME = striped skunk; URCI = gray fox; VUVU = red fox

[b] Cameras were placed directly under freeway overcrossings.

Table 5. Continued

Site	Camera	Species[a] CLFA	SYAU	ODHE	CORA	HOSA	UNNK
I-15							
Indian Wash	1	-	-	-	-	1	-
	2[b]	9	-	-	-	2	8
Horsethief Wash	1[b]	2	-	-	-	11	4
Walker Canyon	1	1	2	6	-		3
Gavilan Wash	1	2	-	-	-	14	
	2[b]	8	-	-	-	39	2
Pechanga/Temecula Creek	1[b]	-	-	-	-	4	1
CA-74							
Lamb Canyon	east	-	-	-	-	3	-
	west	-	1	-	-	1	2
I-10							
San Gorgonio Wash	1[b]	-	-	-	-	2	4
	2[b]	-	-	-	-	4	
Constrained Linkage 23							
Calimesa	1	-	-	79	17	1	7
	2	-	-	9	-	4	
Constrained Linkage 2							
Chino Hills State Park	1	-	9	-	-	2	2
	TOTAL	22	12	94	17	88	33

[a] CLFA = domestic dog; SYAU = desert cottontail; ODHE = black-tailed deer; CORA = common raven; HOSA = human; UNNK = unknown

[b] Cameras were placed directly under freeway overcrossings.

Habitat-Linkage Surveys

We recorded coyote tracks and/or scat in all parcels surveyed with area searches in 2009 (n = 11). We also recorded bobcat tracks adjacent to Dripping Springs Campground in Arroyo Seco Creek.

Incidental Observations

We recorded incidental observations of bobcat (n = 6) and coyote (n = 11), but not long-tailed weasel and mountain lion in 2009 (Appendix E). We observed bobcat at the Multi-species Reserve near Lake Skinner during early morning raptor surveys (Existing Core J), at Lake Perris State Park during night surveys for banded gecko (Existing Core H), and along the Santa Ana River at Hidden Valley County Park and the Rubidoux Nature Center during bird surveys (Existing Core A). We also recorded a set of well-defined tracks on the Santa Rosa Plateau. The Center for Natural Lands Management photo-captured bobcat on a number of occasions in 2009 at Johnson Ranch (Existing Core J) (*Kim Klementowski*, *Center for Natural Lands Management, personal communication*), and the US Geological Survey (*Lisa Lyren, personal observation*) observed collared bobcat and coyote using undercrossings of CA-91 at Green River (Proposed Constrained Linkage 2) up until the beginning of a lane expansion project in the area. We also incidentally observed coyote at Chino Hills State Park near the Green River Golf Course, Lake Perris Sate Park, SJWA (Existing Core H), Diamond Valley Lake (Existing Core J), Lake Skinner, Agua-Tibia Wilderness (Existing Core M), and the Tenaja Corridor (Proposed Linkage 9).

Orange County Water District staff at the Prado Basin (Existing Core A) observed a long-tailed weasel in June 2009 entering a riparian area dominated by black willow and *Arundo* (*David McMichael*, *Orange County Water District, personal observation*), and the Center for Natural Lands Management photo-captured an individual in August 2009 near an artificial-burrow entrance installed for burrowing owl (*Athene cunicularia hypugaea*) conservation on Johnson Ranch (*Kim Klementowski*, *Center for Natural Lands Management, personal communication*).

A young mountain lion was reported by SJWA staff on 2 occasions in June 2009 near the ponds at the northeastern portion of the wildlife area (*Scott Sewell, California Department of Fish and Game, personal communication*). A similarly described animal was also observed approximately 2 weeks later by State Park staff north of Lake Perris and within the boundary of the park (*Ken Kietzer, California State Parks, personal communication*). The animal has not been detected since late June 2009.

Carol Bell (*The Nature Conservancy, personal observation*) photo-captured 2 to 3 mountain lions (1 female and 2 juveniles) on the Santa Rosa Plateau Ecological Preserve (SRP) across 2 nights in August 2009. A large male lion was also photo-captured when the Wildlife Health Center (*Winston Vickers, personal observation*) attempted to capture and collar the above individuals. In total, the Wildlife Health Center collared 3 animals on the SRP in 2009, and is currently monitoring a number of individuals across the Santa

Ana Mountains. None of the collared animals have dispersed across I-15 to the east, or CA-91 to the north.

DISCUSSION

All 4 covered carnivore species were present at the Anza-Cahuilla Valley habitat block in 2009, and all but mountain lion were detected at the Vail Lake-Wilson Valley-Aguanga habitat block. Bobcat and coyote were also regularly photo-captured using I-15 undercrossings at Gavilan Wash, Indian Wash, and Horsethief Wash, but only coyote were detected at Pechanga/Temecula Creek and the I-10 undercrossing at San Gorgonio Wash. We did not photo-capture mountain lion at any of our stations, and recorded no evidence of their use of targeted freeway undercrossings in 2009.

To date, we have surveyed all or portions of 10 core areas and 15 habitat linkages for covered carnivores. We can confirm presence of bobcat, coyote, and mountain lion on at least 75% of core areas listed in species-specific objectives, thus meeting core objectives for those species (Appendix F). We can also confirm presence of coyote on 93% (n = 14) of species-specific linkages, but need to conduct further surveys for all other target species to determine if habitat-linkage and dispersal-barrier objectives are being achieved. We also need to record long-tailed weasel on at least 5 additional Core Areas to meet core objectives for this species. In general, coyote have been present wherever we have surveyed. Bobcat have also been regularly detected, but not at Pechanga/Temecula Creek, the I-10 crossing of San Gorgonio Wash, or Tucalota Creek. Long-tailed weasel have not been observed in the Badlands (Proposed Core 3) and each of the surveyed habitat linkages. Mountain lion remains a difficult species to detect, and we can not confirm their absence from areas where we have not observed them.

We investigated methods of detecting covered carnivores to determine presence and confirm absence by examining transect placement (secondary roads vs. off-road drainages) and survey method (scent-station vs. walking surveys). Including off-road drainages allowed more complete coverage of core areas than would have been possible if only secondary roads were surveyed, but did not greatly increase detection probability or encounter rate for any of our target species; mountain lion being the exception. We did observe a significant difference between survey methods in detection probability and encounter rate in 3 of 4 target species. Long-tailed weasels were observed exclusively on scent-stations, while bobcat and mountain lion largely ignored scent lures and walked past our track plates. Use of scent stations limited surveys to drainages ≤ 1.2 km from roads, because set-up required that field personnel haul 25-lb bags of sand through thick chaparral and rough terrain. Scent stations also cost about $11 per transect for material (2 bags of sand at $4.49 each, 4 scent lures at $0.50 each). Efficiency of surveying for bobcat, coyote, and mountain lion could be improved by not expending effort on installing scent stations, and instead recording animal sign along transects.

Detection probabilities were below 1 for all target species despite survey method and transect placement. Poor detectability likely resulted from the lack of regularity in

use of individual transects and visitation to scent stations. Single visits accounted for 55% (n = 29), 85% (n = 11), 90% (n = 19), and 100% (n = 2) of transects used by coyote, bobcat, long-tailed weasel, and mountain lion respectively. Home ranges for bobcat, coyote, and mountain lion are typically large and span multiple square kilometers. It is plausible that individuals recorded at transects were subsequently unavailable for detection due to random movement within a large home range. Long-tailed weasel typically uses a much smaller home range (10 to 24 ha or 80 to 160 ha, depending on food availability) than larger carnivores (Sheffield 1999). It is plausible that weasels were present on transects, but difficult to detect given the spacing between scent stations and the likelihood that a lure was placed within an occupied home range. Detection of long-tailed weasel may be improved by shortening scent-station intervals, thereby increasing the number of lures that could likely fall within a home range.

Camera stations provided an effective means of monitoring freeway undercrossings where entire corridor widths could be surveyed 24 h a day with a minimal staffing requirement. Still, gaps in coverage occurred due to occasional mechanical failure (e.g., dead batteries), and there are a number of large culverts near the Gavilan Wash that were not monitored. Opportunities to record incidents of dispersal across freeways were certainly missed in 2009, but the likelihood of mountain lion using targeted undercrossings during periods of camera inactivity remains low, as we never observed lion sign in the vicinity of camera stations. Moreover, we have conducted numerous surveys in the Gavilan Wash area over the past 4 years (e.g., carnivore, bird, plant), and have never documented sign of lion activity.

We did not record bobcat or mountain lion at the Temecula/Pechanga Creek undercrossing of I-15, but only surveyed the site for 8 days at the end of 2009. Risk of vandalism to equipment is very high here, and we wanted to first test the security of our steel-box design at other sites before risking equipment. The bridge span across Temecula/Pechanga Creek also requires multiple cameras for complete coverage. Still, the site is part of a potentially important corridor (Proposed Constrained Linkage 14) between known populations of bobcat and mountain lion in the Santa Ana and Palomar Mountains. Moreover, we have recorded lion tracks along the Santa Margarita River about 2 km to the west, and the Wildlife Health Center has positions from collared animals using the same canyon (***Winston Vickers, personal observation***), but dispersal of lion across I-15 has not been documented here. Development to the east along Temecula and Pechanga Creeks may diminish the functionality of the linkage as a whole, but few crossings of I-15 exist between CA-79 and San Diego County. The Temecula/Pechanga Creek undercrossing offers a wide corridor, high freeway clearance, and riparian cover (e.g., *Salix* spp., *Baccharis*) that may be attractive to dispersing bobcat and mountain lion. Continued effort should be made to monitor the site.

We surveyed the main channel of San Gorgonio Wash as it crosses I-10 east of Banning, and recorded only occasional images of coyote dispersing under the freeway. A number of box culverts exist in the immediate vicinity that were not monitored, and

topography of the main channel dictated that a portion of the undercrossing was not covered by the 2 cameras we had available. San Gorgonio Wash is described in species-specific objectives for bobcat and mountain lion as a required dispersal corridor, and I-10 poses a potential barrier to movement across the linkage. Continued effort should be made to achieve complete camera coverage, and presence/absence of bobcat and mountain lion should be confirmed in the corridor.

Recommendations for Future Surveys

Core objectives have been met for all covered carnivore species except long-tailed weasel. Future transect surveys should focus on the 4 Existing (F, G, I, M) and 4 Proposed (1, 2, 4, 5) Core Areas that have not been surveyed for long-tailed weasel. Drainages and secondary roads should both be sampled with scent stations to maximize coverage of targeted cores, and live trapping techniques should only be considered if we fail to detect the species on the required number of Core Areas, especially if cumulative detection probabilities fail to approach 1. Habitat linkages should also be surveyed, depending on resource availability, and focus placed on linkages between Core Areas where the species is known to occur (i.e., Proposed Constrained Linkages 2, 3, 4, and Proposed Linkages 1, 11, 16).

Habitat-linkage objectives remain to be met for bobcat and mountain lion. We have extensively surveyed Indian and Horsethief Canyon linkages where they cross I-15, and the USGS has independently monitored Proposed Constrained Linkages 1 and 2 at Green River for approximately 2 years. Our coverage of the San Gorgonio Wash, Badlands, and Temecula/Pechanga Creek linkages, however, are incomplete. Functionality of these corridors largely depends on bobcat and mountain lion willingness to cross freeways that bisect them. Future camera surveys should focus on achieving complete coverage of San Gorgonio Wash at I-10, culverts along CA-60 through the Badlands, and undercrossings of I-15 between CA-79 and San Diego County. Area-search surveys for bobcat and mountain lion sign should also be regularly conducted away from freeway crossings to help determine if the corridor as a whole is functional.

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Appendix A. Habitat Blocks, Linkages, and Dispersal Barriers Defined by MSHCP Species Objectives for Bobcat (LYRU), Coyote (CALA), Long-tailed Weasel (MUFR), and Mountain Lion (PUCO).

	LYRU	CALA	MUFR	PUCO
Habitat Blocks	Santa Rosa Plateau-Santa Mnts., Agua Tibia Wilderness-Palomar Mnts., Vail Lake-Wilson Valley-Aguanga, Anza-Cahuilla Valleys, Badlands-San Jacinto Wildlife Area-Lake Perris, San Jacinto Mnts., Lake Mathews-Estele Mnt., Lake Skinner-Diamond Valley Lake, Santa Ana River-Prado Basin.	None listed.	Existing Cores: A, B, C, F, G, H, I, J, K, L, and M. Proposed Cores: 1, 2, 3, 4, 5, 6, 7.	Santa Rosa Plateau-Santa Ana Mnts., Agua Tibia Wilderness-Palomar Mnts., Badlands-SanJacinto Mnts.-Santa Rosa Mnts., San Bernardin Mnts., Lake Mathews-Estelle Mnt., Lake Skinner-Diamond Valley Lake, and Vail Lake-Sage-Wilson Valley.
Linkages	Santa Ana Mnts. to Chino Hills via Fresno Canyon-Green River, Santa Ana Mnts. to Lake Mathews-Estelle Mnt. via Indian Canyon and Horsethief Canyon, Santa Ana Mnts. to Agua Tibia Wilderness-Palomar Mnts. via Pechanga Creek or future wildlife overpass (I-15), Santa Ana River, Lake Skinner-Diamond valley Lake to Sage-Wilson Valley-San Jacinto Mnts. via Tucalota Creek and adjacent uplands, along Badlands to San Jacinto Wildlife Area-Lake Perris-San Jacinto Mnts., Badlands to San Bernardino Mnts. via Chery Valley, San Jacinto Mnts. to San Bernardino Mnts. via Banning Canyon and San Gorgonio Wash.	Santa Ana River, San Timoteo Creek, Indian Canyon and Horsethief Canyon (I-15), Cole Canyon-Murrieta Creek, Warm Springs Creek, Fench Valley tributary to Warm Springs Creek, upland Lake Mathews to Wildomar, Gavilan Hills, San Jacinto River, Temecula Creek-Santa margarita River, kolb Creek/Arroyo Seco, Tucalota Creek, Wilson Creek, Tule Creek, San Gorgonia Wash.	52,400 acres of linkage habitat between Core Areas.	Santa Ana Mnts to Chino Hills via Fresno Canyon-Green River, Santa Ana Mnts to Lake Mathews-Estell Mnt. via Indian Canyon and Horsethief Canyon, Santa Ana Mnts. to Agua Tibia Wilderness-Palomar Mnts. via Pechanga Creek or future wildlife overpass (I-15), Lake Skinner-Diamond valley Lake to Sage-Wilson Valley-San Jacinto Mnts. via Tucalota Creek and adjacent uplands, Badlands to San Jacinto Mnts. and Santa Rosa Mnts., San Jacinto Mnts. to San Bernardino Mnts. via San Gorgonia Wash.
Dispersal Barriers	State Highway 91 between Santa Ana Mnts. and Chino Hills, Interstate 15 between Santa Ana Mnts. and Lake Mathews- Estelle Mnt. via Indian Canyon and Horsethief Canyon, Interstate 15 between Santa Ana Mnts. and Agua Tibia Wilderness, State Highway 60 in Badlands.	None listed.	None listed.	State Highway 91 between Santa Ana Mnts. and Chino Hills, Interstate 15 between Santa Ana Mnts. and Lake Mathews- Estelle Mnt. via Indian Canyon and Horsethief Canyon, Interstate 15 between Santa Ana Mnts. and Agua Tibia Wilderness, State Highway 60 in Badlands.

Appendix B. Species Detected per Scent-station Transect at Vail Lake-Wilson Valley-Aguanga and Anza-Cahuilla Valley Habitat Blocks.

			Species[a]										
Conserved Land[b]	**Type**	**Transect**	**PRLO**	**MUFR**	**MEME**	**CALA**	**CLFA**	**URCI**	**PUCO**	**LYRU**	**SPBE**	**SYAU**	**ODHE**
Vail-Wilson-Sage													
BLM	Drainage	ST-02	-	-	-	-	-	√	-	√	√	-	-
	Road	RD-01	√	-	-	√	-	-	-	-	-	√	-
		RD-02	-	√	-	√	√	-	-	-	-	√	-
CNLM	Road	RD-06	-	√	-	-	√	√	-	-	-	√	-
		RD-07	-	-	-	-	-	-	-	-	-	√	-
RCA	Drainage	ST-01	-	-	-	√	-	-	-	-	-	-	-
		ST-04	-	-	-	-	-	-	-	√	-	√	-
		ST-06	-	-	-	-	-	√	-	-	√	-	√
		ST-07	-	-	-	√	-	-	-	-	-	√	-
	Road	RD-03	-	-	-	√	√	-	-	√	√	√	-
		RD-04	-	-	-	√	-	-	-	-	-	-	-
		RD-05	-	√	-	-	-	√	-	-	√	√	√
		RD-08	-	-	-	√	-	-	-	-	-	√	-
		RD-10	-	-	-	-	-	-	-	-	-	-	-
		RD-11	-	√	-	√	√	-	-	√	-	√	-
		RD-12	-	√	√	√	-	√	-	-	√	-	-
		RD-13	-	-	-	√	√	√	-	-	-	√	-
		RD-14	-	-	-	√	√	-	-	-	-	-	√
		RD-16	-	√	-	√	-	-	-	-	√	-	-

[a] PRLO = raccoon; MUFR = long-tailed weasel; MEME = striped skunk; CALA = coyote; URCI = gray fox; PUCO = mountain lion; LYRU = bobcat; SPBE = California ground squirrel; SYAU = cottontail; ODHE = black-tailed deer

[b] BLM = Bureau of Land Management, CNLM = Center for Natural Lands Management, RCA = Regional Conservation Authority

Appendix B. Continued

			Species[a]										
Conserved Land[b]	**Type**	**Transect**	**PRLO**	**MUFR**	**MEME**	**CALA**	**CLFA**	**URCI**	**PUCO**	**LYRU**	**SPBE**	**SYAU**	**ODHE**
Anza-Cahuilla Valley													
RCA	Drainage	RD-01	-	√	-	√	-	-	-	-	-	√	-
		RD-02	-	-	-	√	√	-	-	-	-	√	-
		RD-07	-	√	-	√	-	-	-	-	-	√	-
		RD-08	-	√	-	√	√	-	-	-	-	√	-
		RD-09	-	√	-	√	-	-	-	√	-	-	-
	Road	ST-19	-	-	-	-	-	√	-	-	-	-	-
		ST-20	-	√	-	-	-	√	-	-	-	-	-
ABDSP	Drainage	ST-01	-	-	-	-	-	√	√	-	-	-	-
		ST-02	-	√	-	√	-	√	√	√	-	√	-
		ST-03	-	-	-	√	√	√	-	√	-	√	-
		ST-04	-	√	-	√	-	√	-	√	-	-	-
		ST-05	-	-	-	-	√	-	-	-	-	√	-
		ST-07	√	√	-	-	-	-	-	-	-	-	-
		ST-10	-	-	-	-	-	-	-	-	-	-	-
		ST-11	-	√	-	√	-	√	-	√	-	-	-
	Road	RD-11	-	-	-	√	√	√	-	√	-	-	-
		RD-12	-	-	-	√	√	√	-	√	-	-	-
		RD-13	-	√	-	-	-	-	-	√	-	-	-
		RD-14	-	-	-	√	-	√	-	-	-	-	-
		RD-15	-	√	-	√	√	√	-	-	-	√	-
		RD-16	-	-	-	√	-	√	-	-	-	-	-
		RD-18	-	√	-	√	-	-	-	-	-	√	-

[a] PRLO = raccoon; MUFR = long-tailed weasel; MEME = striped skunk; CALA = coyote; URCI = gray fox; PUCO = mountain lion; LYRU = bobcat; SPBE = California ground squirrel; SYAU = cottontail; ODHE = black-tailed deer

[b] RCA = Regional Conservation Authority; ABDSP = Anza Borrego Desert State Park

Appendix B. Continued

			Species[a]										
Conserved Land[b]	**Type**	**Transect**	**PRLO**	**MUFR**	**MEME**	**CALA**	**CLFA**	**URCI**	**PUCO**	**LYRU**	**SPBE**	**SYAU**	**ODHE**
Anza-Cahuilla Valley													
BLM	Drainage	ST-12	-	-	-	√	√	√	-	√	-	√	-
		ST-13	-	-	√	-	-	-	-	√	-	-	-
		ST-14	-	-	-	-	-	√	-	√	-	-	-
		ST-15	-	-	-	-	-	-	-	-	-	-	√
		ST-16	-	-	-	√	-	√	-	√	-	-	√
		ST-17	√	√	-	-	√	√	-	-	-	-	-
		ST-18	-	√	-	√	-	√	-	√	-	√	-
		ST-21	-	-	-	-	-	-	-	-	-	-	-
		ST-22	-	√	-	-	-	-	-	-	-	-	-
		ST-23	-	-	-	-	-	√	-	-	-	-	-
		ST-27	-	-	-	√	-	-	-	-	-	-	-
		ST-29	-	-	-	√	-	√	-	-	-	-	-
	Road	RD-03	-	-	-	-	-	-	-	-	-	-	-
		RD-06	-	√	-	√	√	√	-	-	-	-	-
		RD-17	-	√	-	√	√	-	-	-	-	√	-

[a] PRLO = raccoon; MUFR = long-tailed weasel; MEME = striped skunk; CALA = coyote; URCI = gray fox; PUCO = mountain lion; LYRU = bobcat; SPBE = California ground squirrel; SYAU = cottontail; ODHE = black-tailed deer

[b] RCA = Regional Conservation Authority; ABDSP = Anza Borrego Desert State Park

Appendix C. Akaike's Information Criterion for Small Samples (AIC*c*), Akaike Weights (w_i), Model Likelihoods, Parameters (K), and log likelihood of Models Used for Estimating Species-specific Detection Probabilities of Scent-station and Transect Surveys at 2 Locations (Roads and Drainages).

Bobcat transects

Model	AICc	ΔAICc	w_i	Model Likelihood	K	-2log(L)
p(constant) psi(constant)	87.32	0.00	0.45	1	2	83.09
p(location) psi(constant)	88.25	0.93	0.28	0.63	3	81.79
p(time) psi(constant)	88.68	1.36	0.23	0.51	4	79.89
p(location*time) psi(constant)	92.62	5.30	0.03	0.07	7	76.29

Insufficient data to model psi, and parameters were manually adjusted to calculate AICc. Parameters also failed to estimate for p(location*time) model, and it was removed from candidate set. Reported parameter estimates were averaged across a model set of $w_i = 0.97$.

Coyote scent stations

Model	AICc	ΔAICc	w_i	Model Likelihood	K	-2log(L)
p(constant) psi(constant)	153.75	0.00	0.38	1	2	149.52
p(constant) psi(location)	154.61	0.86	0.24	0.65	3	148.14
p(location) psi(constant)	155.96	2.21	0.12	0.33	3	149.50
p(time) psi(constant)	156.42	2.67	0.10	0.26	4	147.64
p(location) psi(location)	156.78	3.03	0.08	0.22	4	148.00
p(time) psi(location)	157.50	3.75	0.06	0.15	5	146.30
p(location*time) psi(constant)	160.91	7.16	0.01	0.03	7	144.58
p(location*time) psi(location)	162.38	8.63	0.01	0.01	8	143.32

All parameters were estimated, and reported estimates were averaged across the entire candidate set.

Coyote transects

Model	AICc	ΔAICc	w_i	Model Likelihood	K	-2log(L)
p(time) psi(constant)	184.65	0.00	0.33	1	4	175.87
{p(g*t) psi(constant)	185.06	0.41	0.27	0.81	7	168.73
p(time) psi(location)	186.22	1.57	0.15	0.46	5	175.02
p(location) psi(constant)	187.59	2.94	0.08	0.23	3	181.12
p(location*time) psi(location)	187.73	3.08	0.07	0.21	8	168.67
p(constant) psi(constant)	188.59	3.94	0.05	0.14	2	184.36
p(location) psi(location)	189.78	5.13	0.03	0.08	4	181.00
p(constant) psi(location)	189.88	5.23	0.02	0.07	3	183.42

All parameters were estimated, and reported estimates were averaged across the entire candidate set.

Long-tailed weasel scent stations

Model	AICc	ΔAICc	w_i	Model Likelihood	K	-2log(L)
p(constant) psi(constant)	134.07	0.00	0.49	1	2	129.85
p(location) psi(constant)	134.37	0.30	0.42	0.86	3	127.91
p(time) psi(constant)	137.58	3.50	0.08	0.17	4	128.79
p(location*time) psi(constant)	142.13	8.05	0.01	0.02	7	125.79

Insufficient data to model psi, and parameters were manually adjusted to calculate AICc. All p parameters were successfully estimated across all models. Reported parameter estimates were averaged across the entire candidate set.

Appendix D. Operation Summary of 14 Camera Stations Maintained Across 9 Sites.

Corridor	Site	Camera	Date Installed	Date Removed	Camera Nights	Dates out of operation	Explanation
I-15	Indian Wash	1	7/25/2008	2/12/2009	43	-	
		2	5/7/2009	-	238	-	
	Horsethief Wash	1	5/7/2009	-	219	8/8 - 8/27	Batteries failed.
	Walker Canyon	1	4/11/2008	-	297	3/13 - 5/13	Missed 2 routine checks, batteries failed
						9/8 - 9/15	Batteries failed.
	Gavilan Wash	1	7/25/2008	5/13/2009	77	3/18 - 5/13	Missed 2 routine checks, batteries failed
		2	5/13/2009	-	202	8/8 - 8/27	Batteries failed.
						11/12 - 11/23	Batteries failed.
	Pechanga Creek	1	12/22/2009	-	9	-	
CA-74	Lamb Canyon	east	11/7/2008	7/14/2009	195	-	
		west	9/5/2008	-	365	-	
I-10	San Gorgonio Wash	1	6/24/2009	-	174	12/15 - 12/31	Camera not turned on.
		2	8/5/2009	-	123	10/29 - 11/23	Batteries failed.
Constrained Linkage 23	Calimesa	1	1/11/2009	12/23/2009	263	4/7 - 5/21	Missed 2 routine checks, batteries failed
						10/29 - 11/23	Camera not turned on.
						12/6 - 12/23	Batteries failed.
		2	12/23/2009	-	8	-	
Constrained Linkage 2	Chino Hills State Park	1	5/20/2008	5/13/2009	99	4/9 - 5/13	Missed 2 routine checks, batteries failed

Appendix E. Incidental Observations of Covered Carnivore Species Recorded by Biological Monitoring Program Staff.

Species	Core	Conservation Area	Date	Observation
Bobcat	Existing Core A	Hidden Valley County Park	10/7/2009	Two cubs playing on dirt road near ponds.
		Rubidoux Nature Center	12/20/2009	Adult walking on path near stream, and observing birds in a nearby pond.
	Existing Core F	Santa Rosa Plateau	12/10/2009	Very clear and well-defined set of tracks in soft mud.
	Existing Core H	Lake Perris State Park	7/23/2009	Flushed from stand of pepper trees during night surveys for banded gecko.
			10/13/2009	Adult observed at dusk on rock outcropping during surveys for banded gecko.
	Existing Core J	Multi-species Reserve	9/28/2009	Adult on dirt track, observed during early morning surveys for lake birds.
Coyote	Existing Core A	Chino Hills Sate Park	10/6/2009	Walking next to Santa Ana River near Green River Golf Course.
	Existing Core C	Lake Mathews	10/14/2009	Single adult walking along concrete embankment at shoreline.
			12/20/2009	Individual observed stalking ducks near lake shore, 2 others nearby.
	Existing Core H	San Jacinto Wildlife Area	4/17/2009	Healthy adult sitting in field.
			12/22/2009	Adult among ravens in a plowed field.
		Lake Perris State Park	7/30/2009	Three adults and 2 pups observed during night surveys for banded gecko.
			8/17/2009	Observed during night surveys for banded gecko.
	Existing Core J	Multi-species Reserve	10/26/2009	Observed on west damn of diamond valley lake during morning bird surveys.
			10/19/2009	Traveling through riparian area at shoreline of Lake Skinner.
	Existing Core M	Agua-Tibia	12/15/2009	Adult flushed from an arroyo.
	Linkage 9	Tenaja Corridor	12/14/2009	Observed during Engelmann-oak surveys.

Appendix F. Survey Needs for Covered Carnivore Objectives.

Objective	Area Name	Detections
Bobcat		
Habitat Blocks	Santa Rosa Plateau-Santa Ana Mnts	08 transects, 09 incidental
	Vail Lake-Wilson Valley-Aguanga	2009 transects
	Anza-Cahuilla Valley	2009 transects
	Badlands-SJWA-Lake Perris	2008 transects
	Lake Mathews-Estelle Mnt	2008 transects
	Santa Ana River-Prado Basin	2008 incidental
	San Jacinto Mnts	2008 incidental
	Lake Skinner-Diamond Valley Lake	2009 incidental
	Habitat Blocks Needed:	**0**
Linkages	Fresno Canyon/Green River	2008-09 cameras
	Indian/Horsethief Canyons	2008-09 cameras
	Santa Ana River	2008 incidental
	Badlands (southern half)	2008-09 cameras
	Cherry Valley	2008-09 cameras
	San Gorgonio Wash	None to Date
	Pechanga Creek	None to Date
	Tucalota Creek	None to Date
	Linkages Needed:	**1**
Dispersal Barriers	CA-9 - Fresno Canyon/Green Rr	2008-09 USGS[a]
	I-15 - Indian/Horsethief Canyons	2009 cameras
	I-15 - Pechanga/Temecula Creek	None to Date
	CA-60 - Badlands	Not Surveyed
	Barriers Needed:	**1**
Coyote		
Habitat Blocks	No objective.	
Linkages	Santa Ana River	2008 incidental
	Badlands/San Timoteo Creek	2008 incidental
	Cole Canyon-Murrieta Creek	2009 linkage survey
	Warm Springs Creek	2009 linkage survey
	Warm Sp. Ck, French Valley trib.	2009 linkage survey
	Lake Mathews to Wildomar	incomplete
	Gavilan Hills	2008 transects
	San Jacinto River	2009 linkage survey
	Temecula Ck-Santa Margarita Rr	2009 linkage survey
	Kolb Creek/Arroyo Seco	2009 linkage survey
	Tucalota Creek	2009 linkage survey
	Wilson Creek	2009 linkage survey
	Tule Creek	2009 linkage survey
	San Gorgonio Wash	2009 cameras
	Linkages Needed:	**0**
Dispersal Barriers	I-15 - Indian/Horesthief Canyons	2009 cameras
	Barriers Needed:	**0**

[a] Lisa Lyren, USGS, Western Ecological Research Center; camera-trap and radio-collar surveys.

Appendix F. Continued

Objective	Area Name	Detections
Long-tailed weasel		
Core Areas	Existing Core A	2008 OCWD[b]
	Existing Cores B, C, H, K	2008 transects
	Existing Core L	2009 transects
	Proposed Cores 6 and 7	2009 transects
	Existing Cores J	2009 CNLM[c]
	Proposed Core 3	None to Date
	Existing Cores F, G, I, M	Not Surveyed
	Proposed Cores 1, 2, 4, 5	Not Surveyed
	Cores Needed:	**5**
Linkages	Plan Area linkages	None to Date
	Total acreage:	**0**
	acreage needed:	**52,400**
Dispersal Barriers	No Objective	
Mountain lion		
Habitat Blocks	Santa Rosa Plateau-Santa Ana Mnts	2005-09 WHC[e]
	Aqua Tibia Wilderness-Palomar Mnts	2008 incidental
	Badlands-San Jacinto/Santa Rosa Mnts	2006-08 WHC[e]
	San Bernardino Mnts	2009 incidental
	Vail Lake-Sage-Wilson Valley	2004-06 WHC[e]
	Lake Mathews-Estelle Mnt	None to Date
	Lake Skinner-Diamond Valley Lake	Not Surveyed
	Habitat Blocks Needed:	**0**
Linkages	Fresno Canyon/Green River	2006-07 WHC[e]
	Indian/Horsethief Canyons	None to Date
	Pechanga Creek	None to Date
	Tucalota Creek	None to Date
	Badlands	None to Date
	San Gorgonio Wash	None to Date
	Linkages Needed:	**6**
Dispersal Barriers	CA-91 at Fresno Canyon/Green Rr	None to Date
	I-15 at Indian/Horsethief Canyons	None to Date
	I-15 at Pechanga Creek	None to Date
	CA-60 through Badlands	Not Surveyed
	Dispersal Barriers Needed:	**4**

[b] David McMichael, Orange County Water District

[c] Kim Klementowski, Center for Natural Lands Management

[d] Objective calls for 52,400 acres of non-specified conserved linkages across Plan Area.

[e] Winston Vickers, Wildlife Health Center, radio-collar surveys