Memorandum

Date: February 12, 2018

From: Rosanne Humphrey, HMP Coordinator

Re: Summary of Wildlife Movement Activities in Carlsbad

This memorandum summarizes the results of wildlife movement monitoring that occurred between 2006 and 2017 within the Carlsbad Habitat Management Plan (HMP) preserve system (Figure 1).

1.0 Background

The MHCP was designed to "maintain connections between each of the major lagoon and estuary systems with larger blocks of inland habitats to allow movement of wildlife species" and allow for "demographic and genetic exchange by all species between preserve areas…to facilitate access by larger predators…between upland scrub and chaparral habitats and coastal habitats." (MHCP, 2003). In order to evaluate the effectiveness of that design, the MHCP identifies several priority monitoring locations to establish where major constraints to mammal movement exist; some of these locations are within the HMP area. Tiering off of the MHCP, a key objective of the HMP is to "maintain functional wildlife corridors and habitat linkages within the city and to the region" (HMP, 2004). The design of the preserve system is based upon the HMP Focus Planning Area, which identified eight core habitat areas connected by six linkage areas (Figure 2). Currently 6,143 of the target 6,478-acre preserve (95%) has been conserved.

The restriction of wildlife movement has been demonstrated to negatively affect the health of wildlife populations by fragmenting existing habitat areas and isolating local populations (Wilcox and Murphy 1985). Urbanized areas (open space areas within a matrix of development) are especially constraining to wildlife because of the high levels of edge, poorer quality habitat, and increased human use (George and Crooks 2006). Therefore, the maintenance of linkage areas is vital to sustaining overall wildlife populations within a region. As local populations naturally fluctuate based on a variety of factors, the maintenance of linkage areas allows for movements between local populations, strengthening the genetic diversity of the overall population. Habitat quality within core areas tends to be higher than within linkage areas, as linkage areas are generally more restricted and subject to increased pressures from surrounding areas (e.g., invasive species, human occupancy, roadway traffic, etc.). Thus, depending upon the species, the use of linkage areas by wildlife is typically restricted to movement between core areas. Elements defining the quality of a given linkage area are varied and tend to be species-specific (Rosenberg et al. 1995). Additionally, the relative restrictiveness of a given restriction (pinchpoint) is generally variable by species, meaning that pinchpoints may restrict the movement of certain species, while allowing for movement of other species. Restricted linkage areas not offering reliable connectivity between core areas may still be used by a species for foraging.

Within highly developed areas such as Carlsbad, channelized and narrow natural drainages often function as corridors. Pinchpoints often exist where these corridors intersect roadways and are further constricted within structures such as underpasses or culverts. Sometimes the undercrossing restrictions are so severe or even nonexistent such that at-grade crossing of the roadway is necessary. Although generally not designed to support wildlife movement, these structures and/or surrounding areas may sometimes be altered to improve wildlife movement. For example, shelving can be placed in culverts to allow movement of medium and small animals if the undercrossing is frequently flooded. If these culverts are large enough, fencing can be provided to help guide wildlife away from the roadway and through the undercrossing. Components common to functioning wildlife pinchpoints include native vegetation, high quality adjacent habitat, natural bottom substrates, limited inundation, and natural lighting (Carr et al. 2003).

2.0 Wildlife Monitoring Activities in Carlsbad

2.1 Linkage and Pinchpoint Evaluation

To understand the current status of wildlife movement in the preserve system, the city partnered with the Center for Natural Lands (CNLM) Management and Environmental Science Associates (ESA) in 2013 to conduct an inventory of possible wildlife movement corridors and constraints throughout the City. This baseline assessment, funded by a California Department of Fish and Wildlife (CDFW) Local Assistance Grant, consisted of three tasks: (1) Linkage/Pinchpoint Inventory; (2) Wildlife Movement Monitoring; and, (3) Analysis and Report (City of Carlsbad et al. 2015).

In the early stages of study design, the team decided to focus on large and medium sized animals, most notably southern mule deer (*Odocoileus hemionus fuliginatus*) and bobcat (*Lynx rufus*), as these species are often considered indicators of functional connectivity (SDMMP 2011). Larger animals typically require larger ranges, thereby needing to move freely through the landscape. In addition, both deer and bobcat are thought to be less adapted to the urban environment and provide a good indication of the functionality of a movement corridor for all other species. Therefore, the criteria used for evaluating the level of constraint posed by a particular pinchpoint and its suitability for inclusion in subsequent camera monitoring was based on the needs of larger and medium sized animals. The methods and results of this analysis are summarized below.

2.1.1 Linkages

The first step in the study involved identifying possible wildlife movement corridors through the city. The MHCP identified three regional corridors extending from each of the city's lagoons (Buena Vista, Agua Hedionda, and Batiquitos) eastward to inland upland areas within and beyond the city boundary. On a more local scale, the HMP Focused Planning Area (FPA) identified five generalized linkages between core areas (Figure 2). The current HMP preserve system configuration is fragmented in some areas, and functional connectivity relies upon narrow movement corridors between habitat patches. There are also riparian areas, drainages, or other open areas such as golf courses that are located outside of the HMP preserve system that enhance wildlife movement throughout the city.

Using the city's open space Geographic Information Systems (GIS) data layer and aerial imagery,

the regional and more local-scale corridors were identified and ranked according to scale and potential function. As shown in Figure 3, the wildlife corridors were grouped into three categories: (1) primary - regional east-west corridors identified in the MHCP [EW]; (2) secondary - core to core corridors between major habitat areas [CC]; and, (3) minor - corridors between non-core habitat areas [M]. A total of three primary corridors, three secondary corridors, and 11 minor corridors were identified.

2.1.2 Pinchpoints

Once the possible wildlife movement corridors were defined and mapped, the next step in the study identified potential constraints to movement. Roads are one of the most important constraints to wildlife movement in Southern California; therefore, this type of constraint was the focus of this analysis. Many of the roads in Carlsbad, which bisect habitat throughout the city, are wide (two to four or more lanes in each direction) with dense, fast-moving traffic during many hours per day. Mortality risks are high for wildlife that travel across roads. Traveling under roads through culverts and bridges that have an adequate configuration is much safer.

The purpose of this task was to create an inventory of all potential pinchpoint, which could be used for future study. First, an in-office assessment was conducted following the methodology used by USGS in a linkage evaluation performed in southwestern San Diego County (Rochester and Fisher 2012). City of Carlsbad GIS data layers (HMP and non-HMP open space) and aerial imagery were used to identify potential movement pathways along the previously identified corridors. A point was placed at every location in which a road crossed the corridor, which might serve as an impediment to movement (i.e., potential pinchpoint). Points generally consisted of culverts and bridges, but at-grade road crossings were also included. Each point was given a unique identification number (104 in all). Each point was then further evaluated by zooming in to the aerial imagery and using Google Street View to assess the type of crossing. Screenshots of aerial imagery and/or Street View were prepared for all pinchpoints. When it was possible to detect fencing that could impact wildlife movement, colored lines were added to the image.

The next step was to visit each of the 104 potential pinchpoints, take photographs of each entrance and surrounding area, collect data describing the condition and characteristics of that location, and input the data into a database. The datasheet was developed in consultation with U.S. Geological Society (USGS) biologists. Examples of data collected include nearest creek, nearest road, road conditions, structure type, bottom type, structure measurements (length, height, width), nearby fencing description, vegetation (type, thickness, cover) at each undercrossing entrance, and specific threats to movement. The entire pinchpoint inventory, including aerial imagery, street view imagery, field visit photos, and field data is included in the final report (City of Carlsbad et al. 2015). An example of the information collected for each pinchpoint is provided below (pinchpoint EW3-6).

Example of pinchpoint inventory information included in 2015 final report (EW3-6 shown)

Example of pinchpoint inventory information included in 2015 final report (EW3-6 shown)

HMP Wildlife Movement Pinchpoint Description

LOCATION DESCRIPTION

Corridor	EW3	Point Code:	EW3-6a	Assessment Date	8/19/2013	Surveyors:	M. Spiegelberg
Latitude:	33.09309000000	Longitude:	-117.22457900000	GPS Datum:	WGS 84		
Nearest River:	San Marcos Creek						
Nearest Road	Rancho Santa Fe Road, S of Avenida Soledad	Road Conditions:	Divided roadway with two or more lanes each				
Structure Type:	arch culvert	Multi Chambers?	no	Structure Material	Metal		
Bottom Type:	dirt, hard armored						
Height(m):	3.93	Width (m)	5.25	Length (m):	91.40	Openness Ratio:	0.2
Constraints	No						
Description of Constraints	Arch wildlife tunnel						
Access Logistics	Not good for tracking.						
Fencing:	Chain link on each side of RSF Rd. Extends over 100 feet in each direction						
Camera Options:	CNLM mounted cameras in tunnel and outside of tunnel						
Tracking Potential	Not good, hard surface						
Species/Sign Observed:	None						

DESCRIPTION OF VEGETATION EW3-6a

N or E Entrance	Veg. Thickness	none	Dominant Vegetation Type	short grasses/forbs			
Cover Classes at 20	Shrubs	1 (1-5%)	Grass/Herbs	1 (1-5%)	Trees:	1 (1-5%)	
	Bare/Rock:	5 (76-100%)	Native Species:	1 (1-5%)	Exotic Species	1 (1-5%)	
S or W Entranc	Veg. Thickness	open	Dominant Vegetation Typ	shrubs			
Cover Classes at 20	Shrubs	2 (6-25%)	Grass/Herb	1 (1-5%)	Trees:	2 (6-25%)	
	Bare/Rock:	3 (26-50%)	Native Species:	2 (6-25%)	Exotic Species	1 (1-5%)	
Veg. Comments:	Open on east side, mostly open on south side, some willows block a portion of opening on west side						

THREATS AND MANAGEMENT RECOMMENDATIONS EW3-6a

Primary Threat:	busy roadway	Severity	3 (moderate/not imminen
Secondary Threat:	Long tunnel	Severity	3 (moderate/not imminen
Mgmt Recommendations	Patrol and keep people out		
Comments:	Unclear why deer are not using tunnel; radio collar deer for study in this area		
	MHCP Monitoring Priority		

2.2 Trail Camera Studies

After analyzing the information collected during the pinchpoint inventory, the team identified selected pinchpoints for further study with trail cameras and tracking. It was determined that trail cameras would provide the best information with the most efficient use of time; therefore, camera monitoring was the primary focus, and tracking was used to supplement camera data. Prioritization was based on MHCP priorities and suitability for camera monitoring as determined in Phase 1 of the pinchpoint assessment. The purpose of pinchpoint camera monitoring was to gain a basic understanding of the presence of wildlife species at certain pinchpoints throughout the city. Generally, only one or two cameras were installed at a given location, mostly within a culvert or under a bridge. Although still or video images of animals would not definitively show that an animal was traversing all the way through an undercrossing, it would provide information about how prevalent certain species are within the city and help determine next steps in wildlife movement monitoring. Between January 2014 - January 2015, a total of 27 cameras were used at various times in 19 locations. Prior to collecting these data, CNLM had been collecting camera data at a number of their preserves since 2010 or earlier. After the study, most of the cameras were taken down, but some were kept running for additional monitoring, and some were moved to new locations, including Lake Calavera Preserve and Agua Hedionda Lagoon Ecological Reserve (Figure 4, Table 1). Details about camera mounting, camera operation, and video review are included in the Wildlife Movement Analysis Report (City of Carlsbad et al. 2015).

2.3 Tracking

Starting in 2000, tracking surveys were initiated by The San Diego Tracking Team (SDTT) using standard SDTT methodology (Figure 4). Transects T38 and T50, located on the eastern side of Carlsbad Highlands Ecological Reserve, were run from 2000 – 2016. These transects were retired because of the heavy mountain biking traffic, making it difficult to find sign. SDTT also assisted CNLM by conducting tracking at Rancho Santa Fe Road near Fire Station #6 near pinchpoint EW3-6 in 2016, visiting the transects quarterly. Tracking was conducted along transects outside and through the tunnel at this location. SDTT also assisted with transects established by the City/CNLM in the Calavera Hills area. Specifically, the transects (T1-T6) were established to document movement between what is known as “Village H” through “Village K” and then to Lake Calavera/Calavera Mountain (Figure 4). Transects were visited ten times between September 9, 2014 and January 23, 2015. To augment the tracking, a wildlife movement camera was installed in the middle of “Village K” to document movement in this parcel.

Between 2015 – 2017, CNLM conducted intensive focused tracking surveys for southern mule deer. The purpose of the surveys was to look for any type of sign, primarily scat or tracks to better understand deer movement within and across the city boundary. Surveys were conducted in Rancho La Costa Preserve at Denk Mountain, Ridgeline and East Ridgeline trail areas, and along a corridor west of Southern Preserve. Surveys were also conducted on Southern Preserve, Carlsbad Oaks North, and on both sides of Palomar Airport Road (at Carrillo Ranch and Raceway Preserves). Karen Merrill assisted CNLM with surveys on Carlsbad Oaks North and Raceway Preserves in 2015 and 2016.

3.0 Monitoring Results

3.1 Linkage Functionality

The general functionality of the linkages identified in Carlsbad were discussed in the 2015 wildlife movement analysis report, and are summarized below.

EW1 is the northern-most corridor that runs along Buena Vista Creek. This is the least functional EW corridor, especially west of the Carlsbad Golf Center, which is just east of the El Camino Real/SR 78 intersection. The biggest threat to wildlife movement along EW1 is the abundance of homeless that are present under most of the bridges. Cameras were not installed along this corridor because the risk of theft or vandalism was high. Other impediments to movement include perennial standing water in many locations, restrictive fencing, and very busy roadways. The east end might be impacted by the new Quarry Creek Master Community, and many new residents will be moving into that area; however, the creek was widened, restored, and conserved as part of project mitigation, which should facilitate movement in this area. Movement beyond the city boundary into Oceanside is further constrained by dense commercial and residential development.

EW2 connects Agua Hedionda Lagoon to the Lake Calavera Preserve/Carlsbad Highlands Ecological Reserve area (northern branch) and to Carlsbad Raceway preserve along Agua Hedionda Creek/La Mirada Creek. The northern branch appears to have fairly good connectivity except where the corridor crosses El Camino Real and College Boulevard. The culvert at EW2-3 (west of El Camino Real/Cannon intersection) has perennial standing water and is impassable; however, camera monitoring has shown that the bridges under Cannon (EW2-4) and El Camino Real south of Cannon (EW2-5) are well-used by all types of small and medium sized wildlife, including bobcats and coyotes, which can then travel along La Mirada Creek to Carlsbad Highlands Ecological Reserve. EW2-3, which connects Robertson Ranch East to Calavera Hills II Preserve appears to function adequately for small to medium sized animals, although bobcats were not observed during the 10-day monitoring period. The southern branch, which extends along Agua Hedionda Creek and Sunny Creek to core habitat on the eastern border of the city appears to be relatively unimpeded for small to medium sized animals.

EW3 connects Batiquitos Lagoon to Rancho La Costa Preserve. The northern branch extends along San Marcos Creek, and the southern branch extends along Encinitas Creek. Along the northern branch, movement under El Camino Real (EW3-3) could be difficult because there may be standing water during high tide, and there is consistent use by the homeless. Movement is likely unimpeded beyond El Camino Real, where the corridor traverses an open golf course all the way to Ranch La Costa Preserve, until Rancho Santa Fe Road. Rancho Santa Fe Road is a busy divided roadway with a 4 x 5 meter arch culvert, approximately 91 meters long. The culvert is regularly used by small to medium mammals, including bobcat, but deer do not use this culvert. Movement along the southern branch appears to be constrained at La Costa Avenue (EW3-7; lack of directional fencing), El Camino Real (EW3-10a; long, low, and muddy), and Rancho Santa Fe (EW3-13; low tunnel). EW3-7 and EW3-10a might also be impacted by human presence – both cameras were stolen within three months.

Other Corridors (Core to Core and Minor) generally run north to south along narrower habitat corridors, and often these corridors consist of upland habitat rather than riparian drainages such as the EW

corridors. Pinchpoints along riparian corridors often require larger bridges and culverts for water conveyance, which are more appropriate for wildlife movement than smaller culverts or ground-level crossing. The core to core and minor linkage functionality is described in detail in the 2015 report. There are a variety of conditions along these corridors, including vegetation cover, bottom type, structure configuration, width of roadway and density of traffic density, and type of human use, time of day of use by humans and/or dogs, directional fencing, etc. High levels of habitat fragmentation, dense residential and commercial development, and an extensive network of roads impede wildlife movement in all directions. It is clear that the biggest barriers to north-south movement within and beyond Carlsbad are SR 78, Palomar Airport Road, and La Costa Avenue.

3.2 Cameras and Tracking

Table 1 below includes a comprehensive list of camera monitoring that has occurred throughout the HMP system, when the cameras were active, and the species observed. As discussed above, mapping and general tracking locations are shown on Figure 4. Figure 5 shows the locations of deer sign that were observed during the 2015-2017 intensive focused tracking surveys, and locations where no deer or sign were observed during tracking or camera monitoring. Camera observations are also shown in Figure 5. Table 2 shows the results of focused deer tracking/monitoring conducted by CNLM. Selected photos are included in the attached photo pages.

General tracking surveys conducted by SDTT were fairly consistent with the camera monitoring in terms of species observed. Results of camera and sign tracking can be summarized as follows.

- The most common mammals observed by camera monitoring are bobcat, coyote, raccoon, opossum, rabbit, and squirrel. Other observations included skunk, bat, weasel, birds (roadrunner, waterfowl, songbirds, crows, and raptors) and rodents (most often non-native rat).
- Bobcats were observed throughout the city at almost all of the camera and tracking stations.
- It *appears* that that bobcats are using undercrossings throughout the City; however, the monitoring methodology was designed to identify presence, rather than determine if bobcats are successfully traveling all the way through.
- Bobcats were observed mostly at night, but a significant number of photos were captured during the day.
- Bobcats were observed even in locations with a heavy presence of dogs and people during the day (i.e., AHLER1 and AHLER3).
- The other species commonly observed appear to be very well adapted to the urban environment, especially coyotes, raccoons, and rabbits.
- Deer appear to be concentrated on the eastern portion of the city where there are larger blocks of core habitat, although tracks have been identified farther west, most prevalently at The Crossings preserve.
- Deer are much more restricted in their movements, requiring large, open structures such as bridges or culverts with an openness ratio ([height*width]/length) of 0.8 -0.9 (Cavallaro et al. 2005).
- Deer also prefer open vegetation at the mouth and to/from an undercrossing entrance.

Table 1. Camera Monitoring Results

Camera ID	Operator	Date in Service	Species Observed
AHLER1[1]	City	July – December 2017	**Bobcat**, coyote, rabbit, raccoon, dog, human
AHLER3[1]	City	June – December 2017	Bird, **bobcat**, coyote, rabbit, raccoon, dog, human
LC1[1]	City	March – December 2017	Bird, **bobcat**, coyote, rabbit, raccoon, dog, housecat, non-native rodent, human
LC2[1]	City	November 2016 – December 2017	Bird, coyote, rabbit, raccoon, human
Calavera Ck	CNLM	2015-2017	bird, **bobcat**, coyote, **deer**, rabbit, raccoon, skunk (striped and spotted), and squirrel
CC1-3	CNLM/SDTT	Village K; August 2014 – 2016	**Bobcat**, coyote, rabbit, raccoon, roadrunner, skunk
CC3-1a	City	July 2014 – September 2016	Bat, **bobcat**, coyote, rabbit, raccoon, squirrel, weasel, rodent
CC3-1b	City	December 2016 – April 2017	bird, **bobcat**, coyote, raccoon, rodent, squirrel, housecat
CC3-6a	City	January – March 2014 (stolen)	Coyote, rabbit, raccoon
CC3-6b	City	January – April 2014	
CH1[1]	CNLM/SDTT	2016	**Bobcat**, coyote
EW2-3	CNLM	College Ave; October 9 -19, 2012; 2015-2016	**Bobcat**, coyote, opossum, rabbit, roadrunner, skunk, squirrel, rodents
EW2-4a	City	January – October 2014 (stolen)	**Bobcat**, coyote, opossum, raccoon, skunk, squirrel
EW2-4b	City	January – October 2014 (stolen)	
EW2-5a	City	February – May 2014	Bat, **bobcat**, coyote, opossum, rabbit, raccoon, skunk
EW2-5b	City	April 2015 – April 2017	
EW2-5c	City	December 2015- December 2017	Bird**, bobcat**, coyote, opossum, rabbit, raccoon, rodent, skunk, squirrel, human
EW2-5d	City	March 2016 – December 2017	
EW2-6	City	July 2014 – May 2015	Bird, raccoon
EW2-9	CNLM	Seasonally 2010-2015; year round 2015-2017	**Bobcat,** coyote, **deer**, opossum, raccoon, skunk, squirrel
EW2-10	CNLM	Couple of months 2015-2016 (mule deer focus)	**Bobcat**, coyote, **deer**, skunk
EW3-5a	CNLM	Dam (E of RSF Rd); 2006-2016; (yearly since 2010)	**Deer**, **bobcat**, coyote
EW3-5b	CNLM	Within RSF tunnel; several times 2015-2016	**Bobcat**, raccoon, skunk
EW3-5c	CNLM	West of RSF Rd; several times 2015-2016; redeployed December 2017	**Deer,** coyote
EW3-6	CNLM	2007 (one month); 2015-2016	**Deer, bobcat** coyote
EW3-6a	CNLM	November 2012 – April 2013; October 2013 – March 2014	**Bobcat**, raccoon, skunk
EW3-6b	CNLM	Oct 2010 – Apr 2011; Sept 2011 – Jun 2014; Dec 2014 – Jan 2015	**Bobcat**, coyote, **deer**, rabbit, raccoon, skunk, squirrel
EW3-7	City	January – March 2014 (stolen)	Coyote, opossum, raccoon, squirrel, weasel
EW3-10a	City	February – October 2014	**Bobcat**, coyote, opossum, raccoon
EW3-13a	City	May 2014 – March 2015	**Deer** (did not enter culvert), opossum, raccoon.
EW3-13b	City	January – July 2014	
M2-1	City	January – October 2014 (stolen)	
M5-1	City	July 2014 – April 2015	**Bobcat**, opossum, rabbit, raccoon, rodent, skunk, squirrel
M6-1 (N & S)	City	October 2010 – April 2014	**Bobcat**, coyote, opossum, rabbit, raccoon, skunk,
M6-1a	CNLM	2013 - 2017	**Bobcat**, coyote, **deer** (buck and doe), raccoon, opossum
M6-3	City	July 2014 – February 2015	**Bobcat**, coyote, opossum, rabbit, raccoon, skunk
M10-1	CNLM	October 2013 – January 2014	**Bobcat**, coyote, raccoon, squirrel
M11-1a	CNLM	Leucadia; October 2013 - 2017	**Bobcat**, coyote, raccoon
M11-1b	CNLM	Barcelona; October 2013 - 2017	**Bobcat**, coyote, rabbit, raccoon, squirrel, skunk
PF	City	July 2014 – April 2017	**Bobcat**, opossum, rabbit, raccoon, rodent, squirrel

[1] AHLER = Agua Hedionda Ecological Reserve, CH = Calavera Hills; LC = Lake Calavera Preserve; PF = Post-Fire (burn area).

Table 2. Results of Focused Deer Tracking and Camera Monitoring Conducted by CNLM

Preserve	Type	Location	Monitoring Date	Deer Observations	Management Recommendations
Calavera Hills/ Robertson Ranch	Undercrossing camera/tracking	EW2-3; College Ave	October 9 -19, 2012; 2015-2016	No deer observed	Needs regular patrols and vegetation maintenance.
Calavera Hills/ Robertson Ranch	Trail camera/ focused tracking	CC1-3; Village K	August 2014 – 2016	No deer observed	
Calavera Hills/ Robertson Ranch/ CHER	Trail camera/ focused tracking	Calavera Creek	2015-2017	Good movement along creek by deer and other wildlife	Need study to help determine density, movement patterns and familial relationships
Carlsbad Oaks North/Raceway	Undercrossing camera	EW2-9; Faraday	Seasonally 2010-2015; year round 2015-2017	Deer were not using tunnel prior to 2015, but started using again regularly after vegetation clearing	Keep vegetation cleared to accommodate deer movement; frequent patrols; graffiti removal
Carlsbad Oaks North/Raceway	Undercrossing camera/tracking	EW2-10; Melrose	2015-2016	One deer track in tunnel; likely going over road; using many areas of CON preserve, critical water and foraging resources; deer on both sides of Melrose in Raceway Preserve;	Vegetation management, directional fencing; patrols. Need study to help determine density, movement patterns and familial relationships
Rancho La Costa	Trail camera	EW3-5a; Dam east of Rancho Santa Fe Rd	2006-2016; (yearly since 2010)	Deer observed consistently each year; most common animal observed	
Rancho La Costa	Undercrossing camera	EW3-5b; within Rancho Santa Fe tunnel	several times 2015-2016	No deer observed in tunnel; deer not using EW3-5, but instead going across road	Tunnel too long/dark; needs directional fencing, lighting inside tunnel and some vegetation removal; little annual maintenance required; more patrols.
Rancho La Costa	Trail camera	EW3-5c; West of Rancho Santa Fe Rd	Several times 2015-2016; redeployed December 2017	Deer observed	Proves that deer are crossing RSF Road rather than using the tunnel
Rancho La Costa	Trail camera	EW3-6	2007 (one month); 2015-2016	One deer during 1 month camera up in 2007; 2015-2016 many deer.	No immediate management needs; routine patrols recommended.
Rancho La Costa, Southern Preserve	Focused deer tracking	Denk Mtn, corridor W of Southern Psv, Ridgeline and East Ridgeline trails, Southern Psv	2015-2016	Deer are moving along San Marcos Creek under bridges; using corridor through Southern Preserve/RLC wildlife corridor parcel; crossing Denk Mountain; found on Ridgeline area west of San Marcos Creek.	Need study to help determine density, movement patterns and familial relationships
City right-of-way near HOA open space	Undercrossing camera	EW3-13; Rancho Santa Fe Road south of Olivenhain	2014-2015	Deer observed at culvert entrance but did not enter the tunnel	
Encinas Creek	Trail Camera	M6-1a; west of Hidden Canyon Rd	2013 - 2017	Deer (buck and doe) observed for first time in 2017	
La Costa Glen	Camera/tracking	M11-1a; Leucadia	2015-2017	No sign of deer 2015-2017; one scat observed in 2017	Needs frequent patrols and homeless camp cleanup. Need study to help determine density, movement patterns and familial relationships
La Costa Glen	Undercrossing Camera	M11-1b; Barcelona	2013-2017	Many animals used undercrossing until 2017, but no deer	Needs frequent patrols and homeless camp cleanup.

4.0 Pinchpoint Adaptive Management

As discussed above, the city-wide pinchpoint inventory and wildlife movement evaluation included information about potential constraints to movement at each location, including traffic, vegetation, human presence, undercrossing structure, and fencing. After the final report was completed, the City worked with CNLM and the Preserve Steward (ESA) to evaluate and prioritize the pinchpoints for adaptive management actions that could improve wildlife movement. In addition to the type and severity of threats at each location, feasibility of task implementation was also evaluated. Locations or management actions that were thought to have significant constraints to management implementation were eliminated from further consideration. Examples of significant constraints include areas with major hydrological issues that might require remedial engineering or dredging, actions that might trigger the need for jurisdictional permitting, remedial work requiring structural changes to an undercrossing, areas with complex landownership issues (e.g., installing fencing on land owned by multiple jurisdictions), or actions considered to be cost prohibitive. After this initial pass was made, a number of pinchpoint locations were re-evaluated in the field to document current conditions. Finally, six pinchpoints were prioritized (Table 3) for possible adaptive management.

Funding to implement these management actions was requested by the City in partnership with CNLM and ESA through a Local Assistance Grant proposal submitted to the California Department of Fish and Wildlife on August 17, 2017. The proposal was not funded; therefore, these tasks are not funded at this time.

Table 3. Priority Pinchpoints for Adaptive Management

Task	Site-Specific Threats	Solution[1]
1 (EW3-6)	Previous camera studies show that deer, coyotes and other species of mammals cross on the busy roadway instead of using the undercrossing; openness ratio = 0.2; western entrance obstructed by dense vegetation.	(1) Install approx. 250 LF of 5-foot chain link fence to guide animals to the tunnel; (2) install solar two powered lights within the tunnel; (3) thin vegetation at the western entrance to make the tunnel opening more apparent; and (4) install 4 wildlife cameras to document movement.
2 (M1-2)	Undercrossing is gated to deter human use; animals may cross on the busy roadway instead of using the undercrossing; eastern entrance obstructed by dense vegetation and debris.	(1) Install approx. 1,000 LF of fence along both sides of Tamarack Ave to guide animals through the tunnel and dissuade human trespass; (2) create small opening in gates at tunnel entrance; (3) clear debris and thin vegetation; (4) increase routine patrols; and (5) deploy cameras to monitor movement.
3 (EW2-10)	Dense vegetation blocks the undercrossing entrances and tunnel visibility from a distance is compromised. Previous monitoring studies show that deer are mostly going over the busy roadway rather than using the undercrossing.	(1) Remove vegetation from the tunnel openings and thin to create a "path" to the eastern tunnel opening; and (2) deploy wildlife cameras (3) increase routine patrols.
4 (CC-3-6)	Northern entrance obstructed by dense vegetation and debris.	(1) Remove vegetation that blocks the northern entrance (2) remove debris from the tunnel; (3) increase routine patrols; and (4) conduct tracking to monitor movement.
5 (M10-1)	Animals may cross on the busy roadway instead of using the undercrossing. Homeless people are commonly observed using the undercrossing. Previous monitoring studies documented only a few animals using this undercrossing.	(1) Install approx. 500 LF of fence to guide animals through the tunnel and dissuade human trespass; (2) conduct tracking or camera monitoring; and (3) increase routine patrols
6 (EW3-1)	Animals may cross on the busy roadway instead of using the undercrossing.	(1) Install approx. 100 LF of fence to encourage wildlife movement under bridge; and (2) conduct tracking or camera monitoring

[1] LF = linear feet

Although the Local Assistance Grant project was not funded, CNLM was able to conduct adaptive management at one of the pinchpoints on the Carlsbad Oaks North Preserve. Quantitative data from camera monitoring clearly shows the improvement of deer movement as a result. Prior to 2015, deer had stopped traveling under Faraday through the EW2-9 undercrossing, but were instead traveling over the road. In 2015 vegetation was cleared from the entrance and vegetation was thinned along a path so that deer could clearly see to the other side of the tunnel. The number of deer captured on camera increased from 0 in 2014 to 221 in 2016 and 188 in 2017. Bobcats and coyotes also frequented the tunnel; however the vegetation clearing did not have as profound an effect, as these species regularly used the tunnel before 2015 (Table 4, Figure 6).

Table 4. Wildlife Observed at EW2-9
Before and After Vegetation Management

Year	Deer	Bobcat	Coyote
2010	0	0	7
2011	1	1	24
2012	0	31	83
2013	0	105	55
2014	0	18	7
2015	11	21	12
2016	221	74	65
2017	188	40	60

* Note: cameras deployed intermittently between 2010-2015

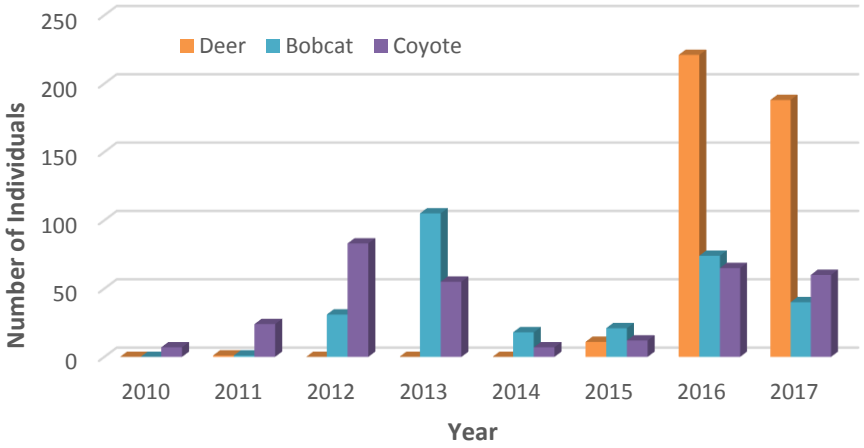

Figure 6. Wildlife Observations 2010-2017

5.0 Discussion

5.1 Summary

Overall, there appears to be a substantial number of small to medium-sized mammals using the undercrossings throughout the city. Many of these mammals, including bobcat, appear to be fairly well-adapted to the urban environment and travel around the city even in areas with daytime presence of humans. This is consistent with a study conducted by Tigas et al. (2002) in which the behavior of bobcats and coyotes in a fragmented urban area northwest of Los Angeles was compared the species' behavior in an unfragmented reference area. This study found that home range sizes were not significantly different in fragmented areas, and that both species adjusted behaviorally by changing their movement patterns temporally and spatially. Although corridors and culverts were used, both species were willing to travel through developed areas between habitat patches, often traveling across well-travelled roads rather than using culverts.

Deer are more restricted than smaller mammals because of their large size and preference for open crossings with a high openness ratio. Restricted movement may lead to insufficient genetic exchange to maintain a healthy population. Southern mule deer, the subspecies that occurs in our region, has been found to have less overall genetic diversity than subspecies elsewhere in the state (Pease et al 2009). Genetic sampling from scat samples in southwest SD County found evidence of limited dispersal, population structure that corresponds to major freeways, and population bottlenecks within the past 60 years (Bohonak and Mitelberg 2014). Because southern mule deer does not migrate, it does not have the opportunity to move to less developed areas during part of the year, and therefore, urbanization can have a greater effect on the southern mule deer than migratory deer elsewhere in the state (Sommer et al, 2007). It is expected that the southern mule deer will experience greater inbreeding effects as population decreases as a result of continued development in the southern California region (Bohonak and Mitelberg).

Overall, the greatest threats to functional wildlife movement throughout the HMP preserve system are: extensive network of roads and heavy traffic, habitat fragmentation from development, and homeless people who are often active at night under bridges when many native mammals are most active. Other threats include sedimentation and hydrological issues that discourage use of undercrossings, and structurally insufficient culverts or undercrossings, as these were not designed with wildlife movement in mind. Adaptive management actions that can improve functional movement include vegetation clearing or thinning at covered entrances, but encouraging adequate native vegetation cover for prey animals to feel safe; sufficient and properly placed directional fencing to direct wildlife into culverts and away from roadways; better access control and patrolling to discourage use of undercrossings or habitat by unauthorized people; and dredging out excess sediment clogging culverts. Constraints to implementing some of the adaptive management strategies includes high cost, insufficient resources, extensive wetland permitting process, obtaining access permission and/or encroachment permits, and complex social issues leading to long-term homelessness or itinerant encampments.

5.2 Potential Future Studies

It is important to note that our study design does not enable us to fully understand the functionality of wildlife movement in Carlsbad. The following questions have not yet been answered:

- Are animals actually traveling through culverts to move from one habitat fragment to another?

- Are they successfully using undercrossings *instead* of roadways, or are they also traveling over roadways?
- How high is the roadkill mortality rate for each species? Are some species more vulnerable than others?
- Are wide-ranging species, such as bobcats and deer, able to move around such that they have a *functional* home range in this urbanized preserve system (e.g., able to find sufficient food and successfully raise young, and the young are able to disperse and establish their own successful home ranges)?
- What effect does authorized (recreational) and unauthorized (homeless, encampments, unleashed dogs, off-trail hiking or mountain biking) have on wildlife movement?
- Are some types of human activities more detrimental to wildlife movement functionality than others?
- Are different functional groups of animals (e.g., songbirds, raptors, roadrunners, large mammals, medium sized predators, small mammals and other vertebrates) differentially affected by human activity, corridor habitat condition, or undercrossing structure?

Potential future studies to help answer some of these questions could include more intensive, targeted camera monitoring, roadkill studies to evaluate roadway mortality, or genetic studies to determine the level genetic exchange in local populations. Much can also be learned from regional studies that are have been conducted or are currently underway, as described below.

5.3 Regional Studies

The SDMMP and collaborators are conducting numerous studies that will help us better understand wildlife movement and genetic connectivity on a regional scale. Examples of these studies are included below.

1. **North County Connectivity Study.** The U.S. Geological Survey (USGS) will perform a preliminary assessment of the potential linkages between the core conserved wildlife areas within northern San Diego County and evaluate connectivity within core areas. GIS and imagery tools will be used to identify points within each linkage where wildlife potentially may move between the core conserved lands. Images of each point, a brief description, and the potential for wildlife to use each will be complied into a report.
2. **Southern Mule Deer.** Amy Vandergast (USGS) will be conducting genetic studies of southern mule deer in North San Diego County and across I-5 to better understand travel routes, population density, territory size, and movement barriers. The study is expected to begin in Spring of 2018.
3. **Bobcat – Connectivity for Large Animals Using Bobcats as a Model Species.** From 2009 – 2012 Megan Jennings and Rebecca Lewison (SDSU and USGS) used remote cameras, GPS telemetry, road kill collection, genetic analysis, habitat/connectivity modeling, and occupancy modeling to better understand connectivity in inland and coastal areas of southern San Diego County (Jennings and Lewison 2013).
4. **Mountain Lion Connectivity Study North San Diego County.** The purpose of this study was to understand which lands in north San Diego County are likely used by mountain lions, and to

assess connectivity within and between current and proposed future conserved lands in North San Diego County and adjacent Riverside, and Orange Counties (Vickers et al. 2017). The results from this study of mountain lion movement, habitat use, gene flow, and highway crossings will be available to inform critical decisions regarding the prioritization of lands for conservation and the potential need and location of highway modifications to enhance connectivity for mountain lions and other wildlife. For this study, Winston Vickers (U.C. Davis) will be conducting genetic analyses, resource selection and movement modeling, and an analysis of potential crossing points of highways.

5. **Coastal California Gnatcatchers.** USGS examined individual relatedness patterns and population genetic structure among gnatcatcher aggregations throughout coastal southern California from Ventura to San Diego Counties to better understand the number of genetically distinguishable populations across the species range, genetic relatedness, dispersal distances of parents and offspring, patterns of genetic diversity, and how these results affect management and monitoring (Vandergast et al. 2014). These results enhance our understanding of the connectedness of gnatcatcher metapopulations across its fragmented habitat.

6. **Small Vertebrates.** In 2012, a small vertebrate underpass study was conducted by USGS (Tracey et al. 2014). The three main objectives in this study were (i) to determine which groups of small vertebrates are currently using or avoiding selected underpasses and understand how these behaviors may be predicted by life history characteristics, (ii) to investigate the effectiveness of adding cover structures to underpasses to enhance small vertebrate use, and (iii) to evaluate the extent to which larger vertebrates often used as focus species in connectivity studies in the region act as indicators of use by small vertebrate species.

7. **Human Impacts.** Sarah Reed, Kevin Crooks and others (Colorado State University) conducted a study on the wildlife response to human recreation on NCCP reserves in San Diego County (Reed et al. 2014). Specific objectives were to develop research recommendations and test methods for monitoring recreation by completing a pilot field study. Phase II of this study will Implement a well-designed study that integrates species monitoring with recreation monitoring to systematically assess recreation's direct and indirect effects on sensitive wildlife species, to improve the understanding of the trade-offs inherent in multiple-use management of reserves, and to ensure that NCCP reserves are providing the required levels of protection and achieving the goals of the NCCP program.

8. **Climate Resilient Connectivity** for the South Coast Ecoregion of California. Megan Jennings and Erin Conlisk (SDSU) are leading an effort to support regional-scale climate-smart connectivity planning by using species distribution and dynamic metapopulation modeling to develop connectivity modeling and planning approaches accounting for climate change, land-use shifts, and uncertainty. Connectivity linkage maps will be prepared for the South Coast Ecoregion, which will be used to develop an implementation guide and decision support framework to aid agencies in the identification and prioritization of land acquisition targets, land management goals, and habitat enhancement projects to protect and improve landscape linkages that will be resilient to climate change

6.0 References

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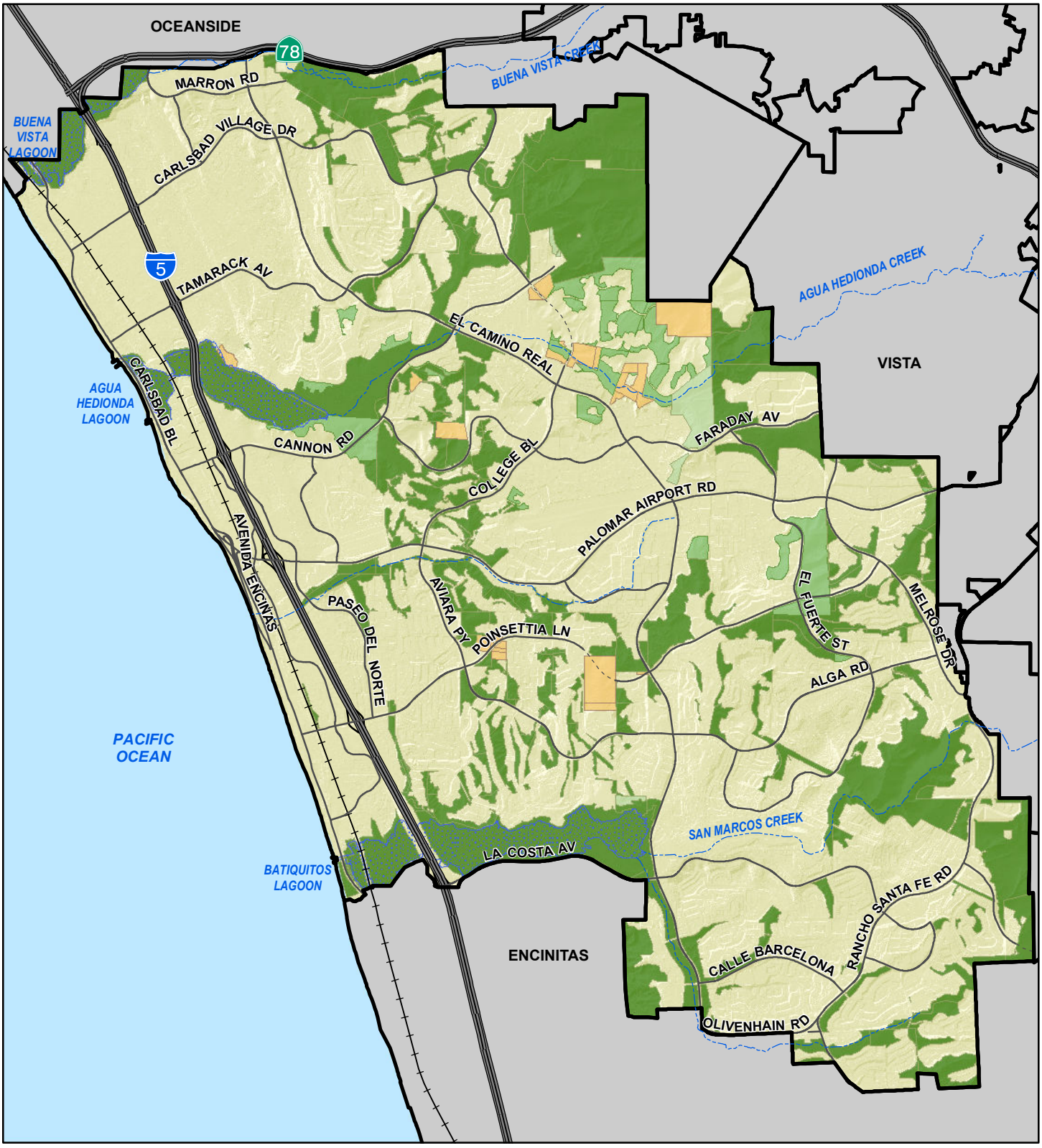
Attachments

Figures
Photo Pages



HMP Preserve Types:

- Existing Hardline
- Outside-Conserved
- Proposed Hardline
- Standards Area

N

0 Feet 6,400

City of Carlsbad

City of Carlsbad
Habitat Management Plan (HMP) Preserve System

Figure 1

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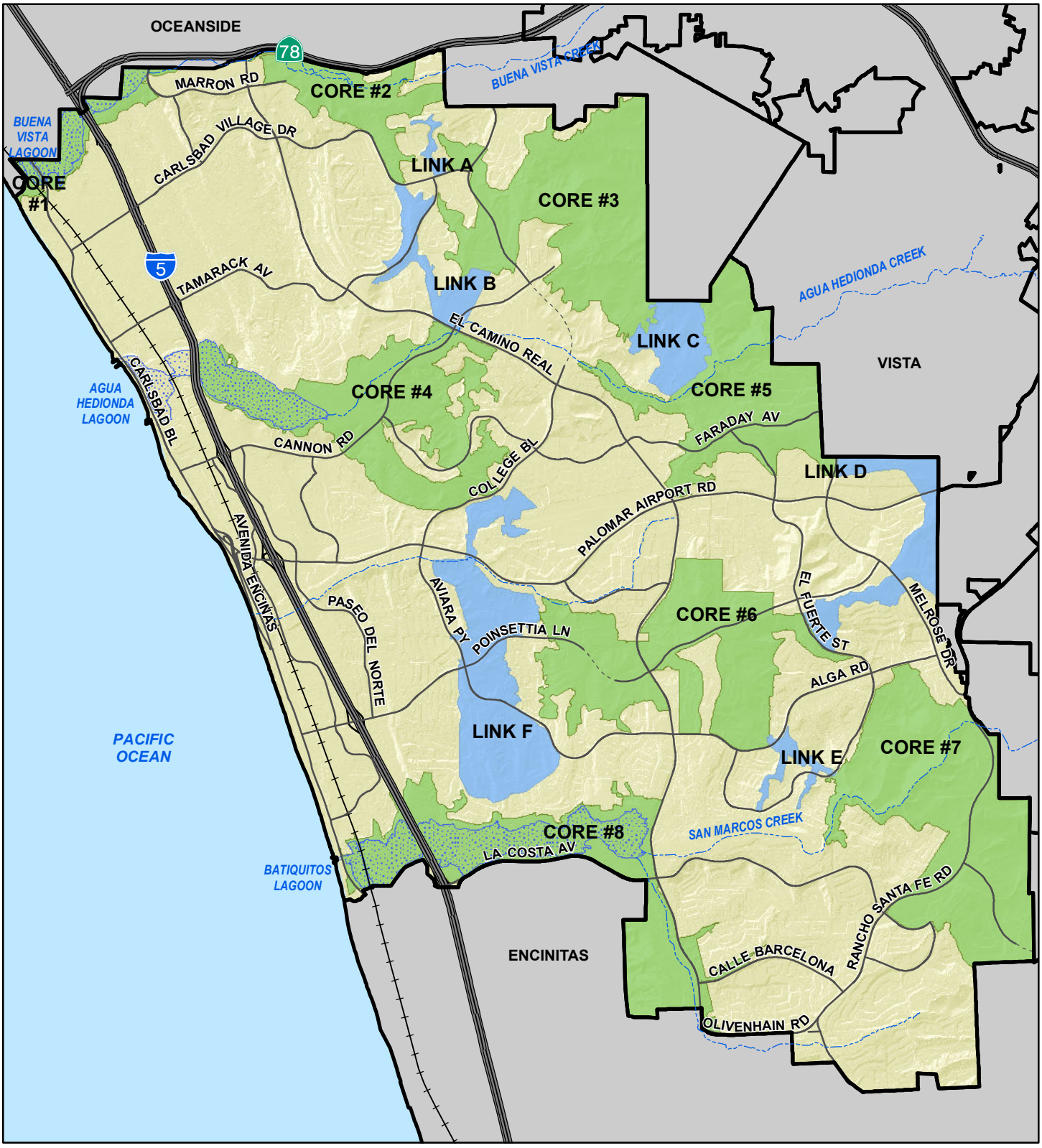

HMP Focus Planning Area:

- HMP Core Area
- Linkage

N

0 Feet 6,400

City of Carlsbad

City of Carlsbad
HMP Focus Planning Area (FPA) Showing Core Areas and Linkages

Figure 2

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Date: 02/13/2018

HMP Preserve Types:

- Existing Hardline
- Outside-Conserved
- Proposed Hardline
- Standards Area

Potential Pinchpoint

HMP Linkages:

- East-West
- Core to Core
- Minor

N

0 Feet 6,400

City of Carlsbad

City of Carlsbad
Potential HMP Wildlife Movement Corridors and Pinchpoints

Figure 3

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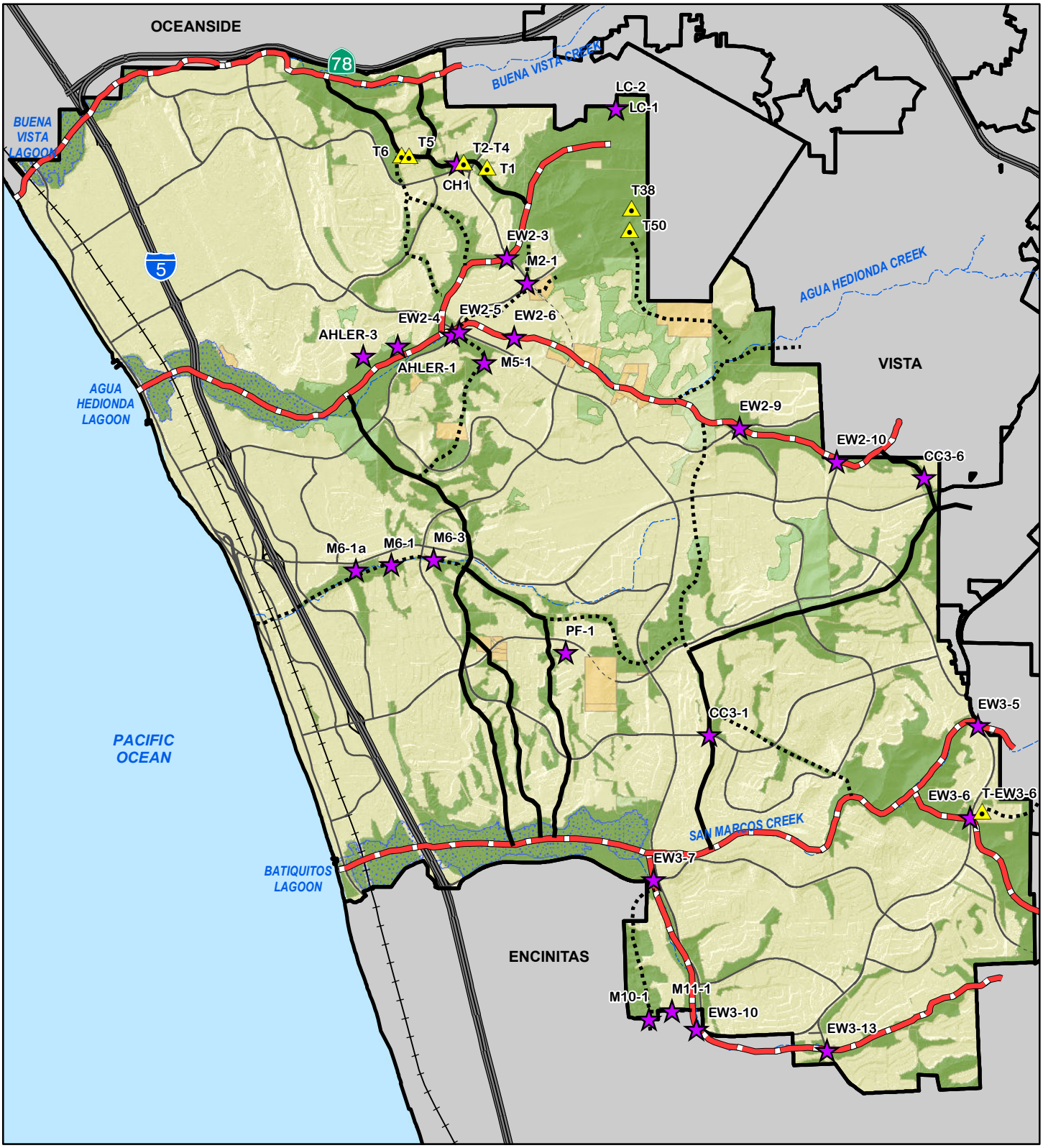

City of Carlsbad

City of Carlsbad
HMP Wildlife Camera and General Tracking Locations 2006-2007

Figure 4

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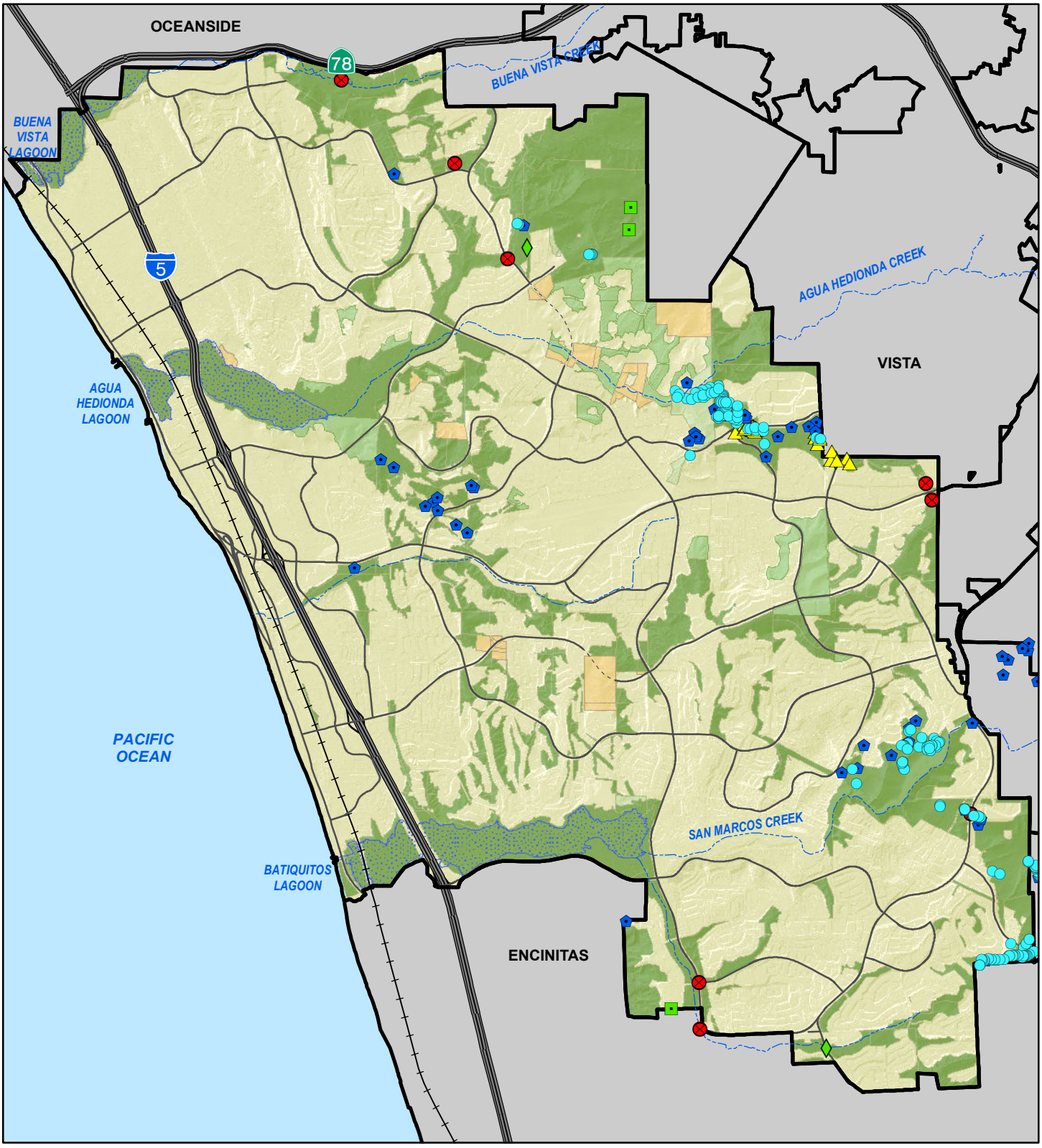

City of Carlsbad

City of Carlsbad
2015-2017 Deer Sign and Direct Observations

Figure 5

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Date: 02/14/2018

Sample Wildlife Movement Photos

Southern Mule Deer at Carlsbad Oaks North (CNLM)

Southern Mule Deer at Carlsbad Oaks North (CNLM)

Bobcats at Various Preserves (CNLM and City)

Sample Wildlife Movement Photos

Coyote, rabbit, pocket mouse, spotted skunk, striped skunk, dog, cat, raccoon, and roadrunner