Urban Biodiversity Assessment: Baldwin Hills Biota Update

Edited by

Travis Longcore
University of Southern California

November 2016

Prepared for

Baldwin Hills Conservancy
Proposition 84

Baldwin Hills Regional Conservation Authority
Proposition A

THE BALDWIN HILLS

BALLONA CREEK

Preferred Citation

Longcore, T. (ed.). 2016. *Urban Biodiversity Assessment: Baldwin Hills Biota Update*. Los Angeles: University of Southern California for Baldwin Hills Conservancy (Proposition 84) and Baldwin Hills Regional Conservation Authority (Proposition A).

Contents

Chapter 1. Introduction

Travis Longcore
University of Southern California, School of Architecture and Spatial Sciences Institute

The Baldwin Hills are visible rising out of the Los Angeles Basin to a height of 510 feet, sitting near the northern terminus of a series of hills along the Newport-Inglewood fault that stretches southward to Orange County. They are at a point of confluence, straddling three major groundwater basins, and marking a junction between the City of Los Angeles, Culver City, unincorporated County of Los Angeles, and the City of Inglewood. Once seen as land worthless except to graze animals, the hills became and remain the site of a major oilfield that reaches northwest to southeast across its slopes. Major purchases of land that have been developed as parkland to serve the local community and beyond have created a network of public lands along the northern extent of the hills that is sufficiently contiguous that a trail network is now under construction that will allow a visitor to walk from the slopes above Leimert Park, the historical center of African American art, music, and culture in Los Angeles, across the hills, along the Ballona Creek channel and to the ocean.

Major assessments of the natural history of the Baldwin Hills were undertaken in the late 1970s through early 1980s as part of the acquisition and development of Kenneth Hahn State Recreation Area. Then in the early 2000s an assessment of the biota was undertaken and released in 2001, leading up to the formation of the Baldwin Hills Conservancy. Since that assessment, several developments have led to the decision to undertake a focused study to update various parts of the description of the natural history of the Baldwin Hills. First, the Baldwin Hills Scenic Overlook has been purchased as public land and developed with a hugely successful public trail system. Second, many small restoration and landscape projects have been undertaken that have changed the natural landscape. Third, the opportunities for communication with the public have undergone a revolutionary change, with most park and open space visitors carrying a device with them capable of accessing information at any location at any time. Taken together, these developments indicated the need to update information about the distribution of species and habitats in this region and to develop pathways to communicate this knowledge to visitors that take advantage of the ubiquity of mobile telecommunications devices.

In February 2001, the Natural History Museum of Los Angeles County and Community Conservancy International released *The Biota of Baldwin Hills: An Ecological Assessment* (Molina 2001). The report contained chapters on vegetation, arthropods, reptiles and amphibians, birds, and mammals. Although the distribution of species in the Baldwin Hills is not expected to have changed dramatically since 2000, various advances in survey techniques and improved local expertise make it worthwhile to revisit specified topic areas. This is needed to provide information at a scale that is suitable to track restoration of vegetation, to ascertain the status of taxonomic groups left out of previous efforts, and to clarify the status of species in some groups for which previous survey efforts might not have detected rare species.

Focus of Biota Update

Vegetation

The 2001 biota report used a modified vegetation mapping scheme that is useful to identify vegetation types of interest, but is not well suited in resolution or classification approach to use as baseline information to track restoration progress. The resolution of the mapping units is coarse and does not follow current California Native Plant Society (CNPS) vegetation classifications (Sawyer et al. 2009), which are also those recognized by the California Department of Fish and Wildlife. The 2001 map does not include the oil field because access was not available. Using remote sensing techniques (e.g., high-resolution photography, LIDAR, and multispectral imaging), we set out in this study to develop a map of all areas, including those for which access was not possible (Longcore and Noujdina, Chapter 2). The new vegetation map covers the oil field, uses CNPS Alliance classifications, and incorporates other existing mapping efforts (e.g., weed maps, maps for various environmental review documents).

Reptiles and Amphibians

The 2001 report was based on a small number of visual encounter surveys for reptiles and amphibians (Beaman 2001). Because of the weather during the surveys and the lack of other sampling methods, key species were missed in the 2001 survey (e.g., salamanders). Furthermore, park officials reported that some visitors were concerned about the possible presence of rattlesnakes, so understanding the possible presence of venomous snakes was a priority. In this study, Pauly et al. (Chapter 3) investigated the reptile and amphibian fauna using five types of surveys: visual encounter surveys, nighttime visual and acoustic surveys, turtle trapping, coverboards, and pitfall traps. Additionally, Pauly et al. (Chapter 3) reviewed relevant museum records and incorporated citizen science observations.

Bats

No previous survey efforts had been undertaken for bats in the Baldwin Hills. It is now possible to record ultrasonic bat calls and determine the species that are present using computer-assisted identification techniques. These technological advances made it an opportune time to survey for bats. Monthly visits were made to the public lands and along Ballona Creek with teams carrying a handheld bat detector led by bat expert Stephanie Remington (Chapter 4).

Mesocarnivores

The 2001 report included trapping for small mammals and the development of a species list for larger species through observations of scat, tracks, runways, or sightings of live or roadkilled individuals (Dines 2001). Since that time, the feasibility of using remotely triggered infrared wildlife cameras has dramatically increased and their use is the cornerstone of the surveys by Ordeñana and Dines (Chapter 5). Nocturnal camera trapping was considered to be beneficial to confirm continued presence of native mammals recorded in 2001 (e.g., gray fox) and to learn more about their distribution. Coyotes were not recorded in 2001 and had colonized the Baldwin Hills and surrounding neighborhoods before the start of this study so their distribution was of interest as well.

Other Taxonomic Groups

Birds

The bird surveys in the Baldwin Hills were quite extensive (Garrett 2001) and the various public open spaces continue to be the site of recreational birding. The collaborative bird observation reporting system eBird was launched in the early 2000s and has become a valuable source of bird monitoring data that is used extensively in scientific studies (Fitzpatrick et al. 2002, Sullivan et al. 2009, Wood et al. 2011). Rare species that are spotted by the public are usually reported in eBird and then vetted by a regional editor to ensure that claims are supported by appropriately detailed supporting documentation. For example, a California Gnatcatcher (*Polioptila californica*) was reported from Baldwin Hills Scenic Overlook in 2016. This record was accompanied by a recording of the unmistakable call of the species and has been accepted as a record in the eBird system. California Gnatcatcher is listed as threatened under the Endangered Species Act and the volunteered observation with supporting details, which was not part of this study, would likely trigger the need for surveys for this species in appropriate habitats in advance of any future developments that would affect those habitats. California Gnatcatcher is a confirmed resident in the Ballona Wetlands and can disperse considerable distances over urban landscapes (documented up to 7.5 km; Bailey and Mock 1998, Galvin 1998) so its presence in the Baldwin Hills, especially at a location closest to the Ballona Wetlands is consistent with its known ecology.

Arthropods and other Invertebrates

Although additional surveys throughout the year would enhance knowledge of arthropod groups, we did not pursue further surveys in this update. The 2001 survey (LaPierre and Wright 2001) provided an excellent snapshot of arthropod diversity and no sensitive species require additional focus at this time. Furthermore, volunteered observations by members of the public that are shared through online tools have become a commonplace tool to obtain natural history observations. The social natural history platform iNaturalist was launched in 2008 and contains over 4,000,000 observations submitted by volunteers with species identifications vetted by the user community (Pimm et al. 2015). Many observations of arthropods and other invertebrate species have been reported in iNaturalist within the study area for this project. These efforts have been enhanced by public education efforts to encourage iNaturalist reporting in the form of a Bioblitz in the Baldwin Hills led by the Natural History Museum of Los Angeles County in 2016 as well as its ongoing SLIME program (Snails and slugs Living in Metropolitan Environments).

Geographic Scope

Specific information about locations surveyed are included in each chapter. The area of interest was defined as the official territory of the Baldwin Hills Conservancy, which includes upland areas of the Baldwin Hills and adjacent neighborhoods as well as a reach of Ballona Creek that passes at the foot of the northern side of the Baldwin Hills. California State Parks provided access to the Baldwin Hills Scenic Overlook and Kenneth Hahn State Recreation Area under a Biological Investigations permit dated April 14, 2014. Culver City provided permission to access Culver City Park for the surveys. Observations were also made from public access ways, streets, and roads. A few incidental observations were included for areas that are open to the public but for which permission to conduct formal surveys was not able to be obtained.

Disclaimer

This Report is not intended nor permitted to be used in any legal proceeding or in any manner as a statement concerning the conditions, at any particular time, on privately held property within the Inglewood Oil Field (IOF). Any reproduction or use of this Report without consent is expressly prohibited. The IOF has existed as an operating oil field for over 100 years. Due to its operational functions, unique topography and as privately held property, direct access was not granted for ground-based studies to inform the vegetation map or for faunal surveys for this Report. Permission for aerial mapping of the IOF privately held property was also not granted. No representation or warranties are made with regard to the exact accuracy of statements, charts, or findings in this Report or as to the actual or prospective vegetation map or faunal survey for the IOF. The IOF does not intend for its uses to serve as markers for mapping or surveys. The IOF is subject to a Community Standards District (CSD) enacted by the County of Los Angeles and related post-CSD agreements which govern certain matters pertaining to the oil operations at the IOF and related fire-life safety, brush clearance and landscaping protocols unique to the IOF. This Report is not intended to impact the CSD and related post-CSD agreements.

Literature Cited

Bailey, R. A., and P. J. Mock. 1998. Dispersal capability of the California gnatcatcher: a landscape analysis of distribution data. *Western Birds* 29:351–360.

Beaman, K. 2001. Reptiles and Amphibians of the Baldwin Hills. Pp. 64–76 in *The biota of the Baldwin Hills: an ecological assessment* (K. C. Molina, ed.). Los Angeles: Community Conservancy International and Natural History Museum of Los Angeles County Foundation.

Dines, J. P. 2001. Mammals of the Baldwin Hills. Pp. 127–141 In *The biota of the Baldwin Hills: an ecological assessment* (K. C. Molina, ed.). Los Angeles: Community Conservancy International and Natural History Museum of Los Angeles County Foundation.

Fitzpatrick, J. W., F. Gill, M. Powers, J. V. Wells, and K. V. Rosenberg. 2002. Introducing eBird: the union of passion and purpose. *American Birds* 56:11–12.

Galvin, J. P. 1998. Breeding and dispersal biology of the California gnatcatcher in Central Orange County. *Western Birds* 29:323–332.

LaPierre, L., and P. Wright. 2001. Arthropods of the Baldwin Hills. Pp. 39–63 In *The biota of the Baldwin Hills: an ecological assessment* (K. C. Molina, ed.). Los Angeles: Community Conservancy International and Natural History Museum of Los Angeles County Foundation.

Molina, K. C., ed. 2001. *The biota of the Baldwin Hills: an ecological assessment*. Los Angeles: Community Conservancy International and Natural History Museum of Los Angeles County Foundation.

Pimm, S. L., S. Alibhai, R. Bergl, A. Dehgan, C. Giri, Z. Jewell, L. Joppa, R. Kays, and S. Loarie. 2015. Emerging technologies to conserve biodiversity. *Trends in Ecology and Evolution* 30(11):685–696.

Sawyer, J. O., T. Keeler-Wolf, and J. Evens. 2009. *A manual of California vegetation*. Second ed. Sacramento, CA: California Native Plant Society.

Sullivan, B. L., C. L. Wood, M. J. Iliff, R. E. Bonney, D. Fink, and S. Kelling. 2009. eBird: a citizen-based bird observation network in the biological sciences. *Biological Conservation* 142:2282–2292.

Wood, C., B. Sullivan, M. Iliff, D. Fink, and S. Kelling. 2011. eBird: engaging birders in science and conservation. *PLoS Biology* 9 (12):e1001220.

Chapter 2. Vegetation of the Baldwin Hills

Travis Longcore and Nina Noujdina
University of Southern California, School of Architecture and Spatial Sciences Institute

Introduction

The Los Angeles Basin is bisected by the Santa Monica Mountains, which separate the San Fernando Valley from the large coastal plain extending from Santa Monica southward to Orange County. The only topographic features of note in this wide zone, encircled by other coastal mountain ranges (the Puente-Chino Hills), are the Palos Verdes Peninsula and a series of hills stretching from Newport in the south to the Baldwin Hills in the north (Figure 2-1). These hills are the result of an earthquake zone, the Newport-Inglewood fault, which has been the site of extensive exploration and extraction of oil over the past 100 years (Byrne et al. 2007). Because of its origin in the geological past and the dynamics of the Los Angeles River over time, the Baldwin Hills have been a site of relative ecological isolation as a plant and animal community — and island surrounded in part by wetlands (Dark et al. 2011) and in part by the sloping alluvial fan and floodplain of the Los Angeles River.

This island, rising slightly over 500 feet above sea level, has a long and interesting history. It was apparently not the site of any permanent camps by Native American people, with such locations being concentrated closer to the ocean in the Ballona Valley (Stoll et al. 2009). It was, however, grazed extensively during the Rancho period and eventually by Lucky Baldwin's ranch at the turn of the 20th Century. Baldwin purchased close to 4,500 acres of the Rancho Cienega O'Pasa de la Tijera in the 1880s (Byrne et al. 2007) and used the land almost exclusively for grazing. Oil was discovered in Los Angeles in 1892; exploration of the Baldwin Hills started in 1916 (Byrne et al. 2007). In 1924 explorations proved successful and extraction of hydrocarbons from the Baldwin Hills continues to this day.

The Baldwin Hills were used as the site of the Olympic Village in 1932 and as a location for a water reservoir that failed in 1963, killing 5 and causing $12 million in property damage (Byrne et al. 2007). This failure was attributed to tectonic activity and subsidence associated with oil field operations and two oil companies settled with the City of Los Angeles to handle claims from the disaster. It was in this context that in 1966 then-County Supervisor Kenneth Hahn saw the potential for a park in the vicinity of the former reservoir and set into motion the actions that would result in accumulation of parkland in the Baldwin Hills over decades to follow.

Surveys of the natural resources of the Baldwin Hills, especially the vegetation, were essentially nonexistent until the County efforts to plan for the new park. At that time in the late 1970s the

Longcore, T. and N. Noujdina. 2016. Vegetation of the Baldwin Hills. Pp. 6–38 in *Urban Biodiversity Assessment: Baldwin Hills Biota Update* (T. Longcore, ed.). Los Angeles: University of Southern California for Baldwin Hills Conservancy (Proposition 84) and Baldwin Hills Regional Conservation Authority (Proposition A).

County undertook a multi-year effort to describe the natural features of the hills and their history to plan the future for the land that would become "Baldwin Hills Park." The vegetation mapping was a modest effort, with more attention paid to developing a plant list and quantifying relative cover of plants at different areas within the hills (Marqua 1978), and on detailed description of the distribution of different plant associations. Subsequent mapping efforts were undertaken for studies that would launch the Baldwin Hills Conservancy (Anderson 2001), to support a Community Standards District for the oilfield operations (Marine Research Specialists 2008), and associated with environmental review for the Parks to Playa trail system (BonTerra Consulting 2013). Together, these efforts represent a baseline for vegetation in the Baldwin Hills. The current management area for the Baldwin Hills Conservancy, however, includes a greater geographic footprint than any of the previous mapping efforts and although most of the undeveloped (or industrial use) areas have been mapped at one time, no map with the same mapping standards and classifications for the entire territory has been made. This report documents the production of a map of vegetation types that covers the entire territory of the Baldwin Hills Conservancy using a standard methodology that incorporates high-resolution aerial photography over the entire territory.

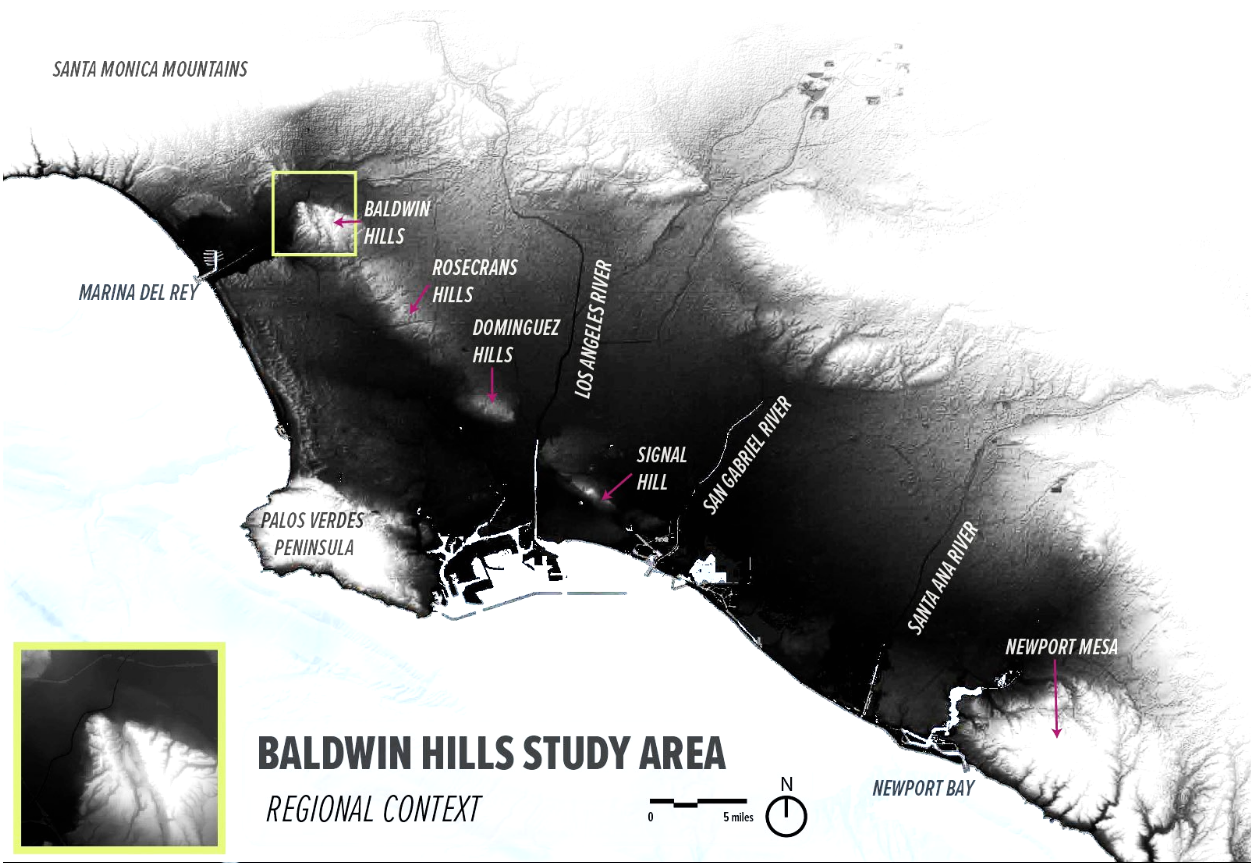


Figure 2-1. Location of Baldwin Hills within the context of the Los Angeles Coastal Plain.

Vegetation Classification

Mapping vegetation over large areas in the 21st century usually relies on high-resolution images from airborne sensors, either flown in planes or satellites and more recently on small unmanned aerial vehicles (Anderson & Gaston 2013). Many mathematical techniques are available to classify such images, including spectral clustering, expert systems, neural networks, and decision tree classifiers (Homer et al. 2004).

Table 2-1. National Vegetation Classification Standard hierarchy (Federal Geographic Data Committee 2008).

Hierarchy for Natural Vegetation	Example
Upper Levels	
1 – Formation Class	Scientific Name: Mesomorphic Shrub and Herb Vegetation Colloquial Name: Shrubland and Grassland
2 – Formation Subclass	Scientific Name: Temperate and Boreal Shrub and Herb Vegetation Colloquial Name: Temperate and Boreal Shrubland and Grassland
3 – Formation	Scientific Name: Temperate Shrub and Herb Vegetation Colloquial Name: Temperate Shrubland and Grassland
Mid Levels	
4 – Division	Scientific Name: *Andropogon – Stipa – Bouteloua* Grassland & Shrubland Division Colloquial Name: North American Great Plains Grassland & Shrubland
5 – Macrogroup	Scientific Name: *Andropogon gerardii – Schizachyrium scoparium – Sorghastrum nutans* Grassland & Shrubland Macrogroup Colloquial Name: Great Plains Tall Grassland & Shrubland
6 – Group	Scientific Name: *Andropogon gerardii – Sporobolus heterolepis* Grassland Group Colloquial Name: Great Plains Mesic Tallgrass Prairie
Lower Levels	
7 – Alliance	Scientific Name: *Andropogon gerardii* – (*Calamagrostis canadensis – Panicum virgatum*) Herbaceous Alliance Colloquial Name: Wet-mesic Tallgrass Prairie
8 – Association	Scientific Name: *Andropogon gerardii – Panicum virgatum – Helianthus grosseserratus* Herbaceous Vegetation Colloquial Name: Central Wet-mesic Tallgrass Prairie

Modern vegetation classification involves a hierarchical approach in which categories are mutually exclusive and the organization allows aggregation of mutually exclusive finer-resolution classification into broader and broader classifications (Federal Geographic Data Committee 2008). The higher-level classifications are based on the structure and growth form of the dominant vegetation (tree, grass, shrub) with floristic characteristics such as the dominant plant species introduced at lower levels of the hierarchy (Table 2-1). Floristic information is found in the Alliances and Associations, with the finest scale classification requiring detailed information about coherent stands of vegetation and their species composition to classify properly. If a researcher lacks this information, however, the vegetation can still be mapped at a higher classification in the hierarchy. For example, in this study, vegetation is classified to the Alliance level with identification of the diagnostic dominant species in the uppermost stratum.

Segmentation and Classification Approaches

Classification of aerial or satellite imagery to define units on the ground is the focus of the field of remote sensing. One approach to classifying vegetation in an image is to use the spectral characteristics of color and infrared bands that may be present in the sensor and use those characteristics to describe the features on the ground in a pixel-by-pixel approach (Xie et al. 2008). An alternative approach is to analyze the images in a way that pixels are related to their surroundings and to apply algorithms that attempt to identify "objects" made up of adjacent pixels that share similarities and are different from those around them (Blaschke 2010). This approach builds on a long history of image segmentation and classification in remote sensing (Blaschke 2010). Segmentation is the activity of dividing an image up into coherent units based on the spectral characteristics and geographic configuration of pixels, while classification involves interpreting what those units represent on the ground. The segmentation process produces candidates for definition into a vegetation class, while the classification process provides those categories and accepts or rejects the candidate objects as defined through the image segmentation algorithms (Burnett & Blaschke 2003). This approach outperforms per-pixel classification approaches and can be further improved through incorporation of height measured through LiDAR (Yan et al. 2015).

Previous Vegetation Maps

The 1978 vegetation map identifies two types of coastal sage scrub, dominated by coyote brush or sagebrush, elderberry, prickly-pear cactus, and riparian associations as native vegetation(Marqua 1978). Most of the land was mapped as "low annual growth" or "little or no plant cover." Some limited area supported eucalyptus. The map did not include most of the lands associated with the Holy Cross Cemetery or the Stocker Corridor.

Anderson (2001) undertook extensive field visits to create a map for an overall biota report on the Baldwin Hills. The oil fields were not mapped and the Stocker Corridor was not included. The vegetation classifications included coastal scrub (north-facing and south-facing), coastal sage scrub, prickly-pear populations, annuals two categories of disturbed vegetation, hardpan/seasonal standing water, urban riparian, drainage/runoff areas, grassland/prairie, highly modified/sparsely vegetated, and both habitat and populations of note.

The Community Standards District mapping was restricted to the oil field area and mapped coastal scrub/disturbed coastal scrub, coyote brush scrub/disturbed coyote brush scrub, riparian scrub/disturbed riparian scrub, willows, cottonwood, sycamore, and a range of other nonnative vegetation types (Marine Research Specialists 2008).

The environmental documentation for the Park to Playa trail system includes another map of vegetation of a subset of the Baldwin Hills Conservancy territory, extending along the northern portion of the area with a focus on the publicly owned parcels (BonTerra Consulting 2013). The vegetation classifications for this map included annual brome grasslands, California sagebrush, California buckwheat scrub, coast live oak woodland, elderberry scrub, giant wild rye grassland, ornamental, ruderal, eucalyptus grove, toyon chaparral, and willow thickets.

Methods

The purpose of producing the map is to provide a replicable approach to mapping all of the Baldwin Hills using the same classification scheme in a manner that can be applied to properties to which on-the-ground access is not available. To do so we used ortho-imagery as the primary source to segment and classify the study area. The dataset was provided by the Los Angeles Region Imagery Acquisition Consortium (LAR-IAC) and Infotech Enterprises America, Inc. We did not set a minimum mapping unit, but rather relied on automated clustering algorithm and subsequent editing through air photo interpretation to exhaustively map the study area. The aerial photography did not have an infrared band, which could have been obtained using satellite imagery, but the 4-inch spatial resolution of the data was an advantage that outweighed the lack of infrared data that otherwise might have provided information about the chlorophyll content of the ground substrate and be used to classify vegetation.

Study Area

The study area is the official boundaries of the Baldwin Hills Conservancy territory, as defined in a shapefile provided by the agency. It consists of the undeveloped portions of the Baldwin Hills, the Inglewood Oil Field, several parks, and an extent along Ballona Creek that encompasses the channel upstream and downstream from the closest point to the Baldwin Hills at the Baldwin Hills Scenic Overlook. To help understand the vegetation surrounding the Ballona Creek, we buffered this area by 100 feet and classified the vegetation within this buffer as well.

Plant Species List

We developed a list of plant species that have been observed or collected in the Baldwin Hills. This list was compiled from previous reports on the vegetation of the Baldwin Hills (Anderson 2001; Cardno ENTRIX & ENVIRON 2014; Marine Research Specialists 2008; Marqua 1978) and complemented by herbarium data. We obtained herbarium specimen records for Los Angeles County from the online records maintained by the Jepson Online Interchange (http://ucjeps.berkeley.edu/interchange.html). This database includes records from the Consortium of California Herbaria (http://ucjeps.berkeley.edu/consortium/participants.html). The online service does not allow bulk downloads so requested the data, including "habitat notes" from the herbarium labels directly from the site manager. We imported this dataset into Excel and searched for all records with place names in the Baldwin Hills.

Classification System

We used the plant alliances from *A Manual of California Vegetation* (Sawyer et al. 2009) as the classification system. This approach is consistent with the National Vegetation Classification System (Jennings et al. 2009). We tailored the classification system to the Baldwin Hills area by developing a list of additional alliances and adding them to the classification scheme. These additional alliances described areas where exotic species dominated or co-dominated plant communities. Because alliances are described based on the tallest dominant vegetation, this approach was appropriate for use with aerial photography. The understory floristic details were available from previous mapping and plant collection efforts.

Data Sources

We used the Color Orthophotography (Los Angeles County GIS Data Portal http://egis3.lacounty.gov/dataportal/) as the main source for deriving vegetated land cover. This dataset is a natural color, leaf-off, high-resolution (4-inch and 1-foot), high-accuracy orthorectified aerial imagery, acquired during winter 2010/2011. In addition, we used datasets derived from the LAR-IAC 2006 initiative: tree canopy raster data, Normalized Difference Vegetation Index (NDVI), and buildings footprints. Parcel geometry was obtained from the Los Angeles County Office of the Assessor.

NDVI is one of the most common spectral ratio indexes that are used in remote sensing field to characterize vegetation life stage and overall health. The process of photosynthesis — conversion of light to chemical energy with the release of oxygen as a side-product — is kept by the absorption of Sun energy in the visible to near-infrared (NIR) region of the spectrum. At the same time, energy of NIR region is reflected more strongly than that of the visible portion. The amount of chlorophyll contained in a plant's cell, as well as the inner structure of the plant tissue influence the proportion of absorbed and reflected solar radiation in the whole visible–near-infrared region. Analysis of the absorption/reflectance spectra reveals information about the nature, structure, and composition of vegetation substrate.

Field Data

The data were collected during fourteen site visits during fall 2014 and spring 2015 using Trimble GPS unit and ESRI Collector for GIS App. We used ProXH Trimble GPS unit to document the location of observations of vegetation that could be observed from publicly accessible roads and trails but were not open to the public. The GPS unit was equipped with TerraSync software and was configured to accept a Laser Rangerfinder with Compass to correct for the offsets between the location of the observer and the location of an observation. Each plot was recorded using detailed Data Dictionary with attached photographs.

Most data were collected using ESRI Collector for GIS. This tool is built from a template (available at www.arcgis.com), configured to meet the needs of a specific project, and downloaded to a mobile device. The data are recorded into the domain geodatabase using drop down lists, and are automatically logged with the current location and time. The application offers such capabilities as finding features and capturing photos and videos, and allows working on-line or off-line.

We used other vegetation data available from previous surveys to cross-check our results. More specifically, locations of invasive species (as mapped in 2011 in a project led by the nonprofit organization Generation Water), invasive plants polygons (Cardno ENTRIX & ENVIRON 2014), and plant associations and habitats (Marine Research Specialists 2008; Molina 2001).

Map Production

We pursued an iterative classification approach that started with two land cover classes: "Vegetated" and "Unvegetated", and followed with further separation of "Vegetated" class into first, vegetation life forms defined by height (i.e., "Trees and Tall Shrubs", "Shrubs / Scrub / Thickets" of intermediate height, and "Grass"), and then into vegetation species alliances. As classification scheme narrowed, the approach gradually shifted from automatic to manual, more heavily relying on aerial interpretation of the land cover (Figure 2-2).

We built a template in the form of a GIS shapefile that could be filled with vegetation information and excluded unvegetated areas from further analysis. A one-foot resolution color image mosaic was segmented using IDRISI Selva software. Segmentation results served as a template for vegetation classification. An iso-cluster unsupervised classification algorithm was applied to the image. Iso-cluster unsupervised classification is an iterative procedure that does not require *a priori* knowledge of the study area. It clusters pixels around class means that are distributed evenly in data space, recalculates class mean and standard deviation in each iteration, and reclassifies pixels accordingly. We calculated iso-clusters with 2 and 5 classes using color bands, 5 classes using NDVI 2006 data, and 5 classes using a composite file that had color bands from 2011 and NDVI from 2006. The resultant class values for each classification raster were summarized within the segments using majority statistics (ArcGIS Zonal Statistics tool). In addition, we included the trees dataset derived from LAR-IAC 2006 data (Figure 2-3). Segments that did not match values from either classification raster were visually examined against the 4-inch resolution aerial photography and defined. The shape and size of polygons was examined and altered to better match or generalize vegetation patterns. This resulted in the Level 1 classification: "Vegetated" and "Unvegetated".

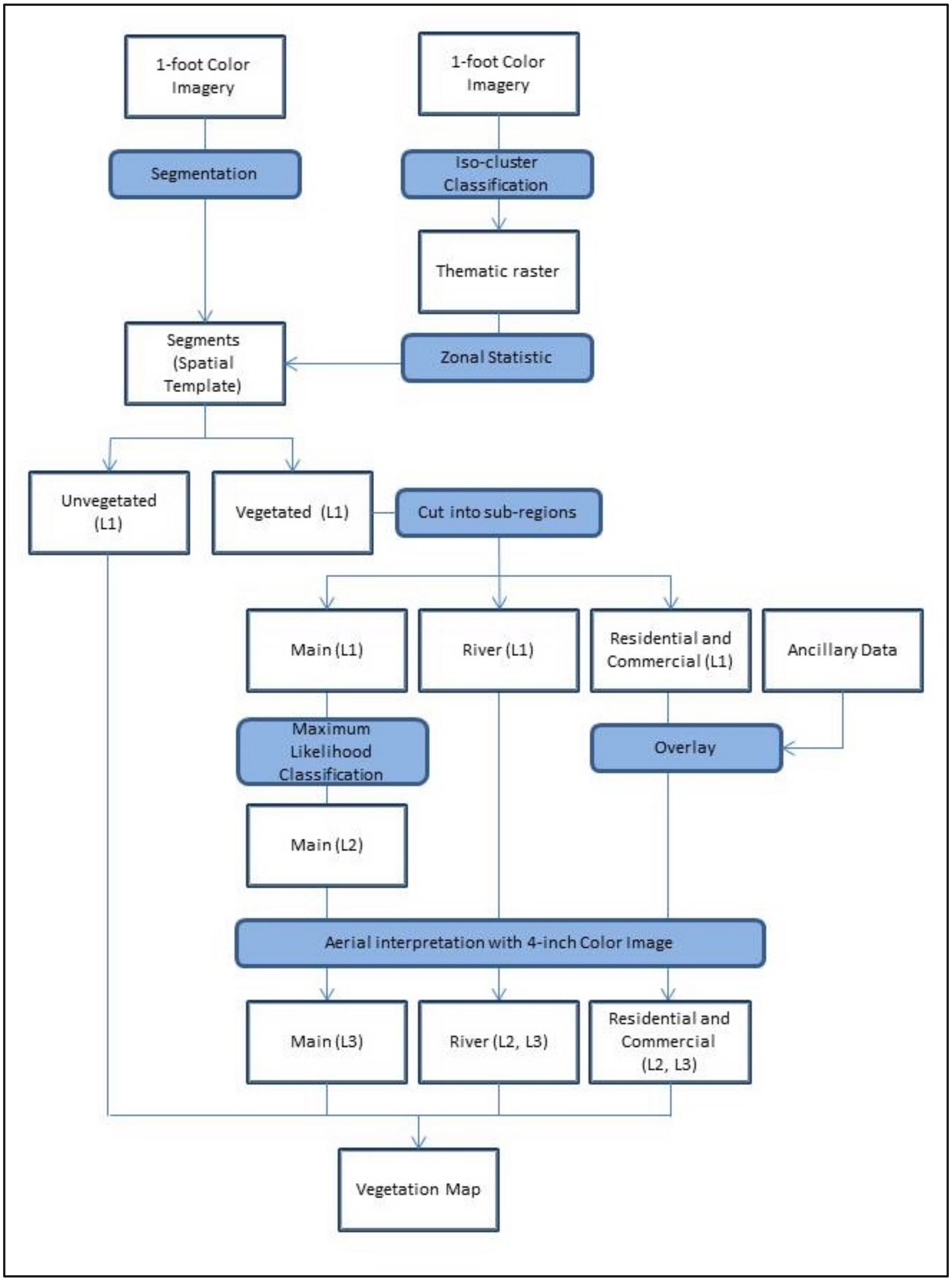
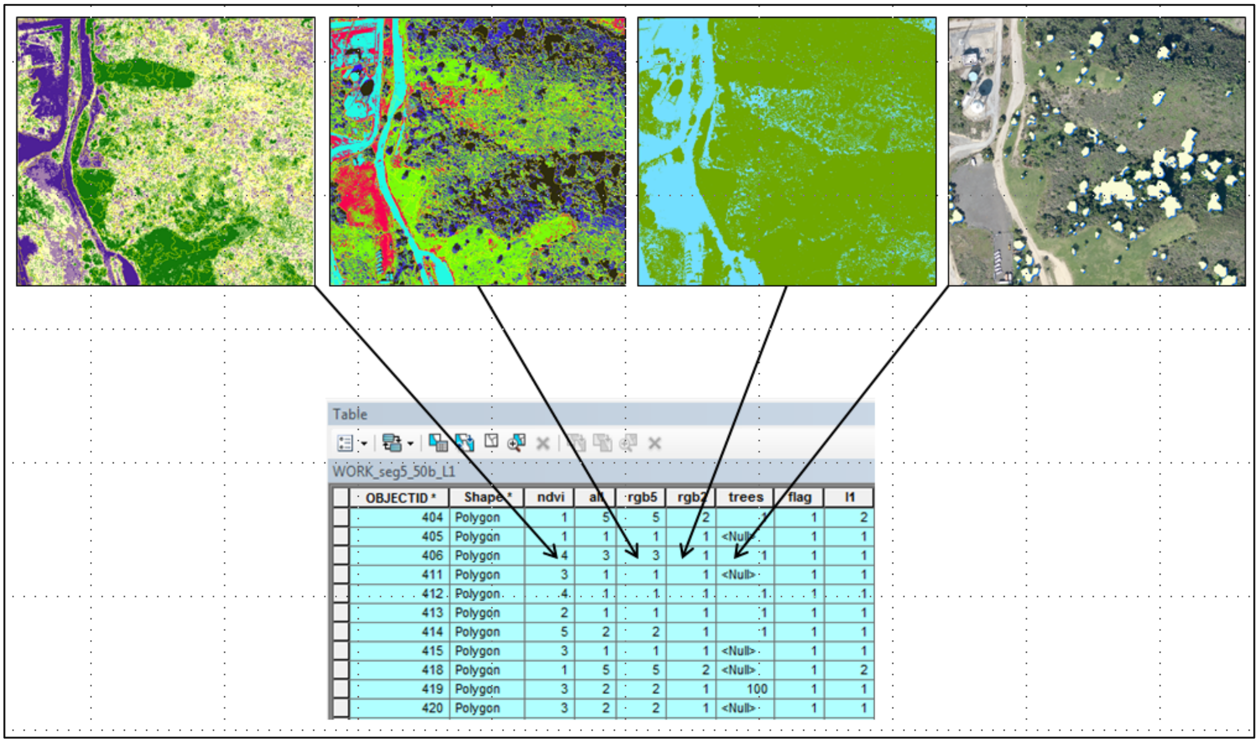


Figure 2-2. Generalized work flow to produce vegetation map.



OBJECTID *	Shape *	ndvi	all	rgb5	rgb2	trees	flag	l1
404	Polygon	1	5	5	2	1	1	2
405	Polygon	1	1	1	1	<Null>	1	1
406	Polygon	4	3	3	1	1	1	1
411	Polygon	3	1	1	1	<Null>	1	1
412	Polygon	4	1	1	1	1	1	1
413	Polygon	2	1	1	1	1	1	1
414	Polygon	5	2	2	1	1	1	1
415	Polygon	3	1	1	1	<Null>	1	1
418	Polygon	1	5	5	2	<Null>	1	2
419	Polygon	3	2	2	1	100	1	1
420	Polygon	3	2	2	1	<Null>	1	1

Figure 2-3. Example of data sources used for vegetation classification.

We decided not to exclude the non-vegetated class from further analysis, but rather to use it to increase confidence in the classifications. We then divided the study area into several sub-regions (Figure 2-4) and proceeded with each section separately.

The Maximum Likelihood classification method was used to discriminate vegetation life forms in the “Vegetated” part of the “Main” sub-region of the study area and to cross-check the results of the first level classification. Unlike iso-cluster algorithm, maximum likelihood classifier requires training data; it assumes that the statistics for each class in each band are normal, computes probability of class membership for each pixel, and distributes pixels among classes based on highest probability. The training set for the whole area contained following classes: Asphalt, Grass, Shrubs, Trees, Soil, and Man-made. The training set for the vegetated part of the study area had Grass, Shrubs, Trees, Dry Vegetation, and Bare Land classes. The training sites for each class were spread throughout the area to encompass spectral variation due to terrain ruggedness. The results were then examined, reclassified, and smoothed with the ArcGIS Majority filter. The spatial template was then populated with the smoothed classification results, examined, and edited where needed. The Level 2 classification of vegetation has the following classes: 1 - Trees and Tall Shrubs, 2 - Shrubs / Scrub / Thickets, 3 – Grass. In this step, Level 1 classification and polygons were edited where needed as well.

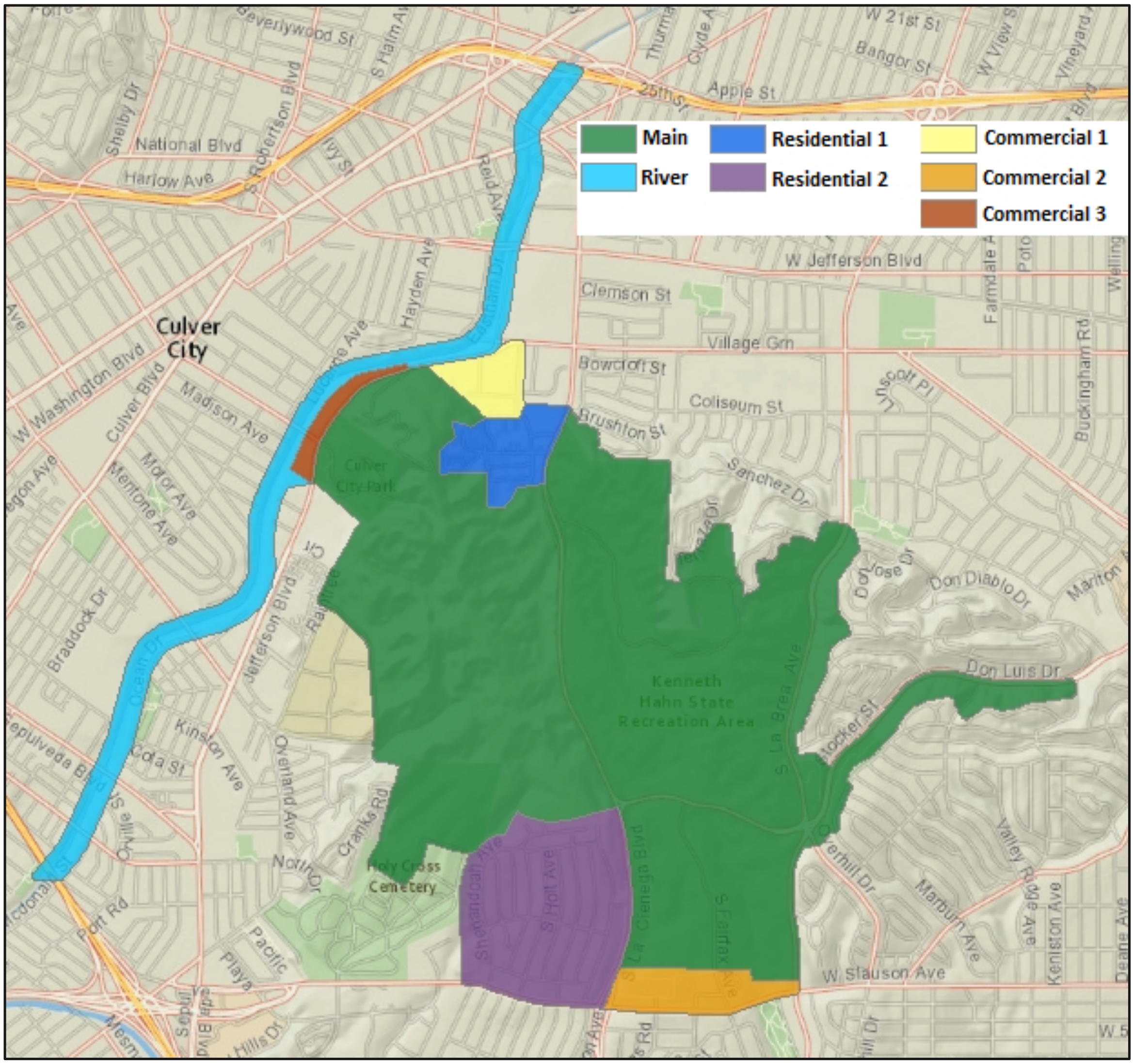


Figure 2-4. Subareas used to produce vegetation map. The "main" area includes several different land uses, including protected open space, industrial land (oil field), recreational areas, and a cemetery.

The Main and the River parts of the study area were further classified into Level 3 vegetation alliances, using newly and previously collected data and aerial photo interpretation.

The two residential and three commercial subsets were mapped by overlaying existing GIS layers: parcels, building footprints and trees. The Roads layer was built by using 12-feet inward buffer on the Parcels layer; the original Trees layer was available in a raster format with pixel values corresponding to trees and shadows. Pixels with values corresponding to "trees" were converted to vector format, buffered with 2-feet distance and simplified in ArcGIS software. The area other than roads, buildings and trees was masked out and subjected to image classification to define vegetated and unvegetated areas. Finally, the listed files were overlaid; the results were cleaned using Eliminate ArcGIS tool. Vegetation in most of residential and commercial areas consisted of ornamental trees and shrubs. Therefore, they were all assigned to a class named "Ornamental". The "River" sub-region received least of the automatic processing. Vegetation of this sub-region was mapped using extensive field data and aerial interpretation. The vegetation data were matched with the spatial template produced during the segmentation process.

Completed datasets were cross-checked with the existing maps (ecosystems, habitats, plant communities, invasive plants) and validated in the field from varying distances. We validated the segmentation and classification by observing and taking photographs of vegetation and individual plants to confirm or update identifications that had been made through air photo interpretation. Field visits were limited to the parks and public lands where permission was granted to undertake research (Culver City Park, Kenneth Hahn State Recreation Area, and Baldwin Hills Scenic Overlook) and other spaces open to the public along streets, roads, and sidewalks. We used binoculars and a combination of GPS with a laser rangefinder to locate and identify plants that were on lands to which access on foot was not feasible, such as the Inglewood Oil Field.

Map Analysis

We used ArcGIS tools to produce summary statistics for land use/land cover and vegetation cover for the different levels of our classification hierarchy. To visualize the results, we classified the vegetation alliances into the exclusive categories of native shrubland, native woodland, exotic shrubland, exotic woodland, or exotic grassland. These categories are based on the dominant plant species only and when co-dominant species were observed, the origin (native or exotic) of the more common species was used to classify the patch.

We compared our classification to previous maps of Baldwin Hills vegetation by querying our new map within the extent and land cover/land use categories presented in previous maps.

Results

Plant List

The cumulative plant list includes herbarium specimens, observations from previous survey efforts with more attention and time given to developing a comprehensive plant list, and those species encountered during our mapping (Table 2-2). Failure to report a species during any particular survey should not necessarily be interpreted as its absence because the survey efforts and survey purposes were not the same.

The plants are categorized into those that are California natives introduced to the Baldwin Hills, species not native to California at all, and species native to the Baldwin Hills prior to European colonization.

Table 2-2. Plant species documented from the Baldwin Hills from herbarium, survey, and citizen science sources. Date of most recent herbarium record is given. Reports from 2016 are not the result of a comprehensive floristic survey, but rather those species encountered in process of documenting dominant species in uppermost stratum.

Family	Scientific Name	Common Name	Herbarium	1980	2001	2016
Introduced California Natives						
	Dicots					
Anacardiaceae	*Rhus integrifolia*	lemonadeberry				X
Asclepiadaceae	*Asclepias vestita*	woolly milkweed			X	
Betulaceae	*Alnus rhombifolia*	alder			X	X
Fabaceae	*Cercis occidentalis*	western redbud			X	
Fagaceae	*Quercus agrifolia*	coast live oak		X		X
Fagaceae	*Quercus lobata*	valley oak			X	
Malvaceae	*Fremontodendron californicum*	flannelbush			X	
Oleaceae	*Fraxinus latifolia*	Oregon ash				X
Exotic Species						
	Dicots					
Aizoaceae	*Carpobrotus edulis*	iceplant		X	X	X
Altingiaceae	*Liquidambar styraciflua*	sweet gum			X	
Anacardiaceae	*Schinus molle*	Peruvian pepper			X	X
Anacardiaceae	*Schinus terebinthifolius*	Brazilian pepper				X
Apiaceae	*Conium maculatum*	poison hemlock		X	X	
Apiaceae	*Foeniculum vulgare*	sweet fennel		X	X	X
Apocynaceae	*Nerium oleander*	oleander		X		
Araliaceae	*Hedera helix*	English ivy		X		
Asteraceae	*Ageratina adenophora*	sticky snakeroot			X	
Asteraceae	*Bellis perennis*	English daisy			X	
Asteraceae	*Bidens pilosa var. pilosa*	common begggar-ticks			X	
Asteraceae	*Centaurea melitensis*	star thistle		X	X	
Asteraceae	*Chamomilla suaveolens*	pineapple weed			X	
Asteraceae	*Chrysanthemem coronarium*	garland chrysanthemum		X	X	
Asteraceae	*Cirsium arvense*	Canada thistle			X	
Asteraceae	*Cirsium vulgare*	bull thistle			X	
Asteraceae	*Conyza bonariensis*	Flax-leaved horseweed			X	
Asteraceae	*Cotula coronopifolia*	brass buttons		X		
Asteraceae	*Delairea odorata [=Senecio mikanioides]*	Cape ivy			X	
Asteraceae	*Gazania linearis*				X	
Asteraceae	*Lactuca serriola*	prickly lettuce			X	
Asteraceae	*Picris echioides*	ox-tongue		X	X	
Asteraceae	*Senecio angulatus*	Kennelworth ivy		X		
Asteraceae	*Silybum marianum*	milk thistle		X	X	
Asteraceae	*Sonchus oleraceus*	sow-thistle		X	X	
Asteraceae	*Xanthium strumarium*	cocklebur		X	X	

Bignoniaceae	*Jacaranda mimosifolia*	jacaranda			X
Brassicaceae	*Brassica nigra*	black mustard	X	X	X
Brassicaceae	*Brassica rapa ssp. Sylvestris*	field mustard	X		
Brassicaceae	*Hirschfeldia incana*	shortpod mustard		X	
Brassicaceae	*Lobularia maritima*	sweet alyssum	X	X	
Brassicaceae	*Raphanus sativus [Raphanus raphanistrum]*	wild radish	X	X	X
Caryophyllaceae	*Silene gallica*	catchfly	X	X	
Caryophyllaceae	*Spergularia villosa*	hairy sandspurry		X	
Casuarinaceae	*Casuarina sp.*	beefwood		X	
Chenopodiaceae	*Atriplex semibaccata*	Australian saltbush	X		
Chenopodiaceae	*Bassia hyssopifolia*	fivehook bassia		X	
Chenopodiaceae	*Chenopodium album*	Lamb's quarters		X	
Chenopodiaceae	*Chenopodium glaucum*	oak leaved goosefoot		X	
Chenopodiaceae	*Chenopodium sp.*	goosefoot	X		
Chenopodiaceae	*Salsola iberica [S. tragus]*	Russian thistle	X	X	X
Cistaceae	*Cistus sp.*	rockrose		X	
Crassulaceae	*Aeonium sp.*	stonecrop	X		
Crassulaceae	*Crassula argentea*	jade plant	X		
Euphorbiaceae	*Euphorbia maculata*	spotted spurge		X	
Euphorbiaceae	*Ricinus communis*	castor bean	X	X	X
Fabaceae	*Acacia sp. [Acacia longifolia]*	Acacia	X	X	X
Fabaceae	*Ceratonia siliqua*	carob tree	X		
Fabaceae	*Lotus corniculatus*	Birdfoot trefoil		X	
Fabaceae	*Medicago polymorpha*	California burclover		X	
Fabaceae	*Melilotus alba*	white sweetclover		X	
Fabaceae	*Melilotus indica*	yellow sweetclover		X	
Fabaceae	*Meliotus sp.*	sweet-clover	X	X	
Fabaceae	*Pisum sativum*	garden pea	X		
Fabaceae	*Spartium junceum*	Spanish broom	X	X	
Fabaceae	*Trifolium repens*	White clover		X	
Fabaceae	*Vicia benchalensis*	purple vetch		X	
Geraniaceae	*Erodium botrys*	long-beaked storksbill	X	X	
Geraniaceae	*Erodium cicutarium*	filareee	X	X	
Geraniaceae	*Pelargonium sp. [Geranium retrosum]*	geranium	X	X	
Lamiaceae	*Marrubium vulgare*	horehound	X	X	
Lauraceae	*Cinnamomum camphora*	camphor tree			X
Lauraceae	*Persea americana*	avacado	X		
Magnoliaceae	*Liriodendron*	Tulip Tree			X
Magnoliaceae	*Magnolia grandiflora*	magnolia			X
Malvaceae	*Hibiscus sp.*	hibiscus	X		
Malvaceae	*Malva parviflora*	cheeseweed		X	
Myoporaceae	*Myoporum laetum*			X	
Myrtaceae	*Eucalyptus sideroxylon*	red iron bark		X	
Myrtaceae	*Eucalyptus sp.*	eucalyptus	X		

Oleaceae	*Fraxinus nigra*	black ash			X
Oleaceae	*Ligustrum texanum*	privet	X		
Oxalidaceae	*Oxalis pes-caprae*	Bermuda buttercup	X		
Plantaginaceae	*Plantago lanceolata*	plantain		X	
Plumbaginaceae	*Limonium sinuatum*	sea lavander		X	
Plumbaginaceae	*Plumbago auriculata*	Cape plumbago		X	
Polygonaceae	*Polygonum arenastrum*	common knotweed		X	
Polygonaceae	*Rumex crispus*	curly dock		X	
Portlacaceae	*Portulaca oleracea*	portulaca	X	X	
Primulaceae	*Anagalis arvensis*	pimpernel	X	X	
Rosaceae	*Prunus persica*	peach tree	X		
Rosaceae	*Prunus sp.*			X	
Rosaceae	*Rosa sp*	rose	X		
Rutaceae	*Citrus sinensis*	orange tree	X		
Salicaceae	*Populus fremontii*	Fremont cottonwood	X		X
Sapindaceae	*Cupaniopsis parvifolia*				X
Scrophulariaceae	*Verbascum blattaria*	moth mullein		X	
Scrophulariaceae	*Verbascum thapsus*	common mullein	X		
Solanaceae	*Nicotiana glauca*	tree tobacco	X	X	
Solanaceae	*Solandra hartwegii*	cup-o-gold bush	X		
Solanaceae	*Solanum elaeagnifolium*	silver leaf nettle	X	X	
Tropaeolaceae	*Tropaeoleum majus*	garden nasturtium	X	X	
Verbenaceae	*Lantana montevidensis*	lantana	X	X	
Zygophyllaceae	*Tribulus terrestris*	puncture vine		X	
	Euphorbia terracina				
Gymnosperms					
Cupressaceae	*Cupressus sempervirens [C. sp.]*	Mediterranean cypress	X		X
Cupressaceae	*Juniperus sp.*	Juniper		X	
Cupressaceae	*Thuja sp.*	Cedar		X	
Pinaceae	*Cedrus deodara*	deodar cedar		X	X
Pinaceae	*Pinus canariensis*	Canary Island pline			X
Pinaceae	*Pinus halepensis*	Aleppo pine		X	
Pinaceae	*Pinus radiata*	Monterey pine		X	X
Pinaceae	*Pinus sp.*	pine	X		
	Moncots				
Agavaceae	*Agave americana [A. sp.]*	American century plant	X		X
Arecaceae	*Washingtonia robusta [W. sp.]*	fan palm		X	X
Liliaceae	*Narcissus sp.*			X	
Liliaceae	*Yucca elephantipes*			X	X
Poaceae	*Arundo donax*	giant reed		X	X
Poaceae	*Avena barbata*	slender wild oat		X	X
Poaceae	*Avena fatua*	wild oat	X	X	
Poaceae	*Bromus diandrus*	ripgut brome	X		
Poaceae	*Bromus mollis*	soft chess	X		
Poaceae	*Bromus rubens*	red brome	X	X	
Poaceae	*Bromus tectorum*	cheat grass		X	

Poaceae	*Cortaderia jubata*	Pampas grass		X	X	
Poaceae	*Cortaderia selloana*	Pampas grass			X	X
Poaceae	*Cynodon dactylon*	Bermuda grass			X	
Poaceae	*Dactylis glomerata*	orchard grass			X	
Poaceae	*Digitaria sanguinalis*	hairy crabgrass			X	
Poaceae	*Hordeum murinum ssp. leporinum*	barley		X	X	
Poaceae	*Lamarckia aurea*	goldentop		X		
Poaceae	*Lolium sp.*	annual ryegrass		X		
Poaceae	*Paspalum dilatatum*	Dallis grass			X	
Poaceae	*Pennisetum setaceum*	fountaingrass		X	X	X
Poaceae	*Piptatherum miliaceum*	smilo grass			X	X
Poaceae	*Polypogon monspeliensis*	rabbitfoot grass		X		
Poaceae	*Schismus barbatus*	schismus grass		X	X	
Native Species						
	Dicots					
Anacardiaceae	*Rhus laurina*	laurel sumac		X	X	
Anacardiaceae	*Rhus ovata*	sugar bush		X	X	
Anacardiaceae	*Toxicodendron diversilobum*	poison-oak		X	X	
Apiaceae	*Sanicula arguta*	sharp toothed snakeroot	1927			
Asclepiadaceae	*Asclepias fascicularis*	California milkweed			X	
Asteraceae	*Achillea millefolium*	yarrow			X	
Asteraceae	*Achyrachaena mollis*	blow-wives			X	
Asteraceae	*Ambrosia psilostachya var californica*	western ragweed		X	X	
Asteraceae	*Artemisia californica*	California sagebrush		X	X	X
Asteraceae	*Artemisia douglasiana*	mugwort		X		
Asteraceae	*Baccharis pilularis ssp. consanguinea*	coyote brush		X	X	X
Asteraceae	*Baccharis salicifolia [=glutinosa]*	mulefat		X	X	X
Asteraceae	*Corethrogyne filaginifolia*	common sandaster	1927		X	
Asteraceae	*Deinandra fasciculata [Hemizonia ramosissima]*	common tarweed	2009	X	X	
Asteraceae	*Encelia californica*	California sunflower	1986	X	X	X
Asteraceae	*Ericameria palmeri var. pachylepis*	broad scaled Palmer's goldenbush	1931			
Asteraceae	*Erigeron foliosus*	leafy fleabane		X		
Asteraceae	*Filago californica*	California cottonrose			X	
Asteraceae	*Grindelia camporum*	common gumplant	1931		X	
Asteraceae	*Haplopappus pinifolius*	pinebush		X		
Asteraceae	*Helianthus annuus*	common sunflower		X		
Asteraceae	*Heterotheca grandiflora*	telegraph weed		X	X	
Asteraceae	*Isocoma menziesii var. vernonioides*	coastal goldenbush	1931	X		
Asteraceae	*Lasthenia gracilis*	needle goldfields	1927			

Asteraceae	*Malacothrix saxatilis var. tenuifolia*	cliff malacothrix		X	X	
Asteraceae	*Pseudognaphalium beneolens*	cudweed			X	
Asteraceae	*Pseudognaphalium biolettii [=Gnaphalium bicolor]*	two-color rabbit-tobacco		X	X	
Asteraceae	*Pseudognaphalium californicum*	ladies' tobacco			X	
Asteraceae	*Pseudognaphalium ramosissimum*	pink cudweed			X	
Asteraceae	*Pseudognaphalium stramineum*	cottonbatting plant			X	
Asteraceae	*Stephanomeria exigua subsp. coronaria*	milk aster	1931			
Boraginaceae	*Cryptantha intermedia*	Clearwater cryptantha	1927			
Cactaceae	*Opuntia littoralis / Opuntia X occidentalis*	prickly-pear cactus		X	X	X
Cactaceae	*Opuntia oricola*	coast prickly-pear		X		
Caprifoliaceae	*Sambucus nigra ssp. caerulea*	elderberry	2008	X	X	X
Caryophyllaceae	*Silene laciniata subsp. major*	cardinal catchfly	1937			
Convolvulaceae	*Calystegia macrostegia ssp. intermedia*	south coast morning-glory	2008	X	X	
Crassulaceae	*Crassula erecta [C. ovata]*	pigmy weed		X		X
Crassulaceae	*Dudleya lanceolata*	lanceleaf liveforever	1986		X	
Cucurbitaceae	*Cucurbita foetidissima*	calabazilla		X	X	
Cucurbitaceae	*Marah macrocarpus*	bigroot		X	X	
Cuscutaceae	*Cuscuta californica*	Dodder			X	
Euphorbiaceae	*Croton californicus*	California croton	2008	X		
Euphorbiaceae	*Eremocarpus setigerus*	turkey mullein		X	X	
Euphorbiaceae	*Euphorbia albomarginata*	rattlesnake weed		X	X	
Euphorbiaceae	*Euphorbia crenulata*	Chinese caps			X	
Fabaceae	*Acmispon americanus*	Spanish lotus	2009	X	X	
Fabaceae	*Acmispon glaber*	deerweed		X	X	
Fabaceae	*Acmispon maritimus*	coastal lotus	1925		X	
Fabaceae	*Acmispon strigosus*	strigose lotus		X		
Fabaceae	*Astragalus trichopodus var. lonchus [mis-ids as Astragalus curtipes]*	locoweed	1903	X	X	
Fabaceae	*Lupinus bicolor*	miniature lupine	2009		X	
Fabaceae	*Lupinus hirsutissimus*	nettle annual lupine		X		
Fabaceae	*Lupinus longifolius*	bush lupine		X	X	
Fabaceae	*Lupinus succulentus*	succulent lupine	1934	X	X	
Fabaceae	*Trifolium albopurpureum*	Indian clover			X	
Fabaceae	*Trifolium depauperatum var. truncatum*	dwarf sack clover			X	
Fagaceae	*Quercus dumosa*	scrub oak			X	

Hydrophyllaceae	*Phacelia cicutaria var. hispida*	caterpillar phacelia			X	
Hydrophyllaceae	*Phacelia ramosissima*	branching phacelia		X		
Juglandaceae	*Juglans californica*	California black walnut		X	X	X
Lamiaceae	*Prunella vulgaris var. vulgaris*	self-heal			X	
Lamiaceae	*Salvia apiana*	white sage				
Lamiaceae	*Salvia mellifera*	black sage		X	X	
Lamiaceae	*Stachys ajugoides*	hedge-nettle		X		
Lamiaceae	*Stachys bullata*	California hedgenettle	1925			
Nyctaginaceae	*Mirabilis laevis var. crassifolia [=M. californica]*	California four o'clock	1937		X	
Onagraceae	*Camissonia bistorta*	sun cup		X		
Onagraceae	*Epilobium canum*	zauschneria			X	
Onagraceae	*Epilobium ciliatum ssp. ciliatum*	fringed willowherb			X	
Onagraceae	*Oenothera elata*	hairy evening primrose	2008			
Papaveraceae	*Eschscholzia californica*	California poppy			X	
Plantaginaceae	*Plantago erecta*	dotseed plantain	1897			
Platanaceae	*Platanus racemosa*	western sycamore			X	X
Polemoniaceae	*Gilia angelensis*	chaparral gilia	2009			
Polemoniaceae	*Linanthus dianthiflorus*	fringed linanthus	1927			
Polygonaceae	*Chorizanthe staticoides*	Turkish rugging			X	
Polygonaceae	*Eriogonoum fasciculatum*	wild buckwheat		X	X	X
Polygonaceae	*Eriogonum elongatum*	long-stemmed buckwheat		X		
Polygonaceae	*Rumex hymenosepalus*	wild rubarb		X		
Rhamnaceae	*Ceanothus spinosus*	greenbark ceanothus			X	X
Rosaceae	*Adenostoma fasciculatum*	chamise	2008			
Rosaceae	*Heteromeles arbutifolia*	toyon		X	X	X
Rosaceae	*Prunus ilicifolia ssp. Ilicifolia*	holly-leafed cherry			X	
Rosaceae	*Prunus ilicifolia ssp. lyonii*	Catalina cherry	1986	X	X	
Rosaceae	*Rosa californica*	California wild rose		X	X	
Rosaceae	*Rubus ursinus*	wild blackberry		X		
Rubiacae	*Galium angustifolium*	narrow-leaved bedstraw		X	X	
Rubiacae	*Galium aparine*	bedstraw		X		
Salicaceae	*Salix hindsiana*	sandbar willow		X		
Salicaceae	*Salix lasiolepis*	arroyo willow		X	X	X
Sapindaceae	*Aesculus californica*	horsechestnut			X	
Scrophulariaceae	*Castilleja affinis*	Indian paintbrush	1931			
Scrophulariaceae	*Mimulus aurantiacus*	monkeyflower			X	
Solanaceae	*Datura meteloides [Datura wrightii]*	jimsonweed		X	X	

Solanaceae	*Solanum douglasii*	Douglas nightshade		X	X	
Urticaceae	*Urtica holosericea*	stinging nettle		X		
Verbenaceae	*Verbena lasiostachys var. lasiostachys*	Common verbena	1986	X	X	
Violaceae	*Viola sp.*	violet		X		
Vitaceae	*Vitis girdiana*	wild grape		X		
	Ferns					
Dryopteridaceae	*Dryopteris arguta*	coastal woodfern			X	
Pteridaceae	*Pityrogramma triangularis*	goldenback fern		X		
	Monocots					
Cyperaceae	*Cyperus odoratus*	nutsedge			X	
Iridaceae	*Sisyrinchium bellum*	blue-eyed grass		X	X	
Juncaceae	*Juncus bufonius*	toad rush			X	
Liliaceae	*Chlorogalum pomeridianum*	soap plant		X		
Poaceae	*Elymus condensatus*	giant wild rye	1948	X		X
Poaceae	*Elymus glaucus*	wild bluerye			X	
Poaceae	*Melica imperfecta*	smallflower melicgrass	1925		X	
Poaceae	*Nassella pulchra*	purple needle grass			X	
Poaceae	*Vulpia microstachys var. pauciflora*	small fescue			X	
Themidaceae	*Dichelostemma capitatum (=pulchellum)*	blue dicks		X	X	
Typhaceae	*Typha latifolia*	cattail			X	

Note: Some historical entries with ambiguous classifications were updated to correspond with modern surveys. Scientific names were updated with current taxonomy.

Vegetation Alliances Mapped

Sixteen vegetation alliances that have been previously described were identified and mapped across the Baldwin Hills study area. Of these, one was dominated by exotic species (Ice plant mats) and two of the alliances dominated by California natives were described as "regionally native" in the Baldwin Hills because the dominant species were introduced through planting (Coast Live Oak, Sycamore, and Cottonwood) and no confirmation of the historical presence of these species in the area where they were planted is available.

Table 2-3. Vegetation Alliances mapped in the Baldwin Hills previously described by Sawyer et al. (2009)

Alliance	Notes
Arroyo willow thickets	With Coyote Brush, Peruvian Peppertree
California buckwheat scrub	
California sagebrush scrub	With California Buckwheat, Coyote Brush, Ice Plant
California walnut groves	
Greenbark ceanothus chaparral	
Coast live oak woodland	Planted; dominant species only, no native understory

Fremont cottonwood forest	Planted; dominant species only, no native understory
Coyote brush scrub	With California Sagebrush, Giant Rye Grass, Ice Plant, Arroyo Willow
Blue elderberry stands	With California Sagebrush, Coast Live Oak, Giant Wild Rye, Toyon
Giant wild rye grassland	
Giant reed breaks	
Ice plant mats	Exotic
Lemonade berry scrub	
Mulefat thickets	With Elderberry, Prickly Pear,
Coast prickly pear scrub	
California sycamore woodlands	Planted. Co-dominant with Blue elderberry, Coyote brush
Toyon chaparral	With Acacia, California sagebrush, Coast live oak
White sage scrub	Along Ballona Creek.
Upland mustards	With Fennel, Giant Rye Grass, Pampas Grass, Wild Radish
Pampas grass patches	With Mule Fat
Pepper tree or Myoporum groves	With Acacia, California Palm, Arroyo Willow, California Sagebrush, California Walnut, Coast Live oak, Coyote Brush, Deodar Cedar, Elderberry, Eucaplyptus, Monterey Pine, Mule Fat, Pampas Grass, Sycamore, Toyon

For those stands of vegetation that did not fit any of the defined vegetation alliances for California, we identified provisional alliances (Table 2-4). These are not true vegetation alliances because details about the floristic composition, associated species, and other elements of vegetation classification (Sawyer et al. 2009) were outside the scope of our effort.

Table 2-4. Vegetation alliances defined for this study by dominant species in uppermost stratum.

Provisional Alliance	Notes
Acacia	Co-dominants: Ash, California Sagebrush, Carrotwood, Sycamore, Eucalyptus, Monterey Pine, Pampas Grass, Peruvian Peppertree
Agave	*Agave americana*
Brazilian Peppertree	
California Palm	*Washingtonia robusta*
Camphor Tree	Co-dominants: California Palm, Peruvian Peppertree
Canary Island Pine	Co-dominants: Eucalyptus
Carrotwood Tree	Co-dominants: Acacia

Castor Bean	Co-dominants: Cheatgrass
Cypress	
Date Palm	
Deodar Cedar	
Eucalyptus	Co-dominants: Cherry Plum, Acacia, Arroyo Willow, Ash, California Palm, Camphor Tree, Monterey Pine, Peruvian Peppertree, Sycamore
Exotic Annuals	
Exotic Perennial Cane/Giant Reed	Co-dominants: California Palm, Willow
Exotic Perennial Succulents	
Exotic Shrubs	
Exotic Trees	
Fennel	
Fountain Grass	Co-dominants: Russian Thistle
Jacaranda	
Lawn	
Magnolia	
Monterey Pine	Co-dominants: Acacia, Coastal Live Oak, California Balm, Toyon, Coyote Brush, Cypress, Deodar Cedar, Pampas Grass, Peruvian Peppertree, Sycamore, Mule Fat,
Russian Thistle	
White Alder	
Wild Radish	Co-dominants: Castor Bean, Giant Rye Grass
Ash	Co-dominants: Toyon, Cherry Plum
Cheatgrass	Co-dominants: Wild Oats, Castor Bean
Redwood	
Smilograss	Co-dominants: Cheatgrass
Tree Of Heaven	Agave
Bulrush	

Vegetation Mapping

Within the entire study area, 58% of the land is vegetated, while 42% is not vegetated (Table 2-5). The most common vegetated categories were grasslands (including lawns) at 21% of the area, followed by shrublands at 19% and treed areas at 18%. In the unvegetated zones, the most common feature was bare ground in the oil field, constituting 19% of the total study area, followed by buildings (7%), roads (6%) and other commercial and residential uses (6%).

Table 2-5. Level 1 (Vegetated/Unvegetated) and Level 2 classification for entire study area.

Level 2 Class	Area (acres)
Vegetated - Grass	442.2
Vegetated - Shrubs / Scrub / Thickets	402.8
Vegetated - Trees and Tall Shrubs	380.6
Unvegetated - Disturbed inside fenced area	393.5
Unvegetated - Buildings	145.2
Unvegetated - Roads	126.3
Unvegetated - Commercial and Residential	119.8
Unvegetated - River Bank	46.5
Unvegetated - Recreational areas and trails	39.6
Unvegetated - Stream Bed	19.1
Unvegetated - Bikepath	4.3
Unvegetated - Disturbed outside fenced area	3.0
Unvegetated - Ponds, basins, water bodies	3.0
Unvegetated - Bridges	0.2

The alliance-level vegetation map is complex and reflects the long history of disturbance, recovery, and management of the vegetation in the Baldwin Hills (Figure 2-5). As documented in previous maps of the region, the northern and southwestern edges of the territory support the largest blocks of native habitats, predominantly native shrublands. The oilfields, running northwest to southeast diagonally across the study area contain large areas of bare ground interspersed with native and exotic shrublands.

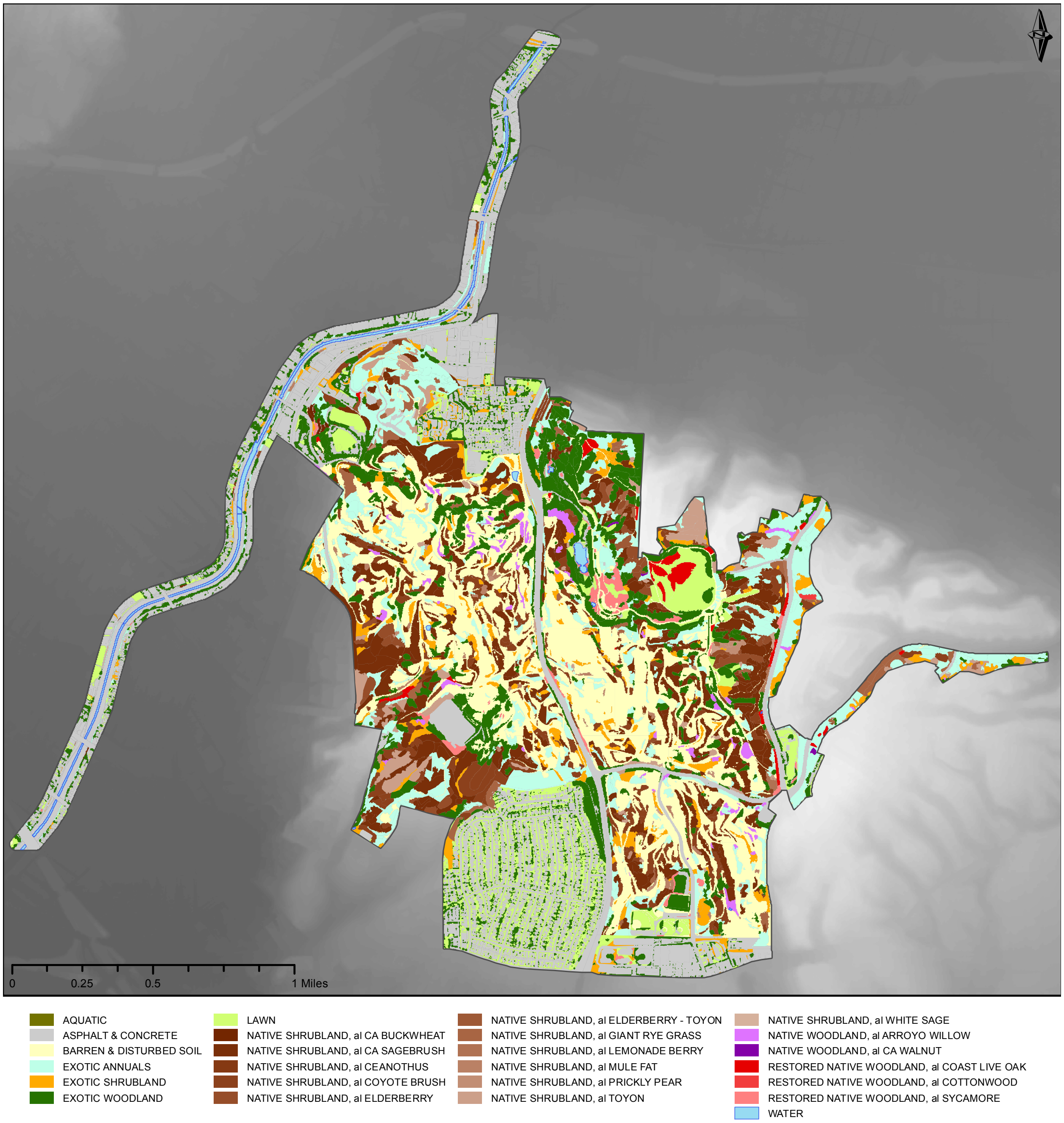


Figure 2-5. Vegetation map of the Baldwin Hills Conservancy territory emphasizing the native habitats.

For the Level 3 classification (subclasses of unvegetated zones and alliances in vegetated zones), the most common cover type was barren and disturbed soil (27% of the Main section of the study area) followed by the California Sagebrush alliance (15%; Table 2-6). The next most common vegetation types were Eucalyptus, Coyote Brush, and exotic annuals, each approximately 6% of the Main region of the study area.

Table 2-6. Cover by level 3 classification in the Main region of the study area.

Classification	Number of Polygons	Total Area	Percent
Barren and disturbed soil	312	417.61	27.20%
California sagebrush scrub	514	230.04	15.00%
Asphalt and concrete	111	96.77	6.30%
Eucalyptus	201	95.09	6.20%
Coyote brush scrub	266	93.55	6.10%
Exotic annuals	295	90.06	5.90%
Upland mustards	149	75.59	4.90%
Pepper tree or Myoporum groves	187	53.96	3.50%
Ice plant mats	214	48.49	3.20%
Lawn	96	46.21	3.00%
Russian Thistle	143	45.76	3.00%
Toyon chaparral	107	44.59	2.90%
Monterey pine forest [out of native range]	75	26.75	1.70%
Giant wild rye grassland	67	23.01	1.50%
Blue elderberry stands	42	21.45	1.40%
Arroyo willow thickets	73	17.79	1.20%
Pampas grass patches	82	16.34	1.10%
California sycamore woodlands	61	15.75	1.00%
Coast live oak woodlands	29	13.75	0.90%
Acacia	55	11.15	0.70%
Mulefat thickets	34	6.10	0.40%
Upland mustards [Wild radish]	14	5.68	0.40%
Coast prickly pear scrub	32	4.26	0.30%
Exotic Perennial Cane	21	3.69	0.20%
Exotic Trees	16	3.05	0.20%
Water	8	2.99	0.20%
Carrotwood Tree	11	2.90	0.20%
Exotic Shrubs	21	2.84	0.20%
California fan palm [planted/naturalized]	25	2.44	0.20%
Lemonade berry scrub	5	2.42	0.20%
Camphor Tree	11	2.27	0.10%
Fennel patches	6	2.05	0.10%
Peppertree or Myoporum groves	8	1.52	0.10%
California buckwheat scrub	6	1.45	0.10%
Deodar Cedar	6	0.75	0.00%
Cypress	3	0.74	0.00%
Exotic Perennial Succulents	5	0.71	0.00%
Fremont cottonwood forest [planted]	1	0.67	0.00%
White alder groves [planted]	2	0.67	0.00%
Ash	5	0.63	0.00%
Jacaranda	3	0.60	0.00%

California walnut groves	4	0.55	0.00%
Canary Island pine	4	0.43	0.00%
Fountain grass swards	6	0.40	0.00%
Castor bean	1	0.27	0.00%
Magnolia	2	0.18	0.00%
Aquatic	3	0.12	0.00%
Greenbark ceanothus chaparral	2	0.07	0.00%
Date Palm	2	0.04	0.00%

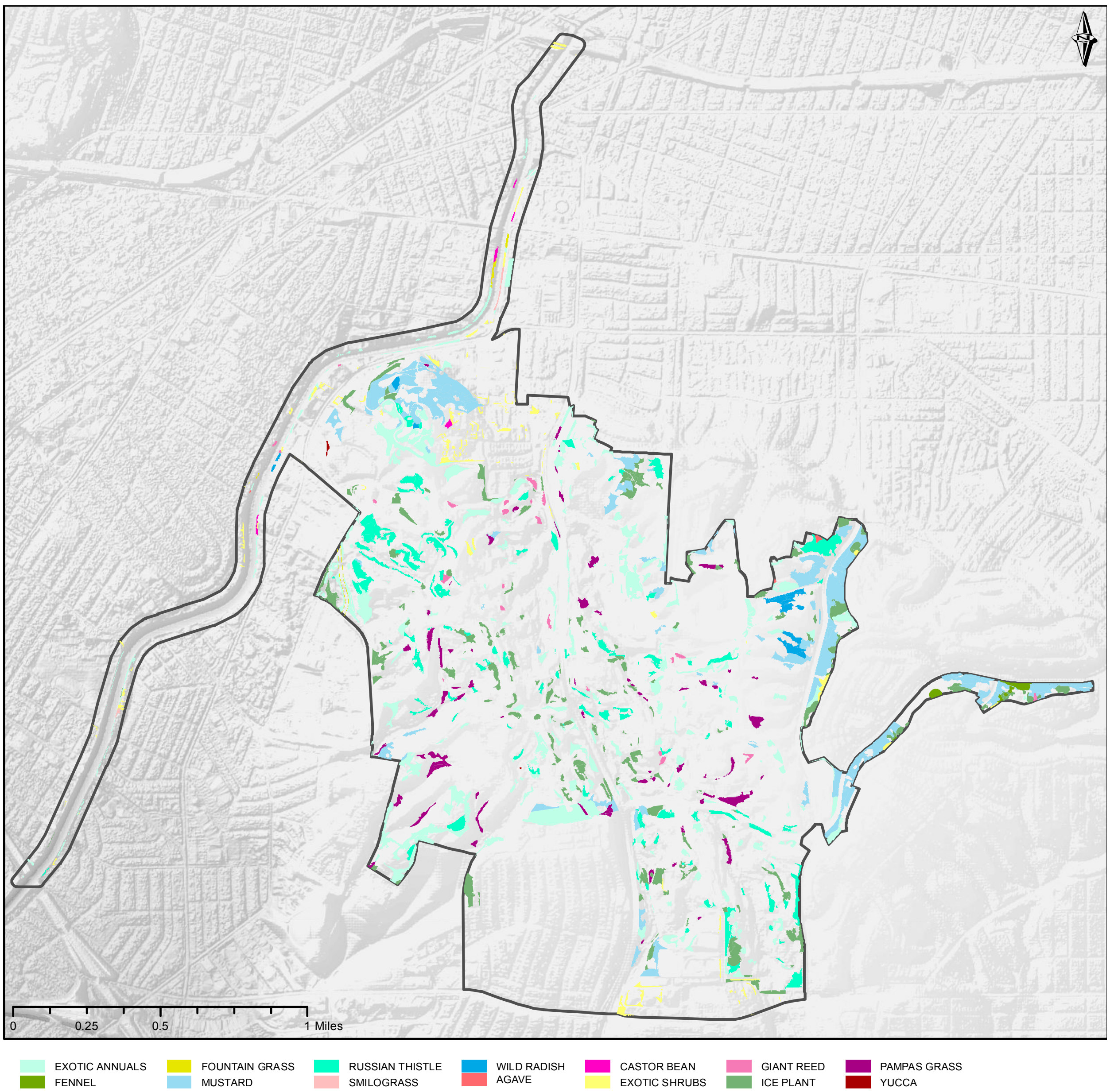


Figure 2-6. Exotic grasslands and shrublands of the Baldwin Hills Conservancy territory.

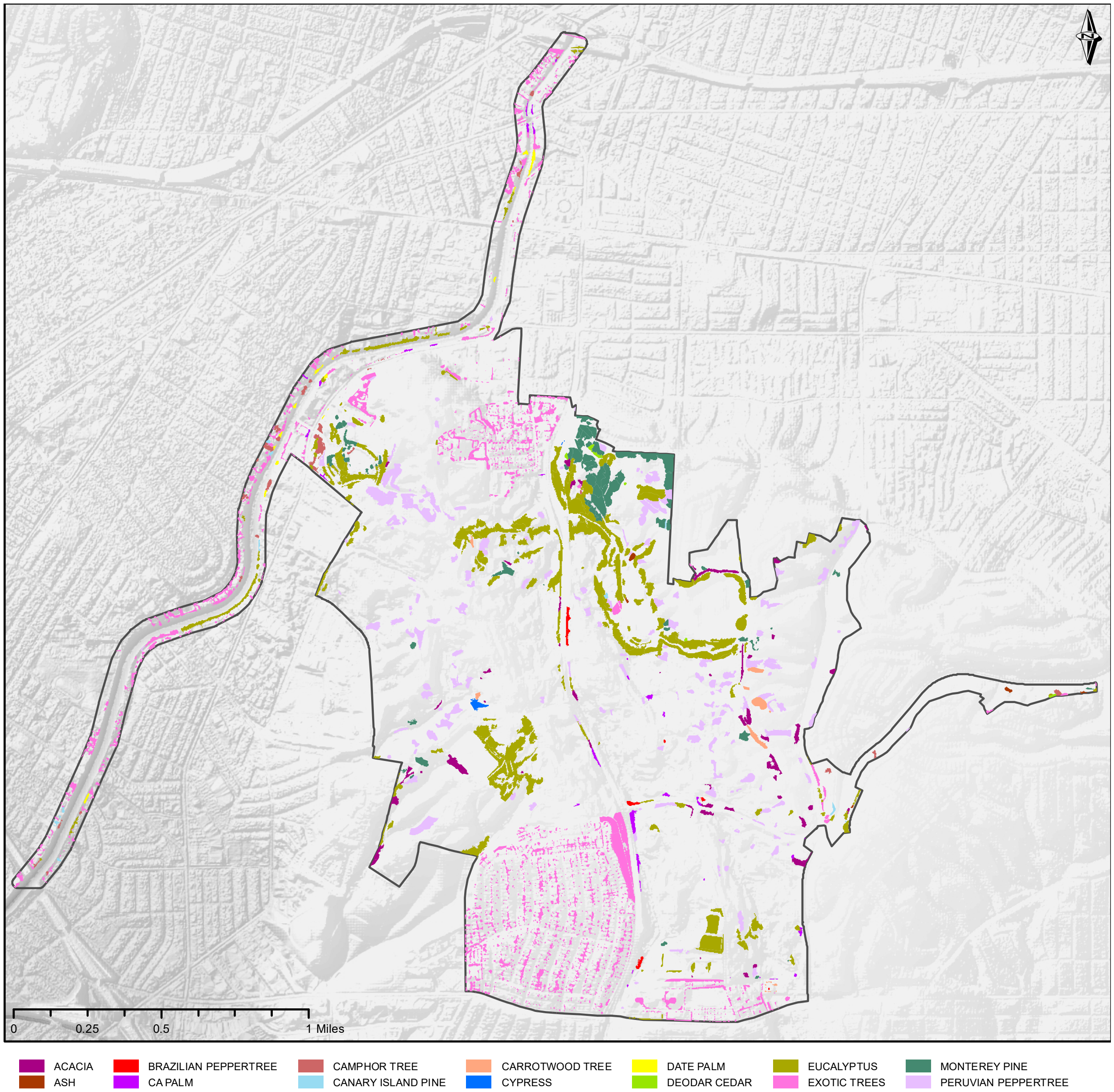


Figure 2-7. Exotic woodlands of the Baldwin Hills Conservancy territory.

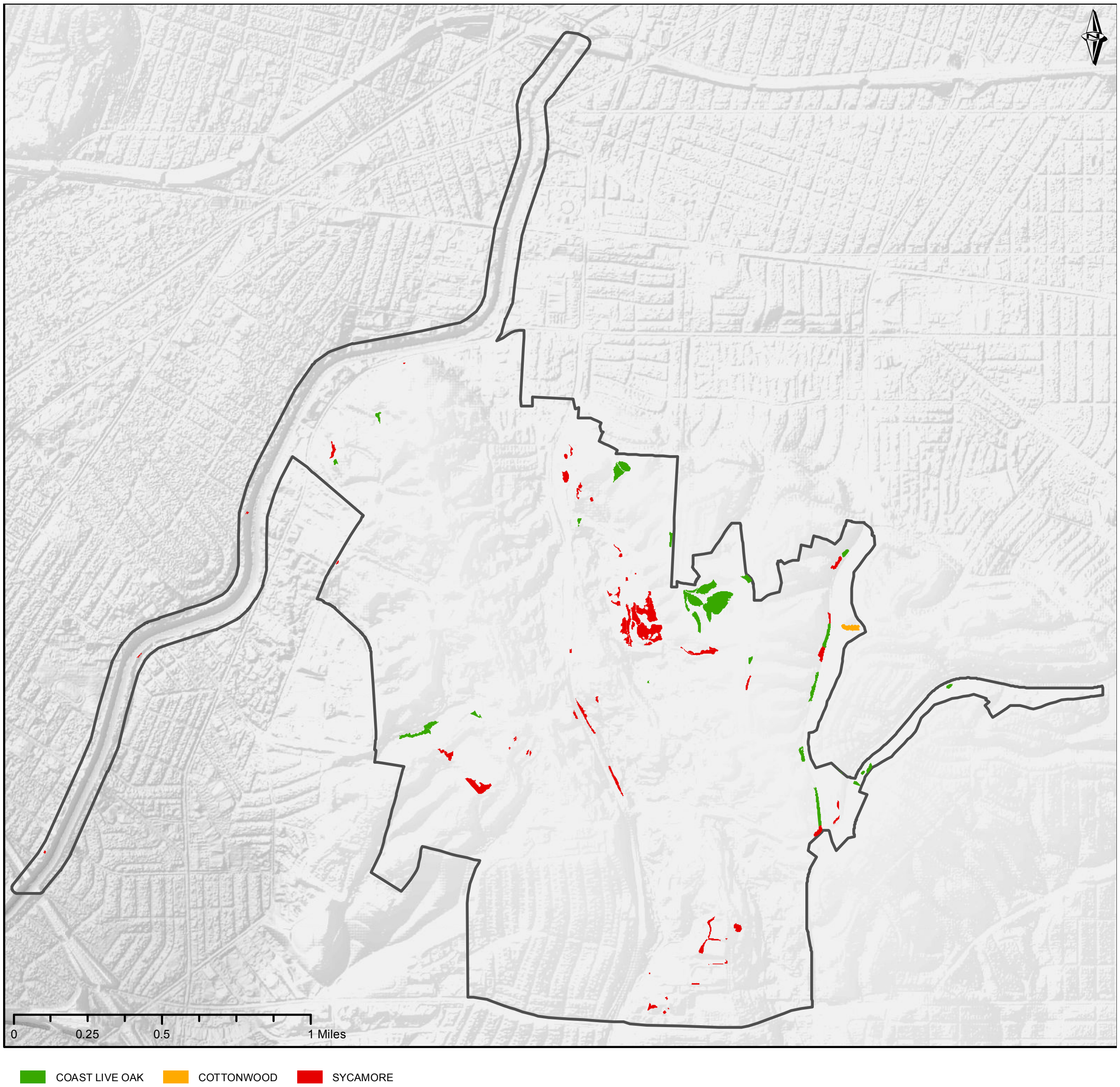


Figure 2-8. Woodlands with regionally native tree species in the Baldwin Hills.

Change Analysis

We compared the area mapped by Anderson (2001) to the 2016 update (Table 2-7), using the generalized categories of exotic/native annuals, shrubland, woodland for the comparison. The differences between the two mapping schemes are attributable both to differences in mapping methodology and to changes in the vegetation. Some interesting results included our mapping of 31.4% of the area identified as annuals in 2001 as Native Shrubland in 2016. Additionally, 52.1% of the area mapped as being disturbed with >50% nonnative vegetation in 2001 was mapped as native shrubland in 2016. We found that the large oil field area not surveyed in 2001 was dominated by bare ground (53.3%) and native shrublands (21.9%).

Table 2-7. Comparison of 2001 vegetation map with 2016 vegetation map. Extent is limited to study area covered by Anderson (2001).

2001 Description	Acres	2016 Divisions	Percentage
Annuals	60.5	Exotic Annuals	48.4
		Native Shrubland	31.4
		Unvegetated	7.6
		Exotic Woodland	6.7
		Exotic Shrubland	4.5
		Native Woodland	1.1
		Lawn	0.2
Coastal Sage Scrub	3.3	Native Shrubland	91.4
		Exotic Shrubland	5.6
		Unvegetated	3.0
Coastal Scrub, north-facing	29.3	Native Shrubland	66.0
		Exotic Woodland	18.0
		Exotic Annuals	6.8
		Unvegetated	6.4
		Exotic Shrubland	2.4
		Native Woodland	0.5
Coastal Scrub, south-facing	64.1	Native Shrubland	87.4
		Exotic Shrubland	4.5
		Exotic Annuals	4.1
		Exotic Woodland	3.1
		Unvegetated	0.4
		Lawn	0.3
		Native Woodland	0.2
Disturbed vegetation > 50% non-natives	204.4	Native Shrubland	52.1
		Exotic Annuals	16.6
		Exotic Woodland	13.0
		Unvegetated	12.7
		Exotic Shrubland	4.5
		Native Woodland	1.0
		Lawn	0.2
Disturbed vegetation > 90% non-natives	82.5	Exotic Woodland	35.6
		Native Shrubland	25.2
		Unvegetated	18.9
		Exotic Annuals	13.9
		Exotic Shrubland	4.1
		Native Woodland	2.1
		Lawn	0.2
Drainage/runoff areas	18.4	Exotic Woodland	33.9
		Native Shrubland	28.2
		Unvegetated	19.5
		Exotic Shrubland	9.0
		Native Woodland	6.1
		Exotic Annuals	2.9
		Lawn	0.4
Grassland/prairie	11.5	Native Shrubland	60.8

		Exotic Annuals	20.1
		Exotic Woodland	17.5
		Unvegetated	1.6
		Exotic Shrubland	0.1
Habitat of note	0.5	Exotic Woodland	18.3
		Native Shrubland	78.0
		Native Woodland	3.7
Hardpan/seasonal standing water	2.2	Exotic Annuals	52.7
		Exotic Shrubland	0.4
		Native Shrubland	41.5
		Native Woodland	0.9
		Unvegetated	4.4
Highly modified/sparsely vegetated	123.8	Exotic Annuals	15.3
		Exotic Shrubland	6.8
		Exotic Woodland	3.6
		Lawn	1.4
		Native Shrubland	14.4
		Native Woodland	1.5
		Unvegetated	56.9
No on-site visits (oil fields)	549.9	Exotic Annuals	9.0
		Exotic Shrubland	4.7
		Exotic Woodland	9.1
		Native Shrubland	21.9
		Native Woodland	1.9
		Unvegetated	53.3
Opuntia populations	2.3	Exotic Annuals	11.6
		Exotic Shrubland	3.2
		Exotic Woodland	5.2
		Lawn	2.0
		Native Shrubland	58.4
		Unvegetated	19.6
Population of note	0.3	Exotic Shrubland	93.6
		Native Shrubland	5.7
		Unvegetated	0.7
Urban riparian	4.9	Exotic Annuals	1.2
		Exotic Shrubland	7.9
		Exotic Woodland	20.4
		Lawn	2.2
		Native Shrubland	29.9
		Native Woodland	35.3
		Unvegetated	3.2

The oil fields were mapped in 2008 to support the development of a Community Standards District. We compared this map with the 2016 results as well (Table 2-8). Again, results will reflect both differences in methodology and changes on the ground. The results were congruent in some ways; 84.8% of disturbed areas were unvegetated, for example. Other categories diverged; only 45.3% of degraded Coastal Sage Scrub mapped for the CSD was mapped as Native Shrubland in our assessment.

Table 2-8. Comparison of area surveyed for Community Standards District area in 2008 to 2016 mapping.

Description (2008)	Acres	Division (2016)	Percentage
Coyote Brush Scrub	1.3	Native Shrubland	74.7
		Unvegetated	10.6
		Exotic Woodland	8.6
		Native Woodland	6.0
California Sagebrush Scrub	147.3	Native Shrubland	61.4
		Exotic Woodland	16.1
		Unvegetated	9.7
		Exotic Annuals	6.0
		Exotic Shrubland	5.1
		Native Woodland	1.7
Cottonwood	0	Exotic Woodland	98.7
		Unvegetated	1.3
Disturbed Areas	378.9	Unvegetated	84.8
		Native Shrubland	6.6
		Exotic Annuals	3.8
		Exotic Woodland	2.1
		Exotic Shrubland	1.6
		Native Woodland	1.0
Coyote Brush Scrub - degraded	3.3	Native Shrubland	68.9
		Exotic Woodland	16.6
		Unvegetated	9.7
		Exotic Annuals	4.7
California Sagebrush Scrub - degraded	168.9	Native Shrubland	45.3
		Unvegetated	20.5
		Exotic Annuals	17.4
		Exotic Shrubland	9.2
		Exotic Woodland	6.4
		Native Woodland	0.9
		Lawn	0.3
Southern Willow Scrub - degraded	4.4	Native Shrubland	78.8
		Unvegetated	18.2
		Exotic Annuals	1.5
		Native Woodland	1.1
		Exotic Woodland	0.4
Eucalyptus Naturalized Forest	34.2	Exotic Woodland	63.7
		Unvegetated	19.0
		Native Shrubland	8.7
		Exotic Annuals	4.6
		Exotic Shrubland	2.3
		Native Woodland	1.1
		Lawn	0.7
Non-Native Ice Plant Dominated	5.4	Exotic Shrubland	62.9
		Unvegetated	13.0
		Native Shrubland	10.9
		Exotic Annuals	9.3
		Exotic Woodland	3.9
Native Grasses	0.9	Exotic Annuals	75.5
		Unvegetated	13.4
		Native Woodland	11.1

Interior Live Oak Woodland	1.5	Exotic Woodland	61.7
		Native Shrubland	27.7
		Exotic Shrubland	6.9
		Exotic Annuals	3.2
		Unvegetated	0.6
Man-Made and Maintained Ponds	4.7	Unvegetated	91.6
		Native Shrubland	2.6
		Exotic Shrubland	2.1
		Native Woodland	1.8
		Exotic Woodland	1.1
		Exotic Annuals	0.8
Pine Trees - planted	0.3	Unvegetated	63.2
		Exotic Woodland	36.8
Southern Willow Scrub	1.3	Native Woodland	52.4
		Native Shrubland	30.0
		Unvegetated	17.6
Sycamores - remnant or planted	0.3	Exotic Woodland	79.6
		Exotic Shrubland	14.7
		Unvegetated	4.4
		Native Shrubland	1.3
Willows	0.5	Native Shrubland	44.2
		Native Woodland	31.3
		Unvegetated	16.2
		Exotic Shrubland	8.1
		Exotic Annuals	0.1
Weed Dominated	96.2	Exotic Annuals	28.2
		Unvegetated	25.8
		Native Shrubland	23.5
		Exotic Shrubland	9.2
		Exotic Woodland	8.9
		Native Woodland	4.4

Discussion

The vegetation map developed from high-resolution aerial photography describes vegetation types across the Baldwin Hills using a single classification scheme that is consistent with national standards. We confirmed alliance-level classifications in the field and integrated all available spatial data from previous studies. To further validate the results, more extensive ground survey data set would be required to those areas for which we did not have permission to survey. The map is, however, informed by site visits by previous investigators for the oil field operations area, and represents the results of a state-of-the-art approach to vegetation mapping. As acknowledged, we do not provide floristic information about stands of vegetation because the level of field work necessary and access to undertake such work were outside the scope of this project.

Our patches of vegetation tended to be smaller and of more complex shapes than previous mapping efforts (Anderson 2001; Marqua 1978). Thus, we mapped areas of native vegetation within disturbed areas that might have been classified previously as unvegetated. It is also possible that we have documented recovery in vegetation resulting from active restoration and management as well as passive recovery in the absence of disturbance, especially on the protected parklands that are being managed for natural resource values.

We produced maps that summarized the alliance-based classification into broader categories of native and exotic annuals, shrublands, and woodlands, in addition to bare ground and other unvegetated categories. These summary maps provide an intelligible level of analysis of the Baldwin Hills territory asa a whole.

Prior to disturbance by agriculture and industrial activities, the vegetation of the Baldwin Hills would have been significantly different from that seen today. The only map of this historic condition is from a state-wide map that shows the region as being entirely coastal sagebrush (Küchler 1977). Our results, and previous vegetation surveys, are largely consistent with this description, with the exception of the vegetation associated with the more mesic areas around the drainages found historically (Dark et al. 2011) and the likely presence of vernal pools (Anderson 2001). The available records do not provide evidence of widespread oak woodlands and the existing localized riparian resources are supplemented by urban runoff. Like Anderson (2001), we documented California Walnut as a dominant species in some areas but whether the species was more common historically is an open question.

Coastal scrub of the pre-agricultural Baldwin Hills was probably interspersed with grasslands (Freudenberger et al. 1987). We can offer little additional information because the grasslands in areas where we mapped were dominated by exotics and the one small area reported to support native grasses is on the oil fields, as reported previously (Marine Research Specialists 2008). In all likelihood there were vernal pools. Vernal pools have been documented to the west of the Baldwin Hills (Mattoni & Longcore 1997) and reference to pools in the "adobe" and on the "mesas" of the Baldwin Hills are found in the Abrams flora (Abrams 1904). For example, the vernal pool indicator species *Navarretia prostrata* was found, "In low adobe places on the mesas of the coast valley. Inglewood" (Abrams 1904). The western ridges of the Baldwin Hills have clay soils and this is the likely location for vernal pools meeting this description. Anderson (2001) reviewed this possibility and we can offer little additional insight.

One of the challenges of not having a vegetation map that covered the whole of the remaining undeveloped Baldwin Hills with the same classification scheme is that it has been difficult to monitor changes in the vegetation over time. Our data compilation points to some broad trends that could be monitored to track the management of this area. The extent of native scrub vegetation certainly appears to have increased in the public parklands over the past 35 years. Large areas described as "little or no plant growth" now support native scrublands and exotic woodlands. The stands of what appear to be relatively undisturbed stands of California sagebrush, coyote brush, toyon, and blue elderberry alliances found along La Brea Avenue and in the hillsides in the southwestern portion of the study area are prominent in terms of their persistence. They also constitute the largest unbroken blocks of native habitats in the Baldwin Hills.

References

Abrams, L. R. 1904. Flora of Los Angeles and vicinity. Stanford University Press, Stanford, California.

Anderson, K., and K. J. Gaston. 2013. Lightweight unmanned aerial vehicles will revolutionize spatial ecology. *Frontiers in Ecology and the Environment* 11:138–146.

Anderson, V. 2001. Vegetation of the Baldwin Hills. Pages 12–37 in *The biota of the Baldwin Hills: an ecological assessment* (K. C. Molina, ed.). Community Conservancy International and Natural History Museum of Los Angeles County Foundation, Los Angeles.

Blaschke, T. 2010. Object based image analysis for remote sensing. *ISPRS Journal of Photogrammetry and Remote Sensing* 65:2–16.

BonTerra Consulting. 2013. Initial Study/Mitigated Negative Declration for proposed Park to Playa Trail. Pages 1–206.

Burnett, C., and T. Blaschke. 2003. A multi-scale segmentation/object relationship modelling methodology for landscape analysis. *Ecological Modelling* 168:233–249.

Byrne, J., M. Kendrick, and D. Sroaf. 2007. The park made of oil: towards a historical political ecology of the Kenneth Hahn State Recreation Area. *Local Environment* 12:153–181.

Cardno ENTRIX, and ENVIRON. 2014. 2013 Invasive Plant Inventory Inglewood Oil Field: Baldwin Hills CSD Provisions E.7.b. Freeport-McMorRan Oil & Gas, Los Angeles, California.

Dark, S., E. D. Stein, D. Bram, J. Osuna, J. Monteferante, T. Longcore, R. Grossinger, and E. Beller. 2011. Historical ecology of the Ballona Creek watershed. Southern California Coastal Water Research Project. Technical Report #671.

Federal Geographic Data Committee. 2008. National Vegetation Classification Standard FGDC-STD-005-2008 (Version 2).

Freudenberger, D. O., B. E. Fish, and J. E. Keeley. 1987. Distribution and stability of grasslands in the Los Angeles [California, USA] basin. *Bulletin Southern California Academy of Sciences* 86:13–26.

Homer, C., C. Huang, L. Yang, B. Wylie, and M. Coan. 2004. Development of a 2001 national land-cover database for the United States. *Photogrammetric Engineering & Remote Sensing* 70:829–840.

Jennings, M. D., D. Faber-Langendoen, O. L. Loucks, R. K. Peet, and D. Roberts. 2009. Standards for associations and alliances of the US National Vegetation Classification. *Ecological Monographs* 79:173–199.

Küchler, A. W. 1977. The map of the natural vegetation of California. Department of Geography, University of Kansas, Lawrence, KS.

Marine Research Specialists. 2008. Final Environmental Impact Report: Baldwin Hills Community Standards District. Los Angeles County Department of Regional Planning, Los Angeles, California.

Marqua, D. 1978. Plant life. Baldwin Hills Project: Inventory of Features. County of Los Angeles Department of Parks and Recreation, Los Angeles.

Mattoni, R., and T. R. Longcore. 1997. The Los Angeles coastal prairie, a vanished community. *Crossosoma* 23:71–102.

Molina, K. C., editor. 2001. *The biota of the Baldwin Hills: an ecological assessment*. Community Conservancy International and Natural History Museum of Los Angeles County Foundation, Los Angeles.

Sawyer, J. O., T. Keeler-Wolf, and J. Evens 2009. A manual of California vegetation. California Native Plant Society, Sacramento, CA.

Stoll, A. Q., J. G. Douglass, and R. Ciolek-Torrello. 2009. Searching for Guaspet: a mission period rancheria in west Los Angeles. *SCA Proceedings* 22:1–9.

Xie, Y., Z. Sha, and M. Yu. 2008. Remote sensing imagery in vegetation mapping: a review. *Journal of Plant Ecology* 1:9–23.

Yan, W. Y., A. Shaker, and N. Al-Ashmawy. 2015. Urban land cover classification using LiDAR data: a review. *Remote Sensing of Environment* 158:295–310.

Chapter 3. Herpetofaunal Surveys of the Baldwin Hills

Gregory B. Pauly, Stevie Kennedy-Gold, Jennifer McKenzie, and Bennett Hardy
Section of Herpetology and Urban Nature Research Center, Natural History Museum of Los Angeles County

Abstract

The Baldwin Hills of western Los Angeles are an island of open space surrounded by a sea of urbanization. Although the Baldwin Hills are themselves heavily impacted by urbanization and habitat fragmentation, they continue to provide crucial habitat for some species that used to be more widespread in the region. We combine multiple types of field surveys conducted in spring and early summer of 2014 and 2015, citizen science observations (through June 30, 2016), and a review of museum specimens to provide a comprehensive update to the herpetofauna of the Baldwin Hills and adjacent reaches of Ballona Creek. We document 5 amphibian species and 11 reptile species in this region including 6 that are new records that were not documented in previous surveys or through museum specimens. Most significant among these new records are Western Skinks, Coachwhip Snakes, and Ring-necked Snakes, although the last two may or may not represent established populations. The American Bullfrog and three species of turtles found in the area are not native to the region. We found no evidence for Western Rattlesnakes being in the Baldwin Hills nor any clear evidence of them being there in recent decades. Lastly, we discuss the low habitat value of lawns, impacts of nonnative species, other human-related threats to the herpetofauna including potential collection of snakes on state park lands, and the value of citizen science efforts in biodiversity inventories.

Introduction

As an island of open space surrounded by a sea of urbanization, the Baldwin Hills provide some of the last remaining habitat for species that were formerly widespread across the Los Angeles Basin. Even so, the Baldwin Hills are themselves impacted by urbanization having been fragmented by major roadways and affected by extensive habitat loss and modification. Because of urbanization, fragmentation, and ongoing habitat modification, it is important to understand the character and distribution of the biota of this region to allow for informed land management and conservation decision-making. Here, we combine extensive field surveys for reptiles and amphibians conducted in 2014 and 2015 with citizen science data gathered through June 30, 2016 to document the herpetofauna of this region.

The present surveys build upon and greatly expand the efforts of two previous surveys. During January 22–26, 1975, August 4–7, 1975 and February through April 1977, biologists with the L. A. County Nature Centers conducted occasional daytime visual encounter surveys for reptiles and

Pauly, G., S. Kennedy-Gold, J. McKenzie, and B. Hardy. 2016. Herpetofaunal Surveys of the Baldwin Hills. Pp. 39–71 in *Urban Biodiversity Assessment: Baldwin Hills Biota Update* (T. Longcore, ed.). Los Angeles: University of Southern California for Baldwin Hills Conservancy (Proposition 84) and Baldwin Hills Regional Conservation Authority (Proposition A).

amphibians in the Baldwin Hills (County of Los Angeles, 1982). These surveys yielded one amphibian and five reptile species (Table 3-1). Another two species, the Coachwhip and the Western Rattlesnake were also reported as having been observed by personnel working in the Baldwin Hills.

Later, additional herpetofaunal surveys were conducted by Beaman (2001) as an update to the earlier work. Beaman conducted daytime visual encounter surveys on five days between February 2 and July 27, 2000, reviewed museum records, and interviewed personnel at Kenneth Hahn State Recreation Area (KHSRA) and Stocker Industries. Beaman reported five species during his visual encounter surveys and received reports of the California Kingsnake occurring in the Baldwin Hills through interviews (Table 3-1). In his review of museum records, Beaman found voucher specimens for eight species in the Baldwin Hills. These museum specimens include the Pacific Treefrog and Western Toad, neither of which were recorded in the on-site surveys (County of Los Angeles, 1982; Beaman, 2001). Thus, by combining the two previous surveys and the review of museum specimens, there was evidence of four amphibian species and six reptile species in the Baldwin Hills as of 2001 (Table 3-1).

In this study, we used three different approaches to assess the herpetofauna of the Baldwin Hills: 1) multiple types of field surveys; 2) observations from the Reptiles and Amphibians of Southern California (RASCals) Citizen Science Project (developed and led by GBP; http://www.inaturalist.org/projects/rascals); and 3) querying natural history museum holdings for relevant specimens. Together, this effort comprises the most exhaustive study of the Baldwin Hills herpetofauna to date.

Methods

Field Surveys

Field surveys involved five different approaches: daytime visual encounter surveys, nighttime visual and acoustic encounter surveys, coverboards, pitfall trapping, and turtle trapping. All inventory efforts were conducted in the spring and summer of 2014 and 2015. All handling of animals was consistent with USC IACUC Protocol No. 20153 and covered under a scientific collecting permit held by GBP (CA-SC-4307).

Visual and acoustic surveys.— These surveys involved 1–4 people conducting visual and acoustic surveys for reptiles and amphibians throughout the study area. Daytime visual encounter surveys were the primary method and were conducted in all areas surveyed. The primary survey areas, meaning those that received the greatest effort, included KHSRA, Baldwin Hills Scenic Overlook (BHSO), Ballona Creek (surveyed from BHSO to the Hwy 90 bridge), and the Stocker Corridor (open space along the south side of Stocker St. between La Brea Ave. and Presidio Dr.). Additionally, surveys were conducted, though less frequently, at Culver City Park, Norman O. Houston Park (NE corner of Stocker St. and La Brea Ave.), and along the La Brea Corridor (E side of La Brea between Don Alberto Place and Don Ricardo Dr.). We also made a single site visit early in this project to Holy Cross Cemetery to assess whether it would be a useful addition to this inventory effort. No formal surveys were conducted there, but we did document any reptiles observed from the main paths. Permission to conduct formal surveys could not be obtained, and no further site visits were conducted.

Within KHSRA and BHSO, we generally stayed on trails in the more densely vegetated and steeper sections. In more open areas, we surveyed more broadly, including away from trails. In all other parcels, we were able to survey both along and away from the major pathways. Areas with three-dimensional structure, whether from man-made structures or surrounding woody vegetation, were especially closely examined because these are preferred habitats for Western Fence Lizards and Southern Alligator Lizards. Aquatic habitats were surveyed with particular focus on emergent logs and vegetation, rocks, and debris; these areas are common turtle basking sites and are also the most likely areas for Bullfrogs and tadpoles of all potential frog species. For the ponds at KHSRA where turtle numbers were highest, the focus for most surveys was on counting the number of turtles and identifying each to species.

Nighttime visual and acoustic surveys were conducted the first night possible following rain events. Because access to KHSRA after dark was not possible, nighttime surveys were restricted to Ballona Creek. These surveys included eye-shine surveys for frogs in the creek and acoustic surveys for any calling frogs.

The latitude/longitude, measurement error, substrate, sex (when possible), life stage (adult vs. juvenile), and amount of sun exposure (full sun, partial sun, and full shade) were recorded for every observation. Latitude/longitude data were taken with a handheld GPS unit (Garmin GPSMAP62S) using the WGS84 datum. Survey times were adjusted throughout the spring and early summer based on weather conditions to maximize the potential for encounters.

Coverboards.—Early in the surveys, we encountered two areas with coverboards in KHSRA. Coverboards are pieces of plywood, metal, carpet, or other material placed on the surface to provide an easy way to observe reptiles and amphibians. The boards create hiding spots where animals have access to temperature and humidity regimes that are not common on the surface. As a result, by checking the boards, people (e.g., biologists, hobbyists, or poachers) can more easily find reptiles and amphibians. One boardline was found running along the north side of the Los Angeles Department of Water and Power (LADWP) access road that enters the park off La Brea Avenue. Another boardline was found in the valley at the northeast corner of KHSRA. Both boardlines were regularly checked during the 2014 and 2015 field seasons. Based on the appearance of these boards and the surrounding soil and vegetation, they had been there for multiple years and were not regularly checked by others during our surveys.

In 2015, a new boardline was discovered along the Jim Webb Trail south of BHSO. This boardline had been set out in the previous year. We checked it during the 2015 field season.

Each boardline consisted of 6–10 sheets of ½ to ¾ inch thick plywood, usually made up of pieces smaller than a full 4' x 8' sheet of plywood.

Pitfall trapping.— For the 2015 field season, three pitfall trap arrays were established, two at KHSRA and one at BHSO. All arrays were set away from trails where they were out of view from the public. The arrays were constructed following Fisher et al. (2008). Each pitfall array consisted of seven 5-gallon plastic buckets buried so the top of the bucket was flush with the ground surface. These buckets were connected by three shade-cloth drift-fences, forming the shape of a Y with 15-meter arms. All buckets had small holes drilled in the bottom to allow drainage in rainy weather. While in use, the buckets were fitted with raised covers to provide shade, shelter from rain, and to prevent the capture of non-target species. In addition, all buckets contained two PVC tubes with foam insulation to provide warmth and shelter for captured animals, as well as a wetted sponge to prevent desiccation of amphibians. Snake traps (i.e., hardware cloth funnel traps) were placed along each arm of the pitfall array. The snake traps consisted of a funnel on each end to allow animals to enter but not exit. As with the buckets, a PVC tube with foam insulation was placed inside to provide shelter for captured animals. While in use, the funnel traps were covered with boards to provide shade.

Pitfall arrays were opened at the start of the week and kept open for 4–6 days. Arrays were always closed for at least one week between open periods. Pitfall and snake traps were checked once daily during sampling periods. Between sample periods, the pitfall traps were completely closed and the funnels of the snake traps were removed so that no animals could be trapped. All animals captured in the pitfall arrays were subsequently removed by hand, at which time the species, sex, and age class of each animal was recorded. Each animal was also uniquely marked with a permanent pen so that any recaptures could be noted.

Array 1 was placed in the east-west running valley in the northeast end of KHSRA (center bucket located at 34.01096, -118.35809). This is the same valley that contains the coverboard array. The immediate area around the array consisted of nonnative, annual grasses. Array 2 was placed along the ridgeline in the northern section of KHSRA (center bucket located at 34.01329, -118.36722). The vegetation surrounding two arms of the array included nonnative, annual grasses and native shrubs while the third arm extended beneath a large Peruvian Pepper. Array 3 was placed at low elevation on the northeast side of BHSO (center bucket located at 34.01949, -118.38062). Surrounding vegetation consisted of nonnative, annual grasses and native shrubs.

We also placed six snake traps (two in KHSRA and four in BHSO) along man-made structures as these structures can work in the same manner as a drift fence. These structures included walls, chain-link fence covered in shade cloth, and buildings. Traps were opened and closed at the same time as the pitfall arrays.

Turtle trapping.— Turtle traps were used in the three ponds along the main watercourse at KHSRA, in the Japanese garden pond at KHSRA, and in Ballona Creek between Centinela Ave. and the Hwy 90 bridge. At both sites, two types of traps were used. One was a submersible, box-style turtle trap installed in areas over 1-m deep. These traps work much like a minnow trap, except that a net chimney extends from the box trap to the surface. This chimney allows turtles to access the surface and breathe while confined inside the trap. The top of the chimney is held above the surface by a float. The second trap was a hoop net with a lead net that extends out from the first hoop and acts much like a drift fence, directing turtles into the baited hoop net. Bait for both trap types was sardine sandwiches. Areas where turtles were observed during the visual encounter surveys were selected as trapping sites.

Citizen Science Observations

Data were acquired from the Reptiles and Amphibians of Southern California (RASCals) Citizen Science Project, which is hosted on the iNaturalist platform (http://www.inaturalist.org/projects/rascals). This project was developed by GBP and went live on iNaturalist June 2013. People across Southern California are encouraged to submit digital photographs and/or audio recordings as vouchers for the occurrence of reptiles and amphibians. Observations can be uploaded directly to iNaturalist, emailed to the Natural History Museum, or tagged to #NatureinLA on Twitter, Instagram, or Facebook. For email and social media submissions, Museum staff upload the observations to the RASCals project. Although the project launched June 2013, citizen scientists can contribute older photographs and/or audio recordings from a known locality and date. For this study, only "research-grade" observations were included. "Research-grade" means that an observation includes a voucher photograph, date, locality, and a community-supported identification. Additionally, observations with error values for latitude and longitude coordinates greater than 500m were excluded. Observations from neighborhoods within 100m of the study area were also included. Although most authors of this report also submitted some observations to the RASCals project over the course of the field surveys, we did not count these as citizen science observations. We only counted RASCals observations made by others and observations made by SKG and GBP from 2016 after the conclusion of the formal field surveys.

Historical Museum Records

We queried the VertNet Database, which is an online search engine that aggregates biodiversity data from over 300 natural history collections around the world. From these queries, we determined which reptile and amphibian species were represented by voucher specimens collected from the Baldwin Hills and deposited into museums.

Results

The visual encounter surveys took place between March 24 and June 5, 2014 and March 10 and July 10, 2015. In total, we surveyed for 33 days in the 2014 field season and 47 days for the 2015 field season. Two of the three pitfall traps were opened intermittently during trap construction (April 6–10, 2015). All three pitfall traps and all fifteen snake traps were opened for six periods of 4–6 trap days from April to July 2015, beginning on April 20, May 4, May 18, June 1, June 15, and July 6. Array 1 and Array 2, located in KHSRA, were open for 31 and 30 trap days respectively and Array 3, located in BHSO, was open for 27 trap days. All snake traps resulted in observations either because the animals entered the traps or were found under or basking on the traps. The six snake traps set against man-made structures yielded observations of 17 Western Fence Lizards, 2 Side-blotched

Lizards, and 6 Southern Alligator Lizards. Turtle trapping was conducted April 24, 2015 and July 31, 2015 at KHSRA and August 6, 2015 for Ballona Creek. Trapping at Ballona Creek was especially challenging due to the significant tidal flux over the course of the day that moved traps and because oil tar stuck to the traps and personnel.

We documented fifteen species of reptiles and amphibians, of which four were nonnative: American Bullfrog, Red-eared Slider Turtle, Soft-shelled Turtle, and River Cooter (Table 3-2). We made 2749 observations of reptiles and amphibians (Appendix 1). For the turtles at KHSRA, a single "observation" could represent a count of up to 43 individuals; for Table 3-2, the value of 105 Red-eared Sliders is the sum of the number of observations across all sites and the five individuals observed during the single visit to the Holy Cross Cemetery Pond (Appendix 2).

The 2014 and 2015 field seasons were conducted in the third and fourth years of a prolonged and historic drought. Rainfall during both field seasons was extremely rare with little precipitation from the few storms that did occur. Amphibian activity in the Baldwin Hills and more generally throughout the region was minimal.

Citizen Science Observations

The RASCals Citizen Science Project yielded 118 observations relevant to this survey (Appendix 2). The observations date from as early as March 8, 2006 (iNaturalist 1157269) to as recently as June 28, 2016. Citizen scientists submitted 100 records, and authors of this report submitted 18 records after the conclusion of the formal field surveys (2 records by GBP and 16 records by SKG). Many other observations were submitted to the RASCals project by the authors during the formal field surveys (Appendix 1), but these are not counted here. Importantly, the iNaturalist platform proved convenient for other personnel working in the park to submit relevant observations. Of special note, L.A. Audubon Restoration Coordinator Carlos Jauregui (iNaturalist username ctwothree), submitted 49 observations, including 35 snake sightings and the only Western Skink sighting provided to RASCals. Although most of the RASCals observations were within the study area, four Southern Alligator Lizards and three Western Fence Lizards were observed at house lots or in business complexes adjacent to Ballona Creek.

Historical Museum Records

Museum specimen records available through the VertNet database included four species of amphibians and four species of reptiles (Table 3-1). All of these species were also documented in a similar survey of museum records reported by Beaman (2001). Most specimens were deposited at either the Natural History Museum of Los Angeles County or the Museum of Vertebrate Zoology at the University of California, Berkeley.

Table 3-1. Species occurrence data for historical (County of Los Angeles, 1982; Beaman, 2001) and current reptile and amphibian surveys of the Baldwin Hills. X denotes species observed by surveyors; ? denotes species reported by people interviewed during the earlier surveys.

Species	1975 and 1978 Surveys	2001 Surveys	Museum Records	2014 and 2015 Surveys							
				KHSRA	BHSO	Ballona Creek	Stocker Corridor	Culver City Park	N. O. Houston Park	La Brea Corridor[1]	Holy Cross Cemetery[1]
Site Visits							6	4	5	1	1
AMPHIBIANS											
Pacific Treefrog *Pseudacris regilla*			X	X		X					
Western Toad *Bufo boreas*			X			X					
American Bullfrog (nonnative) *Rana catesbeiana*				X							
Garden Slender Salamander *Batrachoseps major*	X[2]		X	X							
Black-bellied Slender Salamander *Batrachoseps nigriventris*	X[2]		X	X							
REPTILES											
Western Fence Lizard *Sceloporus occidentalis*	X	X	X	X	X	X	X	X	X	X	X
Side-blotched Lizard *Uta stansburiana*	X	X	X	X	X			X			
Southern Alligator Lizard *Elgaria multicarinata*	X	X	X	X	X	X	X	X		X	
Western Skink *Plestiodon skiltonianus*				X	X						
Gophersnake *Pituophis catenifer*	X	X	X	X	X						
California Kingsnake *Lampropeltis getula*	X	?		X	X						

Coachwhip *Masticophis flagellum*	?				X						
Ring-necked Snake *Diadophis punctatus*					X						
Western Rattlesnake *Crotalus oreganus*	?										
Red-eared Slider (nonnative) *Trachemys scripta elegans*		X[3]		X		X					X
Soft-shelled Turtle (nonnative) *Apalone sp.*						X					
River Cooter (nonnative) *Pseudemys sp.*						X					

[1] Surveys of the La Brea Corridor and Holy Cross Cemetery were cursory. See text for descriptions.

[2] The slender salamander(s) found in the 1970s surveys was/were listed as the Garden Slender Salamander but cannot be confidently assigned to species (M.C. Long, pers. comm.). See text for more details and an explanation for why the Black-bellied Slender Salamander was most likely observed in this survey.

[3] Red-eared Sliders were observed in the pond at Holy Cross Cemetery and were reported by park staff to occur in the KHSRA ponds.

Results by Species

Pacific Treefrog, *Pseudacris regilla* (=*Pseudacris hypochondriaca* of some authors).— Pacific Treefrogs were infrequently observed (Table 3-2; Figure 3-1). Two observations of adults were made at Gwen Moore Lake, one in the reeds on the west side and one calling from a drain area between the bathrooms and northeast corner of the Lake. A single individual was also observed along Ballona Creek at Duquesne Avenue. The greatest activity was at three backyard ponds on Kelly St. adjacent to the Ballona Creek Bike Path. In 2014 and 2015, small choruses of Pacific Treefrogs (fewer than 20 males in each pond) were heard calling from these ponds during nighttime surveys following light rainfalls. This area is at the downstream end of the survey stretch, approximately 200–250 m upstream of the Hwy 90 bridge. Although there are museum specimens of Pacific Treefrogs from the Baldwin Hills, this species had not been observed in either of the earlier studies (County of Los Angeles, 1982; Beaman, 2001).

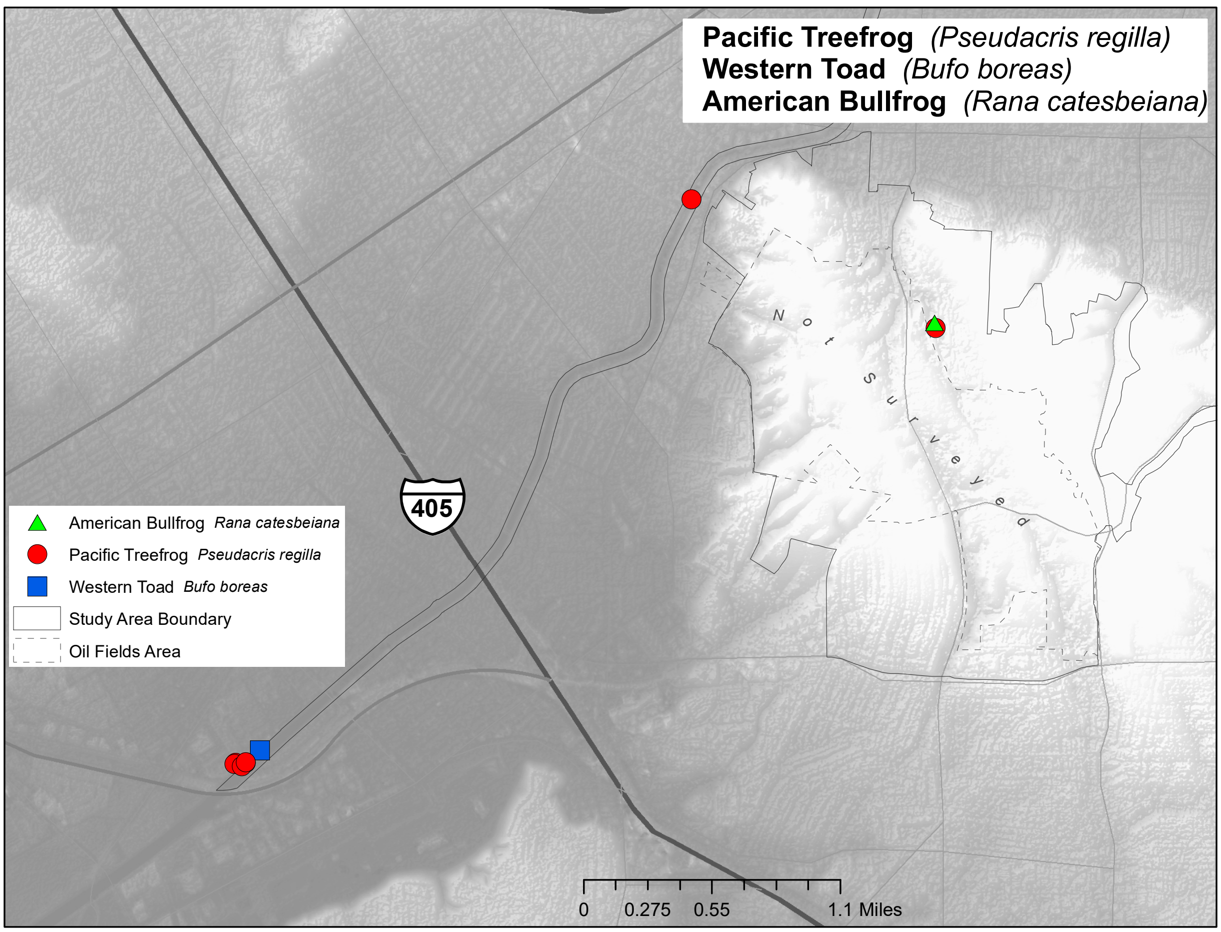


Figure 3-1. Distribution of frog observations in the Baldwin Hills study area.

Downstream from the survey area, Hayes and Guyer (1981) found Pacific Treefrogs at Ballona Wetlands. More recently, this species was documented at the Ballona Freshwater Marsh (Johnston et al., 2012) and in Centinela Creek, where it runs parallel with Bluff Creek Drive (G. Pauly, pers. obs.).

Western Toad, *Bufo boreas* (=*Anaxyrus boreas* of some authors).—Only a single Western Toad was observed, a male along the Ballona Creek Bike Path found at night after a light rainfall (Table 3-2; Figure 3-1). This toad was found near the southern end of the survey stretch, approximately 390 m upstream of the Hwy 90 bridge. Although there are museum specimens of Western Toads from the Baldwin Hills (LACM 951–955) and from Ballona Creek (LACM 11073–11077, 11152, and 11364), this species was not observed in either of the earlier herpetofaunal surveys of the Baldwin Hills (County of Los Angeles, 1982; Beaman, 2001). Further, no observations were submitted to the RASCals Citizen Science Project from this region. The drought conditions and extreme lack of rainfall during the survey period undoubtedly reduced Western Toad surface activity, but their near absence from the study is most likely a result of the significant decline of this species in the area.

Western Toad populations have declined dramatically in the L.A. Area in large part because of habitat loss, including from the channelization of Ballona Creek and loss of surrounding freshwater wetlands (Dark et al., 2011). Moreover, recent extensive herpetofaunal surveys of Ballona Wetlands Ecological Reserve, including "Area C," which is at the SW corner of the intersection of Ballona Creek and Hwy 90 immediately adjacent to our survey area, failed to detect any Western Toads (Johnston et al., 2012). Earlier surveys of the Ballona Wetlands yielded only two sightings (one was roadkill) and an additional report of a third locality (Hayes and Guyer, 1981), suggesting that few Western Toads have been in the area since at least 1980. In contrast, von Bloeker (1941) suggests that Western Toads were breeding in the Ballona region and could be found there and in the El Segundo Sand Dunes south of Ballona Wetlands. The available survey history and museum records, though sparse, suggest that Western Toads were once more common in the Ballona and Baldwin Hills regions but that they have been uncommon since at least the early 1980s.

American Bullfrog, *Rana catesbeiana* (=*Lithobates catesbeianus* of some authors).—We observed a single nonnative American Bullfrog at Gwen Moore Lake, KHSRA on April 24, 2015 (Table 3-2; Figure 3-1). A Bullfrog that was likely this same individual was observed on July 31, 2015 during the turtle trapping at Gwen Moore Lake. Although only a single individual was seen, it is likely that Bullfrog numbers will increase in the area. Large populations of Bullfrogs already exist at the Ballona Freshwater Marsh and along Centinela Creek downstream of Centinela Ave. (Johnston et al., 2012; G. Pauly, pers. obs.). Because of the level of urbanization, Bullfrogs are unlikely to reach KHSRA without human assistance. Unfortunately, given the local availability of this nonnative species and the occasional use of Bullfrog tadpoles as fishing bait, there is a high likelihood of future introductions of this species to the KHSRA ponds.

Although museum specimens demonstrate that Bullfrogs were found in parts of the L.A. Basin by at least the 1950s (LACM 91538, 91544, 91576, and SDNHM 43383), Bullfrogs were not observed in the Baldwin Hills in the previous surveys (County of Los Angeles, 1982; Beaman, 2001) nor were they found at Ballona Wetlands by Hayes and Guyer (1981). Thus, the earliest records of Bullfrogs for Ballona Wetlands and the Baldwin Hills are from Johnston et al. (2012) and our surveys, respectively. Thus, Bullfrogs appear to be a relatively recent arrival to this area.

Table 3-2. Number of observations per species for the surveys and through the RASCals Citizen Science Project. For species found only in one portion of the Baldwin Hills, the name of that area is also listed.

Species	No. observations from surveys	No. RASCals observations
AMPHIBIANS		
Pacific Treefrog *Pseudacris regilla*	1 male KHSRA 1 individual, and 3 choruses adjacent to Ballona Creek	
Western Toad *Bufo boreas*	1 male Ballona Creek	
American Bullfrog (nonnative) *Rana catesbeiana*	1 KHSRA	
Garden Slender Salamander *Batrachoseps major*	1 KHSRA	
Black-bellied Slender Salamander *Batrachoseps nigriventris*	57 KHSRA	1 KHSRA
REPTILES		
Western Fence Lizard *Sceloporus occidentalis*	1937	39
Side-blotched Lizard *Uta stansburiana*	516	14
Southern Alligator Lizard *Elgaria multicarinata*	68	15
Western Skink *Plestiodon skiltonianus*	11	1
Gophersnake *Pituophis catenifer*	39	34
California Kingsnake *Lampropeltis getula*	4	6
Coachwhip *Masticophis flagellum*	1 BHSO	7 BHSO
Ring-necked Snake *Diadophis punctatus*	0	1 BHSO
Western Rattlesnake *Crotalus oreganus*	0	
Red-eared Slider (nonnative) *Trachemys scripta elegans*	105	
Soft-shelled Turtle (nonnative) *Apalone sp.*	2 Ballona Creek	
River Cooter (nonnative) *Pseudemys sp.*	1 Ballona Creek	
TOTAL	**2749**	**118**

Garden Slender Salamander, *Batrachoseps major*.—Of the 59 slender salamander observations over the course of this study, only one was a Garden Slender Salamander (Table 3-2; Figure 3-2). The remaining 58 observations were the closely related and ecologically similar Black-bellied Slender Salamander. This single individual was found in a pitfall trap bucket at Array 2 in KHSRA on April 8, 2015 following a rain event (iNaturalist 1378402). The same morning, 14 Black-bellied Slender Salamanders were also found in Array 2 pitfall traps (Appendix 1).

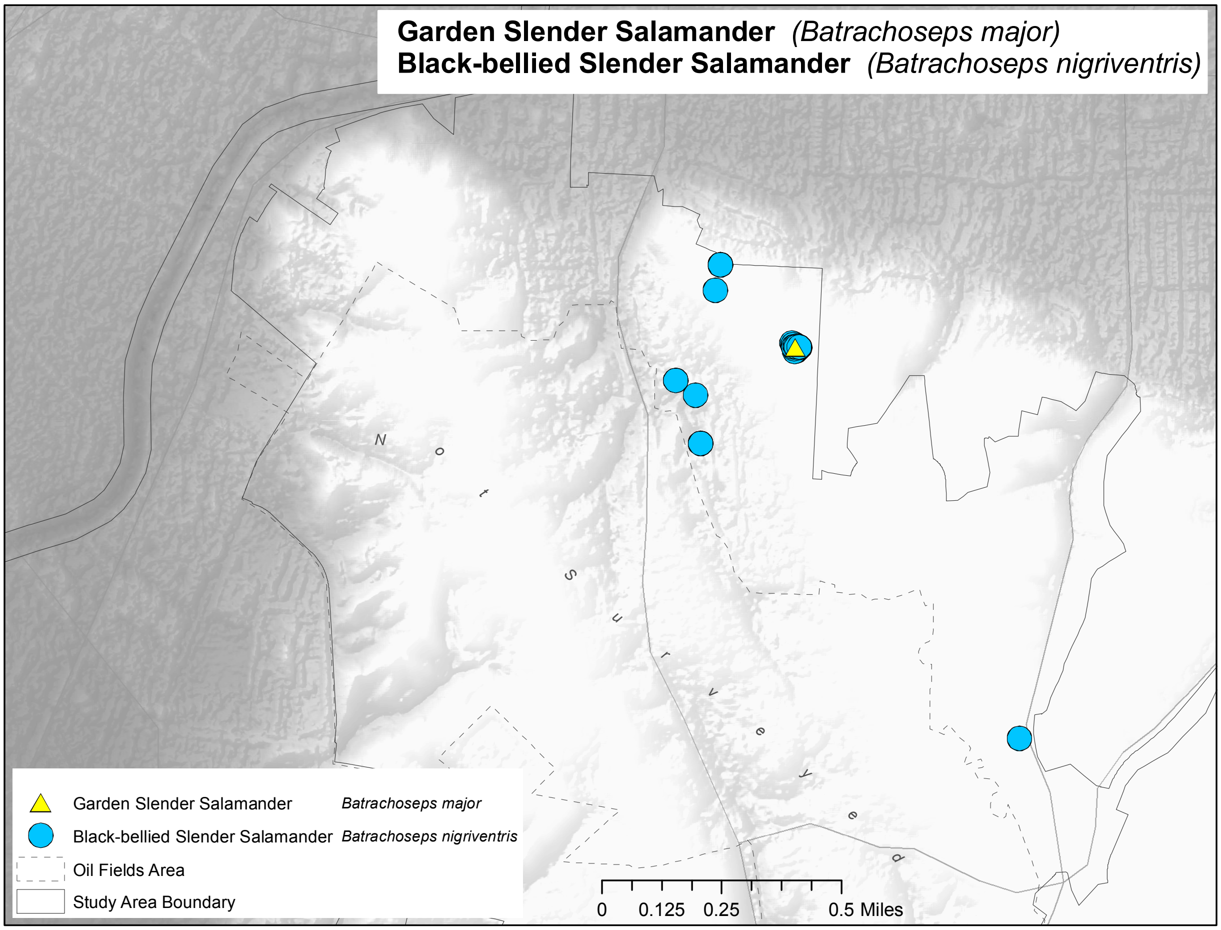


Figure 3-2. Salamander observations in the Baldwin Hills study area.

The history of slender salamanders in the Baldwin Hills is complicated by their changing taxonomy and the difficulty in differentiating between morphologically similar species. Museum specimens demonstrate that Garden Slender Salamanders have been collected at multiple localities in the flats surrounding the Baldwin Hills, including a large series collected in the survey area near the intersection of Overland Ave and Ballona Creek (LACM 33614–33699). Further downstream, Garden Slender Salamanders were also previously documented at Ballona Wetlands (Hayes and Guyer, 1981; Johnston et al., 2012). However, there are no museum specimens or unquestionable records of Garden Slender Salamanders for the uplifted portions of the Baldwin Hills.

Garden Slender Salamanders were reported in the 1970s surveys, but the identity of these salamanders is in question (Table 3-1). Two slender salamander species are listed in County of Los Angeles (1982): the Garden Slender Salamander as having been observed and the California Slender Salamander (*Batrachoseps attenuatus*) as possibly occurring in the Baldwin Hills based on range and habitat. In the late 1970s, Black-bellied Slender Salamanders were not yet recognized as a distinct species and were treated as California Slender Salamanders, *Batrachoseps attenuatus*. Further, it was only just beginning to be recognized that sites in the L.A. Basin could have both the *"attenuatus"/nigriventris* salamander and the more robust Garden Slender Salamander. Because of 1) the low frequency of Garden Slender Salamanders relative to Black-bellied Slender Salamanders in the 2014/2015 surveys, 2) the changing taxonomy of slender salamanders in the L.A. area, and 3) the difficulty in differentiating the two species, we contacted Mickey C. Long, former director of the L.A. County Nature Centers and a participant in the 1970s herpetofaunal surveys (though not the person who found the salamander[s]), to ask him about the species identification. Mr. Long (pers. comm.) suggested that based on the issues described above, the species identification should be considered questionable.

Given the low frequency of Garden Slender Salamanders relative to Black-bellied Slender Salamanders in our surveys, we suggest that the salamander(s) found in the 1970s were most likely Black-bellied Slender Salamanders. No slender salamanders were documented in the later survey (Beaman, 2001).

Conditions for finding slender salamanders were quite poor during the 2014/2015 surveys because of the drought. The lack of salamanders at other surveyed areas should not be interpreted as evidence for their absence. Surveys under more appropriate conditions will likely result in this species being found at other sites in the Baldwin Hills.

Black-bellied Slender Salamander, *Batrachoseps nigriventris*.—We documented 58 observations of Black-bellied Slender Salamanders (Table 3-2; Figure 3-2). All of these were found at KHSRA, with 47 of these observations occurring at Pitfall Array 2, 10 individuals found under debris on the first days of the 2014 and 2015 field seasons, and a single individual found dead on a trail after a rain event in 2016, which was most likely accidentally crushed by a hiker (iNaturalist 2827194). For the 2014 season, salamanders were only found on the cooler, shaded, north-facing slope of KHSRA. Because of the drought conditions, it is likely that conditions at or near the surface later in the field seasons were too warm and dry for slender salamanders.

Black-bellied Slender Salamanders are known from the Baldwin Hills based on museum records, and were likely found, but misidentified as Garden Slender Salamanders (see above for more information on this issue) during the 1970s surveys. This species was also not observed in the 2000 survey (Beaman, 2001).

As described above for the Garden Slender Salamander, conditions for finding slender salamanders during these surveys were quite poor because of the drought. Spring surveys conducted in more typical rain years will likely result in this species being found in other portions of the Baldwin Hills.

Western Fence Lizard, *Sceloporus occidentalis.*—The Western Fence Lizard was by far the most common species observed, accounting for approximately 69% of all observations (Table 3-2; Figure 3-3). As its name implies, this species is highly dependent on the presence of climbable vertical structure; this structure can be man-made such as fences, walls, and power poles, or it can be woody vegetation such as shrubs, trees, or brush piles. Given its habitat preferences and tolerances, it is not surprising that this was the only species found across all survey areas and also in neighborhoods and business complexes adjacent to Ballona Creek (Table 3-1).

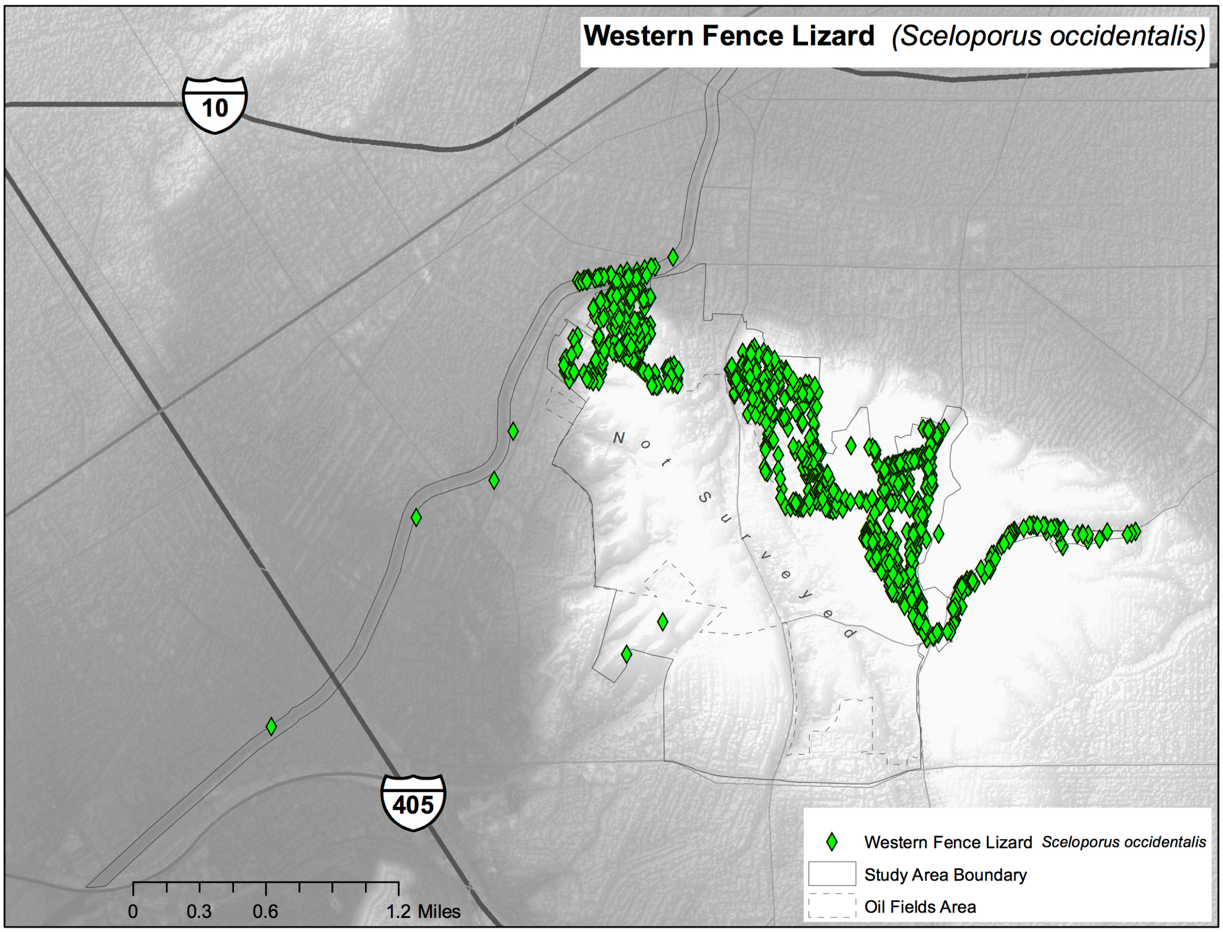


Figure 3-3. Western Fence Lizard observations in the Baldwin Hills study area.

Side-blotched Lizard, *Uta stansburiana.*— The Side-blotched Lizard was the second most common species observed, accounting for approximately 18% of all observations (Table 3-2; Figure 3-4). Side-blotched Lizards are largely ground-dwelling lizards that can be extremely abundant in dry, open habitat with scattered boulders and low vegetation where they can find adequate opportunities to bask and escape potential predators. Historically, the Side-blotched Lizard would have been widespread in the Coastal Sage Scrub and other drier habitats of the Los Angeles Basin, but much of this habitat has been lost to urbanization. Side-blotched Lizards typically avoid areas with dense vegetation including grassy slopes with thick cover from nonnative annual grasses. Given these habitat requirements, it is unsurprising that Side-blotched Lizards were found in the more open portions of KHSRA and BHSO but not in the dense grassy slope along the Stocker Corridor nor in surrounding urban areas (Table 3-1; Figure 3-4).

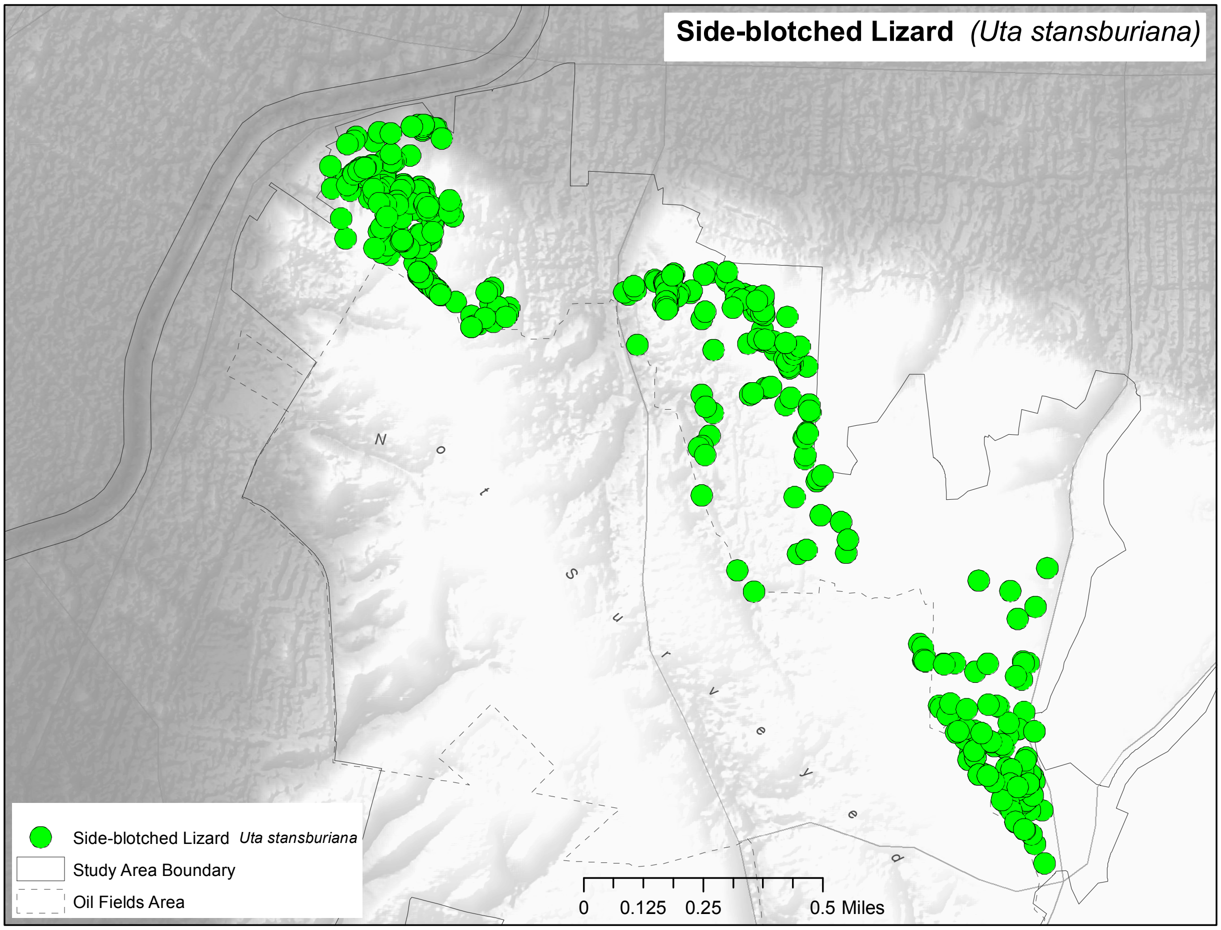


Figure 3-4. Side-blotched Lizard observations in the Baldwin Hills study area.

Southern Alligator Lizard, *Elgaria multicarinata (=Gerrhonotus multicarinatus* in earlier literature).— Southern Alligator Lizards were observed 83 times across nearly all surveyed areas (Table 3-2; Figure 3-5). The only area where this species was not observed was Norman O. Houston Park. Although much of this park is hardscape or lawn, which are not appropriate habitats for alligator lizards, the periphery of the park is likely inhabited by this species. Based on observations submitted to the RASCals project, the Southern Alligator Lizard appears to be the most widespread lizard in urban areas of the Los Angeles Basin and San Fernando Valley, and it likely occurs in most neighborhoods surrounding the Baldwin Hills. Multiple observations of this species were made in one yard adjacent to Ballona Creek and submitted to the RASCals project (Figure 3-5).

Unlike the Western Fence Lizard and Side-blotched Lizard, which bask in prominent locations, the Southern Alligator Lizard does not commonly bask. Instead, it prefers cooler temperatures and is often found in areas with dense vegetation and leaf litter. For this reason, this species is also less commonly observed even though it is widespread in urban areas.

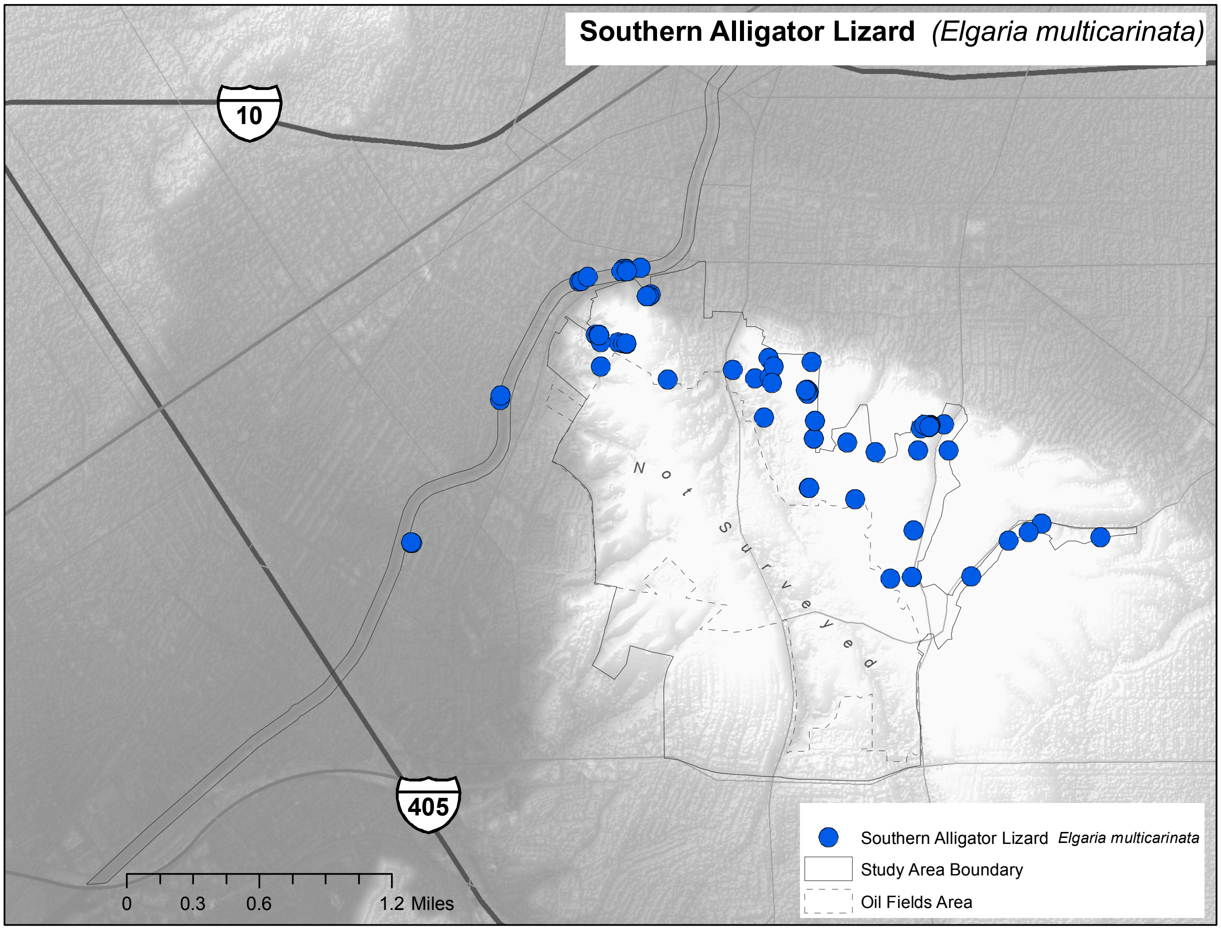


Figure 3-5. Southern Alligator Lizard observations in the Baldwin Hills study area.

Western Skink, *Plestiodon skiltonianus* (=*Eumeces skiltonianus* in earlier literature).—In California, the Western Skink is not found in the major valleys including much of the Central Valley, the San Fernando Valley, and the Los Angeles Basin. However, in the L.A. Basin, it does occur on isolated uplifted areas such as the Palos Verdes Peninsula and Verdugo Mountains. It was also historically found in the El Segundo Sand Dunes (von Bloeker, 1942) and is known from other coastal regions of Southern California (e.g., LACM 99674 from Newport Back Bay, Orange County). We observed this species 12 times in KHSRA, the BHSO, and along the Jim Webb Trail south of the BHSO (Table 3-2; Figure 3-6). These records are the first time this species has been documented in the Baldwin Hills. This species has not been recorded in the surrounding lowlands through the RASCals project, nor was it documented in prior herpetological surveys of Ballona Wetlands (Hayes and Guyer, 1981; Johnston et al., 2012).

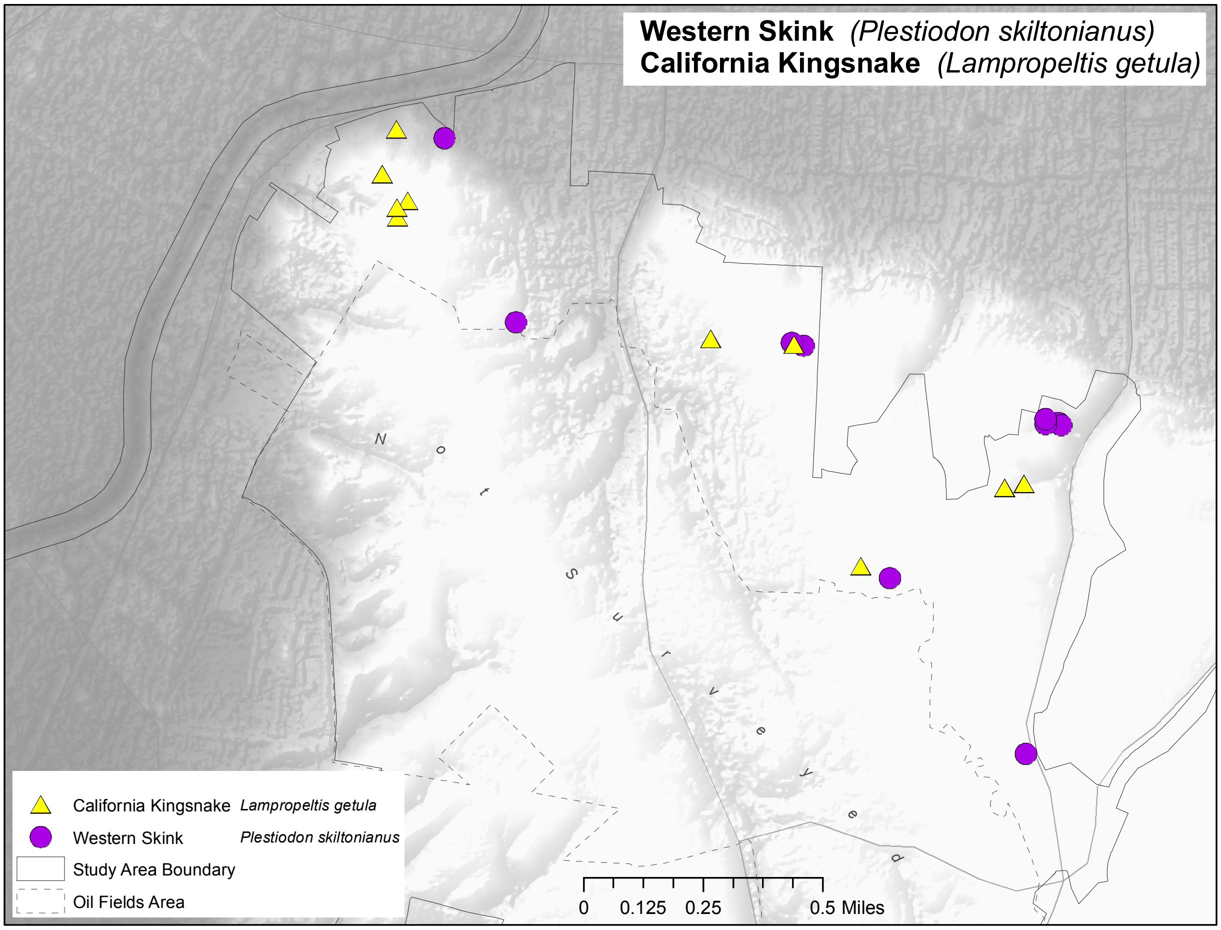


Figure 3-6. Western Skink and California Kingsnake observations in the Baldwin Hills study area.

Gophersnake, *Pituophis catenifer* (=*Pituophis melanoleucus* in earlier literature).—The Gophersnake was the most commonly observed snake species, with 72 sightings at KHSRA and BHSO (Table 3-2; Figure 3-7). Road-killed Gophersnakes were observed on La Cienega Avenue, Stocker Street, and on roads in both BHSO and KHSRA. Gophersnakes were also observed in the two previous surveys (County of Los Angeles, 1982; Beaman, 2001) and are known from museum specimens (Table 3-1).

Interestingly, there appeared to be very little successful recruitment of Gophersnakes in the Baldwin Hills. During the formal surveys, life stage was categorized as juvenile or adult. For 33 of the RASCals observations, the life stage of the snake was determined from the photos and similarly classified. During the survey period (2014 through June 2016), only 3 of 71 Gophersnakes were juveniles. Two of these were recent hatchlings (iNaturalist 1958221 and 2000331) and the other was an approximately 6-month old snake found in the spring. Lack of recruitment could be due to the ongoing drought conditions and lack of adequate food and water.

California Kingsnake, *Lampropeltis getula* (=*Lampropeltis californiae* of some authors).—California Kingsnakes were observed 10 times in both KHSRA and BHSO (Table 3-2; Figure 3-6).

Kingsnakes were also documented in the 1970s surveys and personnel working in the park reported their presence to Beaman in the later surveys although he never observed any (Beaman, 2001).

As with the Gophersnakes, life stage was recorded in the field or ascertained from photographs when possible. Three of eight snakes were juveniles, suggesting that kingsnakes do not have the same remarkably low recruitment as observed for the Gophersnakes during the survey period.

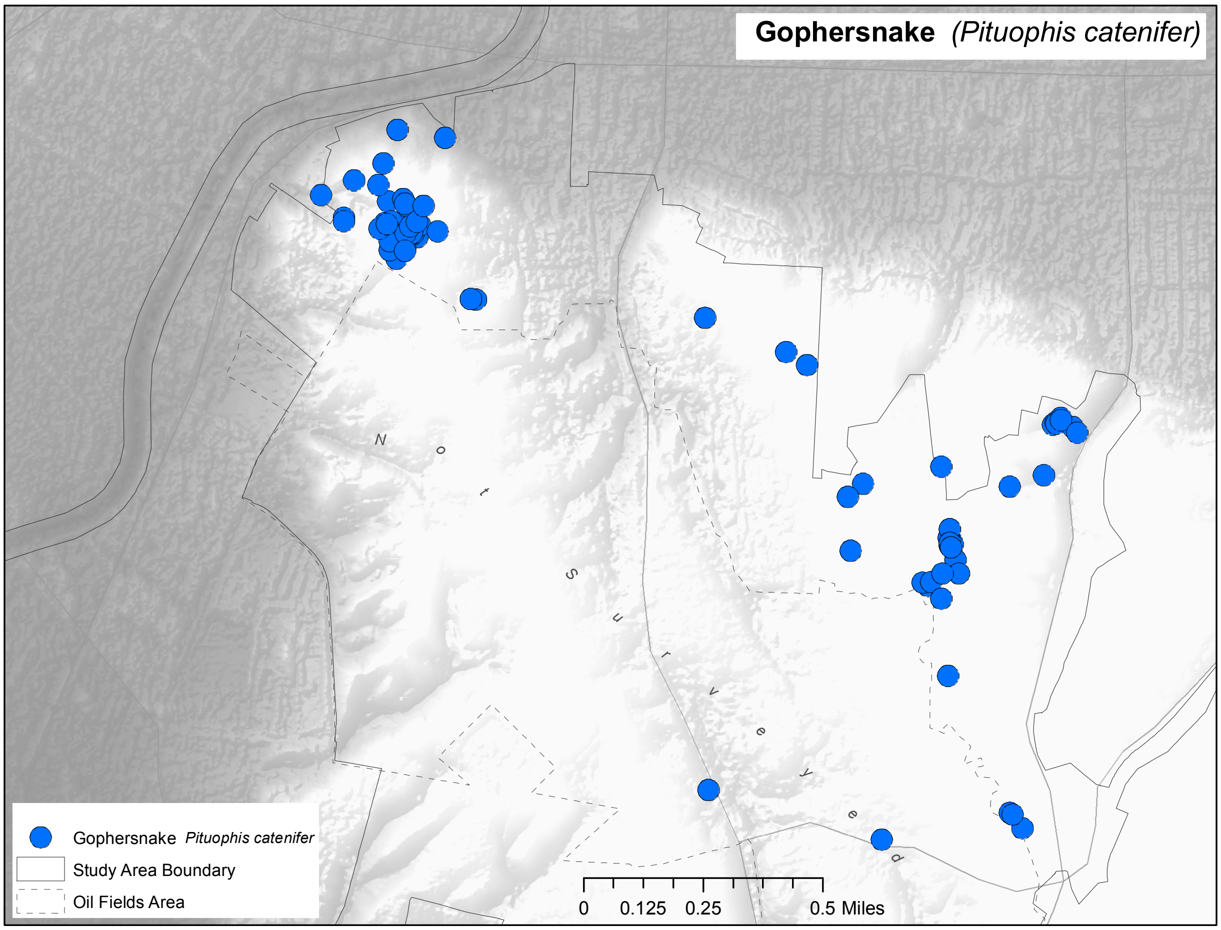


Figure 3-7. Distribution of gophersnake observations. Incidental road-killed observations included.

Coachwhip, *Masticophis flagellum* (=*Coluber flagellum* of some authors).—We observed a Coachwhip one time, and seven additional Coachwhip observations were submitted to the RASCals project (Table 3-2; Figure 3-8). Coachwhips were reported by personnel working in the Baldwin Hills to the authors of the 1970s surveys, but no biologists have documented Coachwhips during the previous surveys (County of Los Angeles, 1982; Beaman, 2001). Further, no Coachwhips were documented in recent surveys of Ballona Wetlands Ecological Reserve (Johnston et al., 2012), and there are no museum vouchers from the study area. There are, however, two older records of Coachwhips from just southwest of the study area. In his herpetofaunal survey of the El Segundo Sand Dunes, von Bloeker (1942) reports a Coachwhip from the "south bank of Ballona Creek, one mile north of Playa Del Rey" that was observed March 13, 1932. Further, von Bloeker collected a

Coachwhip April 11, 1932 from "Hyperion" (LACM 2246). It is not clear why he did not discuss this second specimen in the 1942 publication. Coachwhips can still be found today along the lower reaches of the L.A. (iNaturalist 1396851) and San Gabriel Rivers (iNaturalist 1153637) and in coastal habitat elsewhere in Southern California (Mitrovich et al., 2009).

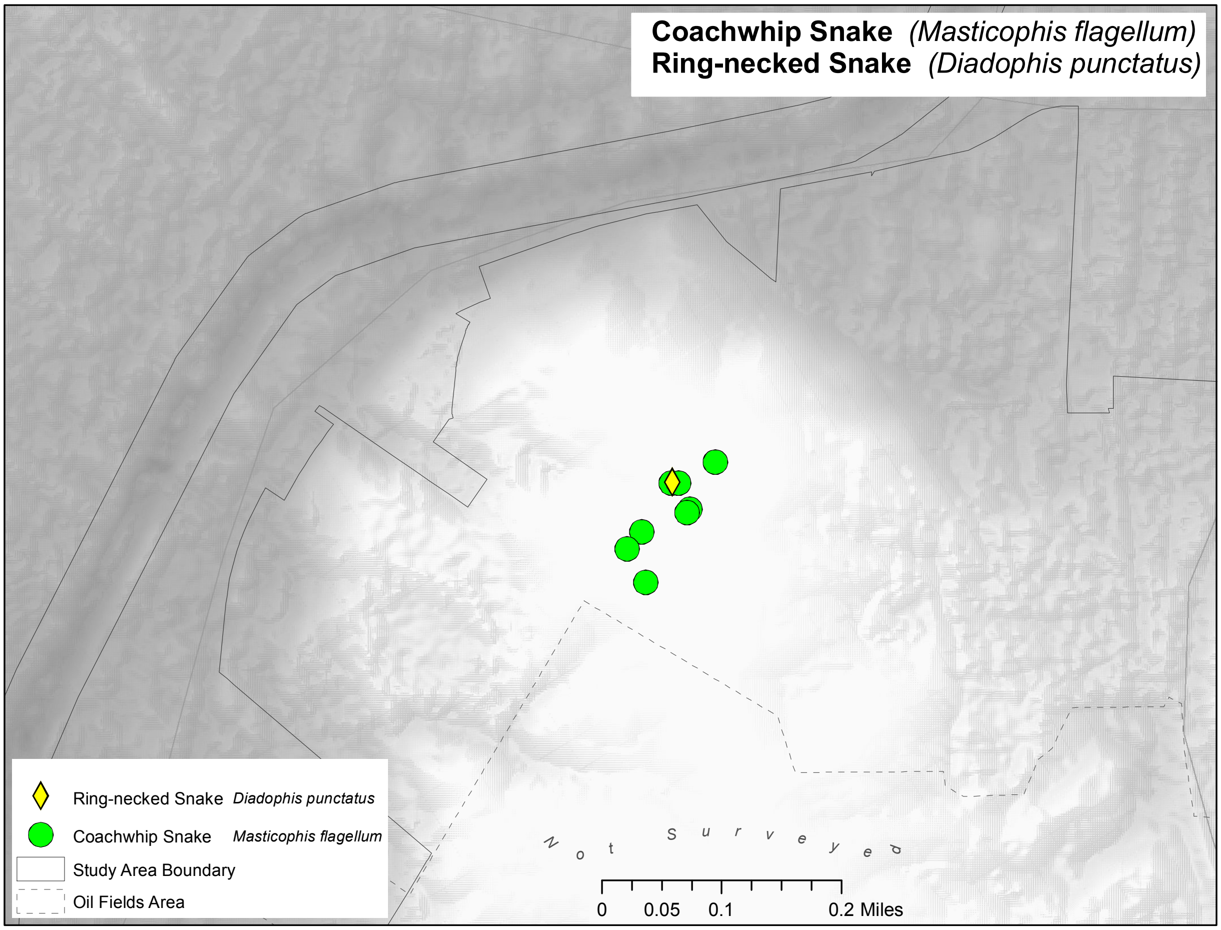


Figure 3-8. Distribution of coachwhip and ring-necked snake observations centered at Baldwin Hills Scenic Overlook.

Interestingly, all Coachwhip observations were at the top of BHSO near the Visitor Center (Figure 3-8). All eight observations were roughly within an area smaller than 1.3 hectares. This area is far smaller than typical home ranges for this species in Southern California. Mitrovich et al. (2009) examined snakes at three fragmented sites and found that the smallest average home range was still 11.2 hectares, far greater than the area in which these observations occurred at BHSO. Because the BHSO observations were in such close proximity (Figure 3-8), we examined the photographs of the seven observations submitted to the RASCals project. Every photograph is of a similarly sized adult. Based on size and an examination of the neck and/or dorsal markings in those photos where they are visible, all observations appear to be of the same individual. The home range data combined with the analysis of photographs suggests that only one Coachwhip was observed in BHSO.

Ring-necked Snake, *Diadophis punctatus.*—A single individual was documented through the RASCals project (iNaturalist 1341697) at the BHSO Visitor Center (Table 3-2; Figure 3-8). Concerned that it could be injured because of heavy human traffic in the area, it was moved to the greenhouse area and released. No other Ring-necked Snakes were observed during the study, making this observation the first (and, thus far, only) time this species has been documented in the Baldwin Hills (Table 3-1). Ring-necked Snake activity was likely depressed during the survey period because of the drought; surveys conducted in more typical years may yield additional observations. A single individual was also documented at Ballona Wetlands using coverboard surveys (Johnston et al., 2012), and von Bloeker (1942) reported them as being "quite common" in the El Segundo Sand Dunes.

Western Rattlesnake, *Crotalus oreganus.* NOT OBSERVED.—This species is only included in this report because of concern over rattlesnake-human encounters. *No rattlesnakes have ever been documented during herpetofaunal surveys of the Baldwin Hills* (Table 3-1). This species was listed as being reported by KHSRA personnel in the late 1970s (County of Los Angeles, 1982), but no biologists observed a rattlesnake during those surveys nor in any subsequent surveys.

Gophersnakes, which are the most commonly seen snake in the Baldwin Hills, are often mistaken for rattlesnakes and are the likely source of the anecdotal reports. The two species have similar color patterns, and the defensive display of the Gophersnake involves mimicking the rattlesnake. A Gophersnake will inhale air to make its body look bigger, flatten out its head into a more angular shape, hiss loudly, and shake its tail in dry vegetation, which can produce a rattle-like sound. This can be a very convincing display and often results in Gophersnakes being mistaken for rattlesnakes. Given that no rattlesnakes have been confirmed in the Baldwin Hills, it is likely that the early anecdotal account results from such a misidentification.

Western Rattlesnakes likely did occur in the Baldwin Hills prior to extensive urbanization of the region, but they appear to have disappeared from the area many decades ago. This species can still be found today at Ballona Wetlands Ecological Reserve and adjacent undeveloped, sand dune habitat (Johnston et al., 2012).

Red-eared Slider Turtle, *Trachemys scripta elegans.*—The Red-eared Slider is the most widespread turtle species in the world. It is native to the central and eastern U.S., but as a result of releases of unwanted pets, it has become established in dozens of countries around the world. This species was first documented in the Baldwin Hills by Beaman (2001) who observed individuals at the Holy Cross Cemetery pond and noted that KHSRA personnel reported this species at Gwen Moore Lake (Table 3-1).

In our surveys, we confirmed at least 5 individuals at the Holy Cross Cemetery Pond, 43 at Gwen Moore Lake, 7 at the middle pond at KHSRA, and 13 in the Japanese Garden pond at KHRSA (Table 3-1, Table 3-2; Figure 3-9). No turtles were observed at the upper lake at KHSRA, though individuals likely move in and out of this pond. This species was also observed multiple times at the lower end of Ballona Creek once it exits the concrete channel.

Turtle trapping at KHSRA resulted in the capture of 27 individuals, including juveniles, adult males, and adult females. Body sizes ranged from 83 g to 1432 g. Multiple individuals were observed with significant pyramiding of their scutes, which is consistent with inappropriate nutrition in a captive environment, suggesting these animals were almost certainly abandoned pets. Many of the turtles observed through visual encounter surveys were most likely abandoned pets, although there may also be successful breeding taking place at KHSRA.

Available habitat in Ballona Creek is relatively small because the soft-bottomed portion has significant tidal influence. Thus, these freshwater turtles are confined by the upstream boundary of the concrete channel and the downstream boundary of salt water. Trapping in this stretch yielded an adult male (801 g) and an adult female turtle (2,150 g). There was no evidence for successful reproduction in this area, and there does not appear to be adequate nesting habitat along the channelized and heavily urbanized creek.

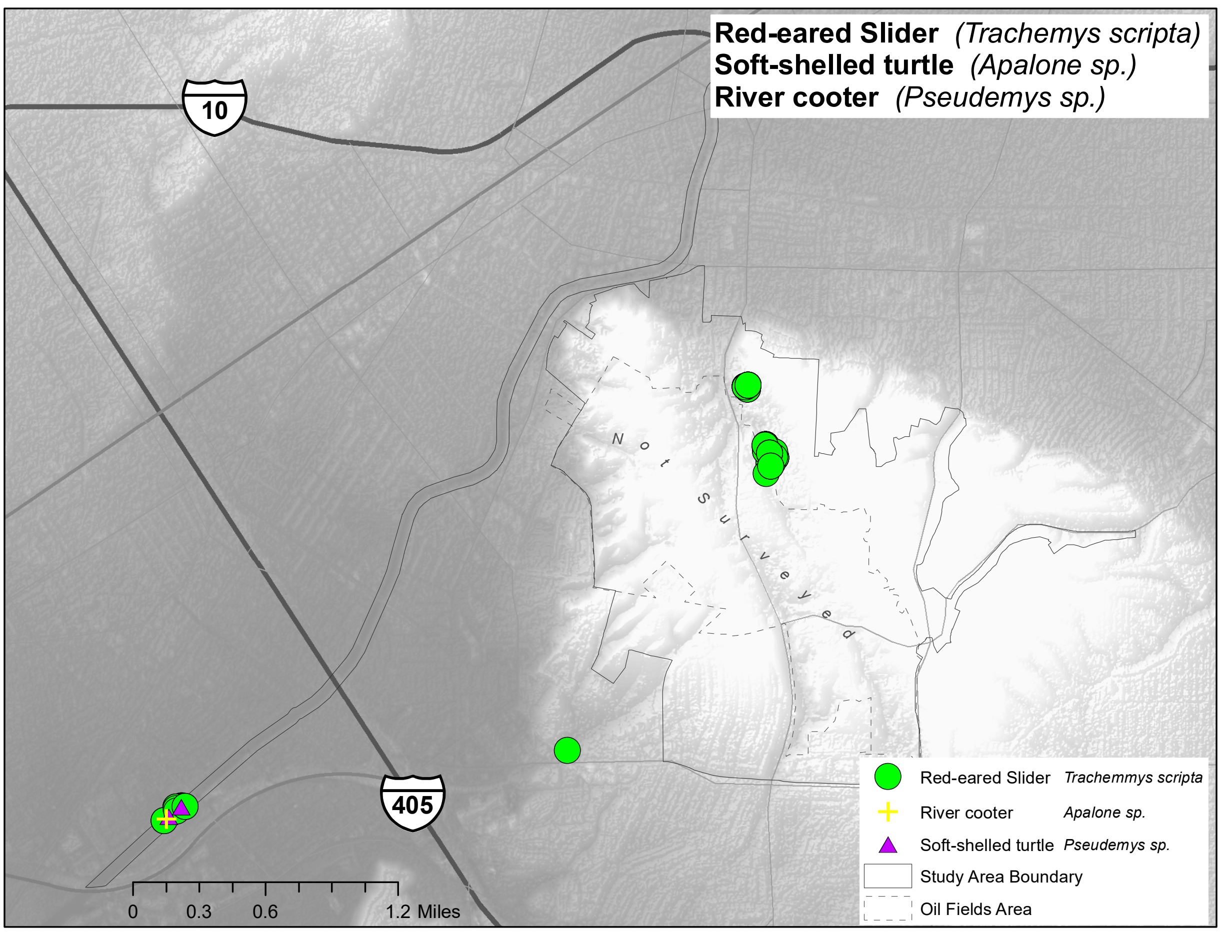


Figure 3-9. Observations of turtles in the Baldwin Hills study area.

Soft-shelled Turtle, *Apalone* sp.—At least one soft-shelled turtle was observed in the lower reaches of Ballona Creek (Table 3-1, Table 3-2; Figure 3-9). Observations were made on June 5, 2014 and April 1 and August 6, 2015. All were of a large turtle, suggesting all observations may have been of the same individual. Soft-shelled Turtles are available in the pet trade and, like Red-eared Sliders, are sometimes illegally dumped by irresponsible pet owners. In California, the most common soft-shelled turtle introduced to urban waterways is the Spiny Softshell, *Apalone spinifera.* However, other species of soft-shelled turtles are also sometimes found in California. Thus, the Ballona Creek turtle is most likely a Spiny Softshell, but we only identify it to genus because we were never able to observe any distinguishing features.

Soft-shelled turtles had not previously been documented from the Baldwin Hills or Ballona Creek. Because this species is in the pet trade, it will likely appear at the KHSRA ponds at some point.

River Cooter, *Pseudemys* sp.—River cooters are a genus of turtles found in the southern and eastern United States. Several species are sold in the pet trade, and as a result of abandoned animals, can appear in urban waterways outside of their native range. A single individual was observed basking on March 31, 2014 in the lower reaches of Ballona Creek (Table 3-1, Table 3-2; Figure 3-8). River cooters, especially outside of their native range, can be extremely challenging to identify without having the turtle in hand. This individual was observed through binoculars so we can only confidently assign it to genus.

Discussion

Reptiles and Amphibians of the Baldwin Hills

Our herpetofaunal surveys documented 5 amphibian species and 11 reptile species in the Baldwin Hills and adjacent portions of Ballona Creek (Table 3-1, Table 3-2). Six of these species are new records for the area that were not documented in previous surveys or through museum specimens: American Bullfrog, Western Skink, Coachwhip, Ring-necked Snake, soft-shelled turtle, and river cooter. Of these six, only the Western Skink is clearly established in the Baldwin Hills; the other five lack evidence of established (i.e., reproducing) populations. Similarly, the Western Toad lacks evidence of an established population in the survey area. Thus, there is evidence for established populations of three amphibian species and seven reptile species in the Baldwin Hills. Below we discuss the evidence for and against recognizing these six species as established.

Nonnative Turtles.—The three turtle species found in the ponds at KHSRA and/or in Ballona Creek all result from the illegal abandonment of unwanted turtles. Only the Red-eared Slider is potentially established in the area, with some successful reproduction likely happening at KHSRA given the large number of adults there. A few juvenile turtles were observed in Gwen Moore Lake, although no recent hatchlings were ever observed, making it unclear if there is successful reproduction at KHSRA. Because hatchling Red-eared Sliders are available in local pet shops and markets in L.A.'s Chinatown despite the ban on sale of turtles under four inches long, it is also possible that even these juveniles are abandoned animals. There is also a dense, established population of Red-eared Sliders at the Ballona Wetlands Freshwater Marsh, just outside of our survey area. However, turtles from the Freshwater Marsh cannot make their way to KHSRA without human assistance.

We only observed a single river cooter, and likely only a single soft-shelled turtle, so these two species are unlikely to have established populations. Further, these two turtle species are confined to a narrow stretch of the soft-bottomed portion of Ballona Creek downstream of the concrete channel and upstream of significant saltwater influence. Both species are occasionally found in urban waterways in California (e.g., Spinks et al., 2003), but there is no evidence of successful reproduction by river cooters in California. Introduced populations of soft-shelled turtles are known in California from Riverside and Imperial Counties (Stebbins, 2003), but it is less clear if there are established populations in coastal waterways of California.

Coachwhip and Ring-necked Snakes.—Historically, Coachwhips were likely quite widespread across the L.A. Basin, including in and around the Baldwin Hills. Ring-necked Snakes, however, were likely absent from much of the floor of the Los Angeles Basin. Most museum records of Ring-necked Snakes from the L.A. Basin are for uplifted areas such as the Palos Verdes Hills, Chino-Puente Hills, and the hills north of Downtown L.A. such as Elysian Park and Mt. Washington. Ring-necked Snakes are, however, known from just outside of our focal area having been found in the El Segundo Sand Dunes (von Bloeker, 1942; see also SDNHM 31292 from Playa Del Rey) and at Ballona Wetlands Ecological Reserve (Johnston et al, 2012). Two specimens have also been recorded from the lower reaches of the L.A. River in Long Beach (LACM 103814 and 103815).

We observed only a single Ring-necked Snake in the Baldwin Hills, and it is likely that all eight observations of Coachwhips are of the same individual. Thus, for these two species, the crucial question for the Baldwin Hills is whether these two individuals are remnants of existing (and potentially dwindling) populations or are recent introductions? It is not possible to give a definitive answer at this time, but we discuss the possibilities and suggest future actions below.

For the Coachwhip, we believe that a recent introduction is the most likely scenario to explain this one individual being found around the Visitor Center at BHSO. Coachwhips are large, diurnally active snakes that hunt reptiles, birds, and small mammals. Relative to other snakes in L.A. County, they tend to be fairly conspicuous where they are found. If there is an existing population at BHSO, we would expect that other individuals and size classes would have been seen. Further, no Coachwhips were observed in the recent surveys of Ballona Wetlands (Johnston et al., 2012), which is a larger area of habitat than BHSO. Future monitoring, including through citizen science (e.g., the recent, joint BHSO-Natural History Museum bioblitz is an excellent example), will be important for getting a better understanding of this species in the Baldwin Hills.

Although Coachwhips are not commonly available in the pet trade, a single individual getting released in the Baldwin Hills is a plausible scenario. Hobbyists and others interested in snakes, especially teenagers, sometimes collect wild snakes with the hopes of keeping them as pets. As they learn more about care requirements, the long-term commitment, or find that the new captive is not adjusting well to the conditions, people sometimes release these animals into what they perceive as reasonable habitat. This scenario could have resulted in this Coachwhip being released at BHSO.

For the Ring-necked Snake, we believe that this species could be present in the Baldwin Hills. This species has been observed recently in the general area and was likely more common in the past (von Bloeker 1942; Johnston et al., 2012). This is a small, secretive snake that spends much of its life in loose soil and leaf litter where it hunts invertebrates, small snakes and lizards, frogs, and salamanders. Thus, even where they are common, they may not be commonly observed by people. Coverboard surveys are an excellent way to document this species, but surface activity throughout our survey period would have been much reduced by the drought conditions. Even in the spring, the ground under the coverboards was often dry and warm. These conditions are not conducive to finding Ring-necked Snakes. Future coverboard surveys (including potentially using the existing coverboards in BHSO and KHSRA) would be useful for further elucidating the presence of this snake in the Baldwin Hills.

American Bullfrog.—Only a single Bullfrog was observed in the survey area, and it was at Gwen Moore Lake. Thus, it is possible that this is not an established population, but merely one individual likely introduced by people. Bullfrogs can be found at high densities at Ballona Freshwater Marsh and portions of Centinela Creek upstream of the Marsh (Pauly, pers. obs.; LACM 186677—186678). However, given the level of urban development in the region, it is unlikely that Bullfrogs could successfully disperse from these established populations without assistance from people. The ponds at KHSRA do appear to provide adequate habitat for Bullfrogs if they were to be introduced (through the release of adults or tadpoles, which are sometimes used as fish bait). Bullfrogs are voracious nonnative predators and will eat small birds, fish, frogs, mammals, reptiles, and a wide variety of other items (Stebbins, 2003). As a result, Bullfrogs should be eradicated from KHSRA if and when they show up there.

Western Toad.—Historically, Western Toads were probably quite common in the vicinity of the Baldwin Hills. This was especially likely before the Rancho Era (1820s to 1870s) when there were extensive wetlands north of the Baldwin Hills and along the Ballona Creek corridor, which at times was also the outlet for the L.A. River (Dark et al., 2011). Museum specimens and the account by von Bloeker (1942) further indicate that toads persisted in the general area until the mid 1900s. However, no Western Toads were observed in previous surveys of the Baldwin Hills (County of Los Angeles, 1982; Beaman, 2001), only a few animals were observed in the 1980 survey of Ballona Wetlands (Hayes and Guyer, 1981), and none were observed in more recent surveys of the Ballona Wetlands (Johnston et al., 2012). Thus, our finding of a single individual along Ballona Creek was a surprise.

As with the Coachwhip and Ring-necked Snake, this animal could be a remnant of what was once a thriving toad population in the region, or it could be a recently released animal. There are multiple backyard garden ponds adjacent to Ballona Creek in the region where the toad was found. Some of these ponds did have active Pacific Treefrog breeding choruses. It is possible that a toad was released in this frog-friendly neighborhood. However, given that toads were found at Ballona Wetlands in the 1980 survey, it is also possible that there are small numbers of toads still in the area. These toads would most likely use vernal pools in the region for breeding. There is not adequate breeding habitat for this species in Ballona Creek, and Centinela Creek and Ballona Freshwater

Marsh have predatory nonnative mosquitofish and Bullfrogs. Mosquitofish will eat amphibian eggs and tadpoles, and Bullfrogs will eat tadpoles, metamorphs, and adult toads. Thus, there is minimal breeding habitat for this species in the area. Habitat restoration at Ballona Wetlands and in the Baldwin Hills that included building vernal pools could benefit Western Toads if they remain in the area. Future surveys for Western Toads should focus on examining any vernal pools at Ballona Wetlands for eggs and tadpoles and nighttime surveys for adults after rainstorms.

The Role of Lawns in Shaping Reptile and Amphibian Distributions

In KHSRA, Janice's Green Valley and the lawns along the entrance road take up large areas but have almost no habitat value for reptiles and amphibians. Our detailed geographic surveys highlight the almost complete lack of reptiles and amphibians in these lawn areas (see, for example, Figure 3-10). For example, although nearly 2000 Western Fence Lizards were observed in these surveys, none were ever found beyond the periphery of the lawn areas (Figure 3-3). This species prefers areas with rocks, woody vegetation, or manmade structures like fence posts and walls (these can be thought of as a third dimension to the landscape); large expanses of lawns, however, are largely a 2-dimensional habitat with minimal prey for lizards and few spots where lizards can seek shelter from predators and unfavorable weather. Side-blotched Lizards, which do like open habitat, still avoid lawns because they prefer more barren ground and are similarly faced with the lack of prey and shelter provided by lawn areas (Figure 3-4). We did observe the occasional Gophersnake on lawns, where they were most likely hunting Botta's Pocket Gophers (e.g., iNaturalist 1368809). However, these snakes were found on the periphery of the lawns where they could easily retreat to areas with increased cover and thereby avoid predators, people, or unfavorable weather (Figure 3-7).

Only two observations were made of reptiles on lawn habitat inside Janice's Green Valley. The first was an adult Gophersnake observed May 21, 2015 (iNaturalist 1521039). The second was also an adult Gophersnake, but this time the animal was found dead on June 18, 2015 (iNaturalist 1644976). The dead snake was too degraded to determine if it was the same animal as the one observed a few weeks earlier. It is also possible that the snake was killed by a predator and then dropped inside Janice's Green Valley. Thus, despite our numerous records of reptiles within KHSRA, we only have a single definite observation of a reptile within a large expanse of lawn. Even in this case, the Gophersnake was observed within a few meters of a small tree (i.e., vegetative cover), and the snake was only 25 m into Janice's Green Valley, which is approximately 375 m in diameter.

Habitat restoration that returns lawn areas to the coastal sage scrub that historically dominated this area will dramatically increase the habitat value of these areas. Similarly, if additional oil field lands are converted to parks, restoring these lands with native vegetation will benefit the native herpetofauna; creating lawn areas at former oil field sites will lead to further declines of the herpetofauna.

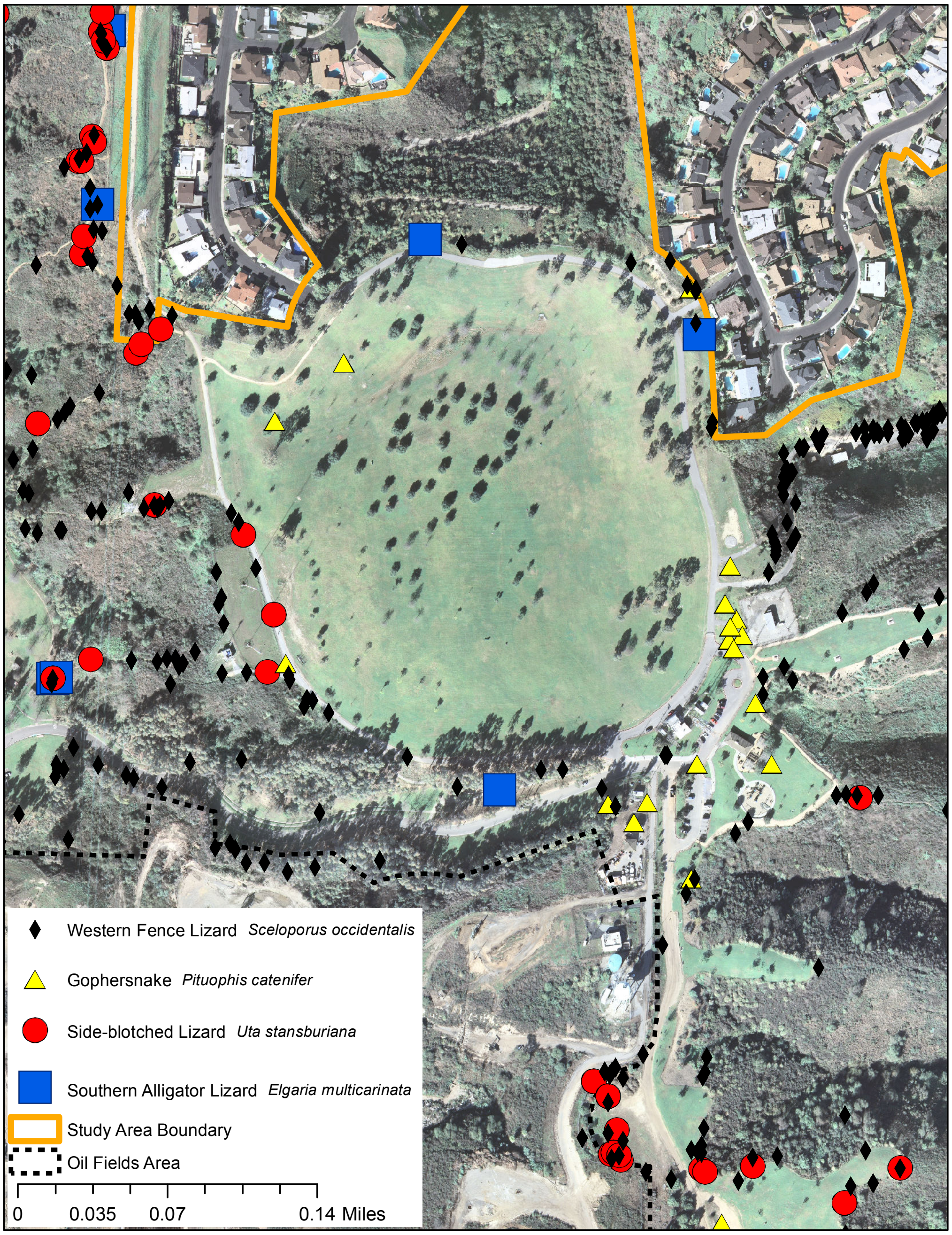


Figure 3-10. Location of snake and lizard observations around large expanses of lawn at Kenneth Hahn State Recreation Area.

Threats from Nonnative Species in the Baldwin Hills

Over the course of our sampling, we encountered multiple nonnative vertebrate species in the Baldwin Hills. Many of these were likely abandoned former pets, including domestic rabbits, cats, a guineafowl, and the three species of turtles discussed previously: Red-eared Slider, soft-shelled turtle, and river cooter. We captured three domestic rabbits by hand shortly after Easter in 2015 in

KHSRA; all were given to new owners or taken to a shelter. The guineafowl was seen on multiple occasions in KHSRA during the spring and summer of 2015. Feral or outdoor cats were also seen across most study areas (KHSRA, BHSO, Ballona Creek, Stocker Corridor, Culver City Park, and La Brea Corridor). We also spoke with one member of the public who had caught and removed three abandoned dogs from KHSRA over a 6-year period. Open spaces in the Baldwin Hills, and, in our experience, especially KHSRA, seem to be used as dumping grounds for unwanted animals. Increased education and signage in the area, and especially at KHSRA, may help reduce abandonment of unwanted animals. Below, we discuss the two nonnative species that have high potential to threaten native herpetofauna in the Baldwin Hills.

Feral cats.—We observed feral cats throughout the study area, including a cat hunting coots along Ballona Creek. We also observed two feral cat feeding stations in KHSRA in 2014, and multiple feeding stations in Culver City Park and at several locations along Ballona Creek. These observations are consistent with findings from Ordeñana and Dines (Chapter 5, this volume), in which feral cats were documented at all camera traps throughout the Baldwin Hills and were the most common mammal photographed after humans. Another measure of the large number of cats in the Baldwin Hills comes from a conversation one of us (GBP) had with an individual on April 6, 2015 who on his own was conducting trap-neuter-release (TNR) of cats in KHSRA with the cats being released in urban neighborhoods instead of returned to KHSRA post surgery. He claimed that over six years, he had removed 54 cats and 3 dogs from KHSRA. GBP observed this person's vehicle multiple times in KHSRA in 2015 and again in early summer 2016. Feral cats are clearly widespread throughout the Baldwin Hills, and there are a number of feeding stations.

Feral cats have significant impacts on wildlife, especially in urbanized landscapes (Loss et al., 2013, and references therein). The impacts of feral cats on birds and mammals have been better studied, but feral cats are known to consume large numbers of reptiles (Henderson, 1992; Medina et al., 2011; Loss et al., 2013). In a study of free-roaming, owned domestic cats, reptiles faced the highest level of predation among prey categories (36%), greater than the percentage of mammals (26%) and birds (13%) killed by cats (Loyd et al., 2013). Other studies have also found that reptiles face high mortality from cat predation (Mitchell and Beck, 1992 [22%]; Crooks and Soulé, 1999 [37%]; reviewed in table 1, Loyd et al, 2013). Amphibians seem to experience far less mortality from cats than other major vertebrate groups, but cats, nevertheless, are a source of mortality for amphibians, especially in urbanized areas (Loss et al., 2013; Loyd et al., 2013).

Reduction in the number of feral cats in the Baldwin Hills is an important management objective to reduce mortality of native lizards and snakes in the area. Similarly, native mammals, birds, and invertebrates will also benefit from a reduction in the feral cat population.

American Bullfrog.—Bullfrogs are an invasive species well known for their ability to consume large prey including other vertebrates, such as ducklings, turtles, fish, mice, snakes, and frogs (Moyle, 1973; Bury and Whelan, 1984; Stebbins, 2003; Casper and Hendricks, 2005). Historically, Bullfrogs would have found the L.A. Basin uninviting. Because of our Mediterranean Climate, and long, dry summers, most ponds in the L.A. Basin were vernal, filling with water from winter rains and drying up in the summer. Bullfrogs could not thrive in this environment because they need permanent water. Even in warm climates, Bullfrog tadpoles need at least 6–8 months before they metamorphose into young frogs, and when possible they often stay in the tadpole stage even longer. Thus, Bullfrogs thrive in many parts of the L.A. Basin only because of the increased number of permanent ponds and greater year-round water availability resulting from urbanization. For example, there are now dense populations of Bullfrogs in Centinela Creek and at Ballona Freshwater Marsh. One of us (GBP) collected a Bullfrog at Ballona Freshwater Marsh that was 205 mm long and weighed 1078 g (2.38 lbs); this represents the upper size limit of this species (Stebbins, 2003) and demonstrates that Bullfrogs can achieve large size in the Baldwin Hills/Ballona Creek region.

The ponds at KHSRA have the potential to support large numbers of Bullfrogs. Fortunately, only a single Bullfrog was observed at KHSRA during our surveys. Future monitoring for Bullfrogs will be essential to prevent them becoming established there. Nighttime eye-shine surveys for juvenile and adult frogs and dipnet or seine surveys for tadpoles are likely to be the most efficient methods for the early detection of Bullfrogs. If encountered, Bullfrogs should be eradicated from the ponds to prevent predation of native wildlife.

Human Threats to Wildlife

Intentional killing of wildlife by people on parklands.—Three snakes were found that appeared to have been intentionally killed by people. An adult Gophersnake was found at KHSRA that appeared to have been beaten to death with a stick (iNaturalist 1380166; LACM 186801). This snake was stretched partially across a dirt road that three of us had walked an hour earlier; thus, the snake was found shortly after it was killed. A subadult California Kingsnake that was chopped into multiple pieces was also found at KHSRA (iNaturalist 3206087). Lastly, an adult Gophersnake was found along Hetzler Road at BHSO that had also been chopped into multiple pieces (iNaturalist 1648012). Other dead snakes were found at both BHSO and KHSRA, but cause of mortality could not be conclusively determined.

Surprisingly, one park user was found to be visiting KHSRA specifically to kill wildlife. On April 6, 2015, one of us (GBP) observed a person carrying a rifle in KHSRA. This incident was reported to park personnel and sheriff's deputies apprehend the suspect. This individual reported that he was teaching his son how to hunt birds, which he claimed was a standard use of public parklands in Mexico where he spent the first half of his life. This incident highlights the unique challenges of managing parklands in extremely diverse, urban settings where the diverse user group also results in diverse ways in which individuals impact parklands and park resources.

Increased education and signage could help reduce the illegal take of wildlife at KHSRA, BHSO, and other parklands in the Baldwin Hills. At present, signs at the entrances to several trails at BHSO state that the area is state park property and all wildlife and plants are protected. Similar signs, ideally in multiple languages to reflect the diversity of park users, could be added at other locations in BHSO and to KHSRA. This is especially important at KHSRA, where no such signs were observed.

Use of coverboards and potential poaching on park lands.— Three sets of coverboards, apparently placed and checked by members of the public, were found on parklands in the Baldwin Hills. Coverboards are pieces of plywood, metal, carpet, or other material placed on the surface to increase the chance of a person seeing reptiles and/or amphibians. Once the boards have been in place for several months, the ground under them provides welcoming temperature and humidity conditions and safety from predators. By checking coverboards, people can more easily find reptiles and amphibians, which is why use of coverboards is a standard approach by biologists, hobbyists interested in *seeing* reptiles and amphibians, and, unfortunately, also by people hoping to collect animals to keep in captivity and/or sell. For this latter category, when collections are made on parklands without permits/permission, this is poaching. Two older boardlines were found in KHSRA at the start of our surveys and a new boardline was found during the 2015 field season along the Jim Webb Trail. All three boardlines consisted of 6–10 pieces of ½ to ¾ inch thick plywood.

In Southern California, many boardlines are set out by hobbyists who simply want to see reptiles and amphibians, especially snakes. Thus, the goal is to observe wildlife and not to take wildlife into captivity. In the Baldwin Hills, only four species of snakes have been documented, and only one of these, the California Kingsnake, is highly desired by hobbyists and common in the pet trade. Thus, the available species are unlikely to generate adequate revenue to justify a poacher's investment of time and resources. Nevertheless, some low level of poaching is likely occurring. It is hard to imagine that boardlines are not at least infrequently checked by hobbyists who take home the occasional animal.

Of the three boardlines found in the Baldwin Hills, only the one along the Jim Webb Trail seemed to be actively used by people other than us. In KHSRA, one boardline is well off-trail and less likely to be found, and the other is somewhat protected by dense stands of Russian thistle, which is challenging and often painful to walk through.

If boardlines are to be removed by park personnel, it is best to do this in mid or late summer when the heat prevents most animals from using them. At other times of the year, small mammals may be nesting under the boards, and reptiles and amphibians may be using them. If the boardlines are left in the park, they should be monitored for human use to prevent illegal take of wildlife. Importantly, these boardlines also provide an opportunity to park personnel for continued long-term monitoring of wildlife. This could be especially useful for documenting Coachwhips and Ring-necked Snakes as discussed above.

Roadkill within and adjacent to parklands.—Parklands in the Baldwin Hills are bordered and crossed by roads, including major thoroughfares such as La Brea Avenue, La Cienega Boulevard, Stocker Street, and Jefferson Boulevard. Vehicular traffic close to open space creates high potential for roadkill mortality. Our surveys documented at least three roadkill mortalities of Gophersnakes in the Baldwin Hills, including on Stocker Street immediately south of KHSRA (iNaturalist 817159), along La Cienega Boulevard adjacent to oil field lands (iNaturalist 3374235), and in the upper parking lot at KHSRA (LACM 186681). Several other snakes were found dead close to Hetzler Road, but the cause of mortality could not be conclusively determined, though roadkill was a likely possibility.

Signage along Hetzler Road in BHSO and along the park road in KHSRA reminding drivers that wildlife is protected in the park and to be cautious of animals crossing roads could help to reduce roadkill mortalities.

Habitat fragmentation.—Available habitat in the Baldwin Hills has been much reduced by habitat loss and modification. Remaining areas of open space are also fragmented by major thoroughfares, especially Stocker Street and La Cienega Boulevard. Thus, many species likely experience greatly reduced or possibly even no connectivity between KHSRA and BHSO, as well as the other remaining habitat fragments (e.g., Stocker Corridor and La Brea Corridor). For the herpetofauna, those species with smaller population sizes, such as Gophersnakes, California Kingsnakes, and possibly Western Skinks, are likely to be most impacted by loss of connectivity. Re-establishing habitat connectivity by constructing wildlife underpasses and/or overpasses for La Cienega Boulevard could help to restore connectivity, thereby increasing gene flow, between sub-populations currently separated by this major thoroughfare.

Value of Citizen Science in Biodiversity Inventories

Our inventory of the Baldwin Hills greatly benefitted from incorporating citizen science data. Over the past four years, the Natural History Museum of Los Angeles County has promoted multiple citizen science programs, including the RASCals project. These efforts have helped to build a large community of citizen scientists in Southern California who contribute natural history observations to the iNaturalist database. Results presented in this herpetofaunal inventory include 118 observations from 32 different citizen scientists. Although accounting for only 4.15% of the total observations, these observations proved especially valuable, particularly for snake species, which are infrequently encountered. Seven of the eight Coachwhip observations, the single Ring-necked Snake record, 34 of the 73 Gophersnake observations, and 6 of the 10 California Kingsnake observations resulted from citizen science. Further, because these observations included photographic vouchers, we were also able to learn life stages of the snakes, and the Coachwhip photos were essential to documenting that all observations are likely of the same animal.

Two strategies were especially useful in generating citizen science observations. First, we recruited interested people who were already spending a lot of time in the Baldwin Hills to participate in the herpetofaunal inventory via the RASCals project. Los Angeles Audubon Restoration Coordinator Carlos Jauregui (iNaturalist user name ctwothree) became an especially active participant contributing 49 of the 118 citizen science observations. Mr. Jauregui is active in restoration efforts at BHSO and KHSRA, and his work gave him excellent opportunities to observe snakes and other species away from trails and roads.

The second strategy that proved useful was holding an iNaturalist training and bioblitz in the Baldwin Hills. Staff from the BHSO and the Natural History Museum (especially Mary Cruz with

BHSO and Miguel Ordeñana with NHM) organized this event on June 12, 2016. Eighteen (15%) of the citizen science observations were submitted on this day.

Long-term monitoring and management of the biota of the Baldwin Hills would benefit from continued promotion of citizen science data collection. We recommend that personnel working at BHSO and KHSRA are encouraged by their supervisors to document the species they encounter, especially species that are observed less frequently, by submitting photographs to iNaturalist. Further, we recommend that park personnel continue to promote bioblitz events and iNaturalist trainings both to gather data during those events and to grow the number of citizen scientists contributing observations in and around the Baldwin Hills. These efforts could prove essential in understanding whether certain species are established or not in the Baldwin Hills (e.g., Coachwhips and Ring-necked Snakes) as well as increasing detection ability for potential invasive species such as American Bullfrogs.

Acknowledgements

We thank all of the citizen scientists who contributed observations to the RASCals project, and especially Carlos Juaregui and his supervisor Margot Griswold who contributed observations and was very encouraging of Carlos' dedication to the RASCals project. Mary Cruz and additional staff at the BHSO helped coordinate the bioblitz. The Citizen Science Office at the Natural History Museum (Lila Higgins, Miguel Ordeñana, and Richard Smart) also coordinated the bioblitz, helped promote citizen science in Southern California, and pulled observations from social media apps into iNaturalist. Nina Noujdina provided GIS support and Travis Longcore arranged access to properties in the Baldwin Hills. Suzanne Goode and Jamie King provided assistance with collecting permits and permission to install drift fence arrays on state park lands; Shawn McAdory also provided permission to install drift fences in KHSRA. All work was carried out under Institutional Animal Care and Use (USC IACUC No. 20153) and California Department of Fish and Wildlife (CA-SC-4307) permits.

References

Beaman, K. 2001. Reptiles and Amphibians of the Baldwin Hills. Pp 64–76 *in* Biota of the Baldwin Hills, Los Angeles County, California.

Bury, R. B., and J. A. Whelan. 1984. Ecology and management of the bullfrog. U.S. fish and Wildlife Service, Resource Publication Number 155, Washington D.C.

Casper, G. S., and R. Hendricks. 2005. *Rana catesbeiana,* Shaw, 1802 American Bullfrog. Pp 540–546 *in* Amphibian Declines: The Conservation Status of United States Species, edited by M. J. Lannoo. University of California Press, Berkeley.

Crooks, K. R., and M. E. Soulé. 1999. Mesopredator release and avifaunal extinctions in a fragmented system. Nature 400:563–566.

County of Los Angeles. 1982. Baldwin Hills Project: Inventory of Features. Department of Parks and Recreation.

Dark, S., E. D. Stein, D. Bram, J. Osuna, J. Monteferante, T. Longcore, R. Grossinger, and E. Beller. 2011. Historical ecology of the Ballona Creek watershed. Southern California Coastal Water Research Project. Technical Report #671.

Fisher, R., D. Stokes, C. Rochester, C. Brehme, S. Hathaway, and T. Case. 2008. Herpetological monitoring using a pitfall trapping design in Southern California: U.S. Geological Survey Techniques and Methods 2-A5, 44 p.

Hayes, M. P. and C. Guyer. 1981. The Herptofauna of Ballona. Pp H1–H80 *in* The Biota of the Ballona Region, Los Angeles County, edited by R.W. Schreiber. Los Angeles County Natural History Museum Foundation.

Henderson, R. W., 1992. Consequences of predator introductions and habitat destruction on amphibians and reptiles in the Post-Columbus West Indies. *Caribbean Journal of Science* 28:1–10.

Johnston, K. K., E. Del Giudice-Tuttle, I. D. Medel, C. J. Piechowski, D. S. Cooper, J. Dorsey, and S. Anderson. 2012. The Ballona Wetlands Ecological Reserve Baseline Assessment Program: Second Year Report. Santa Monica Bay Restoration Commission. Prepared for the California State Coastal Conservancy, Los Angeles, California.

Loss, S. R., T. Will, and P. P. Marra. 2013. The impact of free-ranging domestic cats on wildlife of the United States. *Nature Communications* 4 (1396):1–7.

Loyd, K. A. T., S. M. Hernandez, J. P. Carroll, K. J. Abernathy, G. J. Marshall. 2013. Quantifying free-roaming domestic cat predation using animal-borne video cameras. *Biological Conservation* 160:183–189.

Medina, F. M., E. Bonnaud, E. Vidal, B. R. Tershy, E. S. Zavaleta, C. J. Donlan, B. S. Keitt, M. Le Corre, S. V. Howarth, and M. Nogales. 2011. A global review of the impacts of invasive cats on island endangered vertebrates. *Global Change Biology* 17:3503–3510.

Mitchell, J. C., and R. A. Beck. 1992. Free-ranging domestic cat predation on native vertebrates in rural and urban Virginia. *Virginia Journal of Science* 43:197–207.

Mitrovich, M. J., J. E. Diffendorfer, and R. N. Fisher. 2009. Behavioral response of the Coachwhip (*Masticophis flagellum*) to habitat fragment size and isolation in an urban landscape. *Journal of Herpetology* 43:646–656.

Moyle, P. B., 1973. Effects of introduced bullfrog, *Rana catesbeiana,* on the native frogs of the San Joaquin Valley, California. *Copeia* 1973:18–22.

Spinks, P. Q., G. B. Pauly, J. J. Crayon, and H. B. Shaffer. 2003. Survival of the western pond turtle, *Emys marmorata*, in an urban California environment. *Biological Conservation* 113:257–267.

Stebbins, R. C. 2003. A Field Guide to Western Reptiles and Amphibians, 3rd edition. Houghton Mifflin, Boston.

von Bloeker, J. C. Jr. 1942. The fauna and flora of the El Segundo sand dunes: 13. Amphibians and reptiles of the dunes. *Bulleting of the Southern California Academy of Sciences* 41:29–38.

Chapter 4. Bat Surveys of the Baldwin Hills, Los Angeles County, California, 2014–2015

Stephanie Remington
P.O. Box 12383, Costa Mesa, California 92627 (stremington@earthlink.net)

Introduction

The Baldwin Hills comprise over 1,200 acres of fragmented open space, surrounded and intersected by urbanization, in the Los Angeles Basin. The territory of the Baldwin Hills Conservancy, a state agency, includes three major parks [Kenneth Hahn State Recreation Area (KHSRA), Culver City Park (CCP), Baldwin Hills Scenic Overlook (BHSO)], the Holy Cross Cemetery, privately owned oil fields, 'stringers' of vegetation along Stocker Street and La Brea Avenue, and the major drainage, Ballona Creek, which is channelized and concrete-lined.

The terrain ranges from just above sea level a few miles upstream of the mouth Ballona Creek to over 500 feet in elevation near the former site of the Baldwin Hills Dam at Kenneth Hahn State Recreation Area. The area is bounded by Ballona Creek and Culver City to the northwest, Inglewood to the south, and Los Angeles to the east and northeast. The main native habitats remaining in the Baldwin Hills are variants of scrub habitat, although there are areas of willow and mulefat riparian in some drainages, as well as a few native bunch grasses and annual flowering plants (Anderson, 2001). Molina et al. (2001) considered the majority of the native plant habitat to be degraded and in "disclimax" – with non-natives having replaced important components of plant communities and urban runoff having replaced significant natural watercourses. For these reasons, the authors felt that the patches of riparian vegetation were best described as 'urban riparian.' Due to the rarity of *Salvia* and *Eriogonum* species, they felt that 'coastal scrub' more accurately described the habitat dominated by *Artemesia californica*, *Baccharis pilularis*, and *Encelia californica*.

Non-native vegetation in the Baldwin Hills is prevalent. Non-native annual grasses are predominant over the native bunch grasses, and ornamental trees and shrubs, as well as lawns and pond vegetation, are prevalent in the local parks.

Despite this, there are areas of the Baldwin Hills where efforts are being made to improve the quality of native habitat. Although recent in its inception, habitat restoration is ongoing and an integral part of park planning at the Baldwin Hills Scenic Overlook (T. Longcore and S. Campbell, pers. comm.).

Remington, S.. 2016. Bat Surveys of the Baldwin Hills, Los Angeles County, California, 2014–2015. Pp. 72–101 in *Urban Biodiversity Assessment: Baldwin Hills Biota Update* (T. Longcore, ed.). Los Angeles: University of Southern California for Baldwin Hills Conservancy (Proposition 84) and Baldwin Hills Regional Conservation Authority (Proposition A).

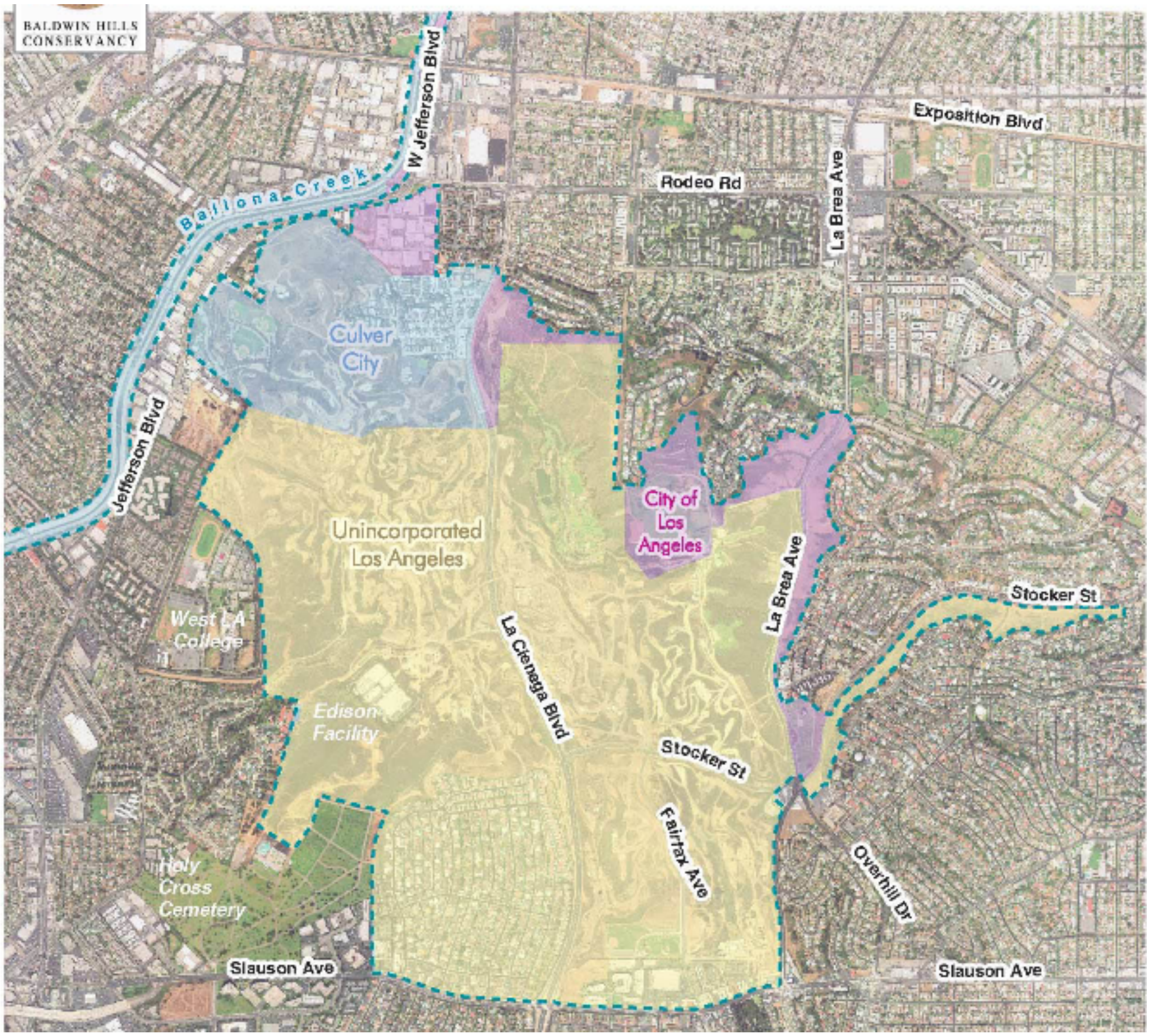


Figure 4-1. Territory of the Baldwin Hills Conservancy and surrounding areas.

There have been two previous inventories of the Baldwin Hills. 1) *The Baldwin Hills Project*, conducted in 1975 and 1978 with the goal of thoroughly cataloguing the natural, cultural, aesthetic, and recreational resources of the area, focused on terrestrial vertebrates for the faunal component of the surveys. 2) *The Biota of the Baldwin Hills: An Ecological Assessment* (Molina et al., 2001) described the effort in 2000 to provide updated data on biological resources, including plant communities, terrestrial vertebrates and arthropods.

Since some ecologically significant taxa were not included in either study, and technological advances since 2000 have enabled new survey techniques, a third project focusing on the Baldwin Hills was initiated in 2014–2015 to update information from the earlier studies and address some remaining gaps. Neither of the past studies included bat surveys. This report focuses on the bat fauna of the Baldwin Hills.

State and federal land management agencies officially recognize over two-thirds of the south coast ecoregion's 24 bat species as sensitive, including one endangered species, a state candidate for threatened status, and nearly half listed as California Species of Special Concern (CSSC). All 24 have been documented in Los Angeles County (Table 4-1).

Hilda Grinnell (1918) conducted the first focused surveys of bats in California, including detailed localities that were lacking in previous work, and compiling the results of previous survey efforts that had included bats. She found 13 bat species in Los Angeles County (one of which she found only on Catalina Island), and four others that occurred in adjacent counties, often very close to the L.A. County border, indicating they probably occurred there, too (Table 4-1).

Vaughn (1954) documented eight bat species in the San Gabriel Mountains, including one that Grinnell (1918) had only found outside the Los Angeles County border. With modern acoustic and capture equipment, Remington (2011) documented sixteen species in the San Gabriel Mountains, including four species that had not been captured by either Vaughn or Grinnell in Los Angeles County.

Four studies of the Santa Monica Mountain Range, from the Channel Islands to Griffith Park [(Brown, 1980; Brown, pers. comm.; Remington and Cooper (2014)] added several new species to the L.A. County list.

One species, the California leaf-nosed bat (*Macrotus californicus*), that had been documented in Ventura, Los Angeles, and San Diego Counties in the early 20th century has not been observed in either of the two former counties for decades (Constantine 1998), and is considered extirpated from both counties (Brown, pers. comm.). Both known roosts (one in each county) were cave roosts; the loss of this bat from the area is most likely due to human disturbance and/or actual destruction of the roost combined with the loss of foraging habitat. Within California, its primary range is the Mojave Desert, where it roosts predominantly in geothermally heated abandoned mines and forages extensively in desert wash vegetation.

Museum and Public Health Records

Twenty-one bat species are represented in museum records from Los Angeles County, primarily from the early 20th century (**Error! Reference source not found.**). Of over 1,100 individuals epresented in the collections of 28 institutions (Appendix 1), 30 specimens comprising five species were collected from the vicinity of the Baldwin Hills – Culver City and Palms. The seven locations of these species are found northwest of the Baldwin Hills (Figure 4-2).

Table 4-1. Bat species documented in and near Los Angeles County, including during the current study.

Latin Name	Common Name	Grinnell (1918)	Channel Islands (1979-2015)	Santa Monica Mts (2002-2004)	Griffith Park (2008)	Pt. Mugu (2014-2015)	San Gabriel Mts (1954)	San Gabriel Mts (2010)	Baldwin Hills (2014-15)
Family Phyllostomidae	**Leaf-nosed bats**								
Choeronycteris mexicana [1]	Mexican long-tongued bat								
Leptonycteris yerbabuenae [4]	Lesser long-nosed bat								
Macrotus californicus [1,2,6]	California leaf-nosed bat	*		E					
Family Molossidae	**Free-tailed bats**								
Eumops perotis [1,2,6]	Western mastiff bat	X		X		X			
Nyctinomops femorosaccus [1]	Pocketed free-tailed bat	X				X		X	
Nyctinomops macrotis [1,2]	Big free-tailed bat					X			
Tadarida brasiliensis	Mexican free-tailed bat	X	X	X	X	X		X	X
Family Vespertilionidae	**Mouse-eared bats**								
Antrozous pallidus [1,5,6]	Pallid bat	X	X	X		X		X	
Corynorhinus townsendii [1,2,3,5,6]	Townsend's big-eared bat	X†	X						
Eptesicus fuscus	Big brown bat	X	X	X	X	X	X	X	
Euderma maculatum [1,2,6]	Spotted bat	X		X					
Lasionycteris noctivagans	Silver haired bat		X					X	
Lasiurus blossevillii [1]	Western red bat	X	X	X	X	X	X	X	X
Lasiurus cinereus	Hoary bat	X	X	X	X	X	X	X	X
Lasiurus xanthinus [1]	Western yellow bat							X	
Myotis californicus	California myotis	X	X	X	X	X	X	X	
Myotis ciliolabrum [2,6]	Small-footed myotis	*		X		X		X	
Myotis evotis [2,6]	Long-eared myotis	X	X				X	X	
Myotis lucifugus	Little brown myotis							X	
Myotis thysanodes [2,5,6]	Fringed myotis	*	X					X	
Myotis velifer [1,6]	Cave Myotis								
Myotis volans [2]	Long-legged myotis	X					X	X	
Myotis yumanensis [2]	Yuma myotis	*	X	X	X	X	X	X	X
Parastrellus hesperus	Canyon bat	X		X	X		X	X	

Key to the Symbols

[1] California Mammal Species of Special Concern
[2] Former Candidate (Category 2) for listing under U.S. Endangered Species Act; Species of Concern
[3] Candidate for Threatened Status in California
[4] Listed under the ESA as Threatened/Endangered
[5] USFS: Sensitive
[6] BLM: Sensitive

* Documented in an adjacent county
† Catalina Island
E Extirpated

Table 4-2. Museum records of bats in Los Angeles County, including the Baldwin Hills area (with dates), and acoustic records of the current study.

Latin Name	Common Name	Museum Records	Constantine (1998)	Baldwin Hills (2014–2015)
Family Phyllostomidae	**Leaf-nosed bats**			
Choeronycteris mexicana [1]	Mexican long-tongued bat	LA County	X	
Leptonycteris yerbabuenae [4]	Lesser long-nosed bat			
Macrotus californicus [1, 2, 6]	California leaf-nosed bat	LA County		
Family Molossidae	**Free-tailed bats**			
Eumops perotis [1, 2, 6]	Western mastiff bat	1939	X	
Nyctinomops femorosaccus [1]	Pocketed free-tailed bat	1994	X	
Nyctinomops macrotis [1, 2]	Big free-tailed bat	LA County	X	
Tadarida brasiliensis	Mexican free-tailed bat	1939		X
Family Vespertilionidae	**Mouse-eared bats**			
Antrozous pallidus [1, 5, 6]	Pallid bat	1971		
Corynorhinus townsendii [1, 2, 3, 5, 6]	Townsend's big-eared bat	LA County		
Eptesicus fuscus	Big brown bat	2005		unconfirmed
Euderma maculatum [1, 2, 6]	Spotted bat			
Lasionycteris noctivagans	Silver haired bat	LA County	X	
Lasiurus blossevillii [1]	Western red bat	1939	X	X
Lasiurus cinereus	Hoary bat	1904		X
Lasiurus xanthinus [1]	Western yellow bat	LA County	X	unconfirmed
Myotis californicus	California myotis	LA County		
Myotis ciliolabrum [2, 6]	Small-footed myotis	LA County		
Myotis evotis [2, 6]	Long-eared myotis	LA County		
Myotis lucifugus	Little brown myotis			
Myotis thysanodes [2, 5, 6]	Fringed myotis	LA County		
Myotis velifer [1, 6]	Cave myotis	LA County	X	
Myotis volans [2]	Long-legged myotis	LA County		
Myotis yumanensis [2]	Yuma myotis	LA County		X
Parastrellus hesperus	Canyon bat	2005		

[1] California Mammal Species of Special Concern

[2] Former Candidate (Category 2) for listing under U.S. Endangered Species Act; Species of Concern

[3] Candidate for Threatened Status in California

[4] Listed under the ESA as Threatened/Endangered

[5] U.S. Forest Service: Sensitive

[6] U.S. Bureau of Land Management: Sensitive

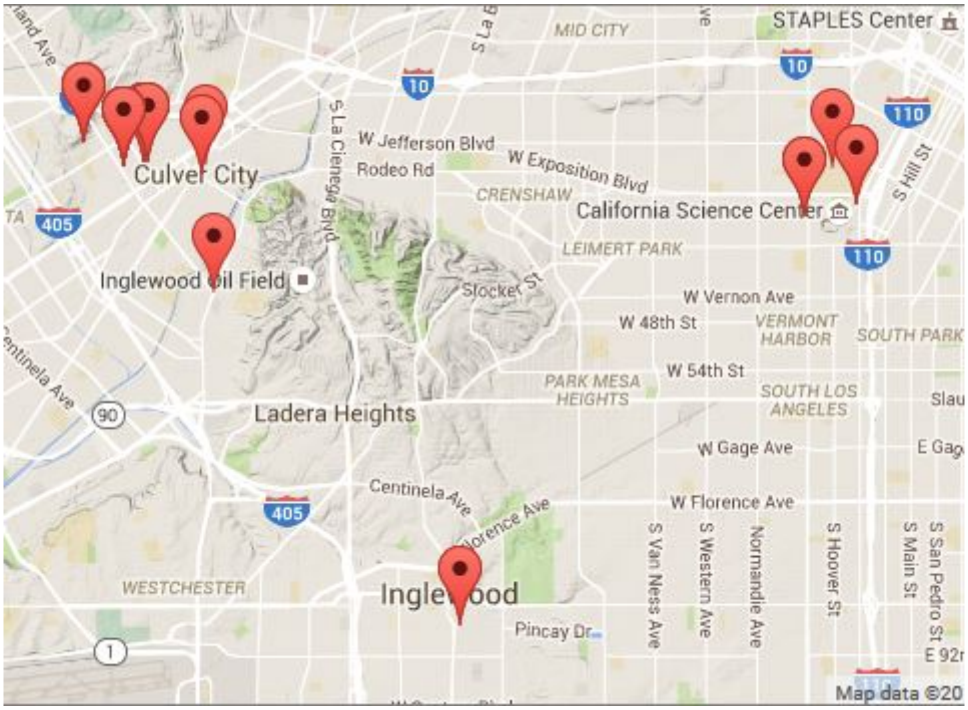


Figure 4-2. **Locations of** *museum records of the 35 bats collected near the Baldwin Hills. Basemap from Google Maps.*

The majority of the museum specimens (21) were Mexican free-tailed bats (*Tadarida brasiliensis*). The second most common species in these records was the pallid bat (*Antrozous pallidus*), with five individuals. There were two big brown bats (*Eptesicus fuscus*) and one each of the western mastiff bat (*Eumops perotis*) and hoary bat (*Lasiurus cinereus*). All were collected from 1925–1939. Most of these collection sites represent multiple individuals – some from the same date, others from repeat visits to the site over months or years – indicating that *T. brasiliensis* and *A. pallidus* probably had maternity colonies in the area.

Four specimens were collected at three sites east of the Baldwin Hills – at or near the USC campus [*L. cinereus* (1904), *L. blossevillii* (western red bat; 1939), *A. pallidus* (1971), and *Parastrellus hesperus* (canyon bat; 2005). A single pocketed free-tailed bat (*Nyctinomops femorosaccus*) was collected in Inglewood, to the south of the Baldwin Hills, in 1994, bringing the total number of species in museum collections from the Culver City/Palms, Exposition Park, and Inglewood areas to eight (see museum records with dates in Table 4-2).

Public Health Records of bats (generated by calls from the public reporting an encounter with, or find of, a bat that resulted in collection and rabies testing) for Los Angeles County included species identification, gender and age designation, biometrics of forearm and other anatomical features, as well as notes about the condition of each specimen, meticulously kept and updated by Denny Constantine (former California State Veterinarian) – beginning in 1955, and regularly from 1977 through the late 1990s when he retired. Unfortunately, he died without publishing the majority of these data and county officials are unsure of whether they retained the records he shared with them. His only publication of these records related to range extensions of several species (Constantine 1998) (**Error! Reference source not found.**). The closest of the records from this paper to the aldwin Hills are a silver-haired bat (*Lasionycteris noctivagans*) from Brentwood in 1977, a big free-tailed bat (*Nyctinomops macrotis*) from downtown Los Angeles in 1985, and a cave myotis (*Myotis velifer*) from Florence in 1992. These three species are considered rare migrants and/or vagrants in the area. *L. noctivagans* is associated primarily with forest habitat. This species is migratory and has been documented in places that are considered atypical, such as the Mojave Desert (pers. obs.) and other xeric habitats, particularly in winter and during migration (Perkins, 1998). Given the total number of specimens of this species in Los Angeles County, its occurrence in the area is more likely related to migratory patterns than accidental occurrences. The Brentwood specimen was collected in November. *N. macrotis* is considered a rare cliff-roosting, long-distance migrant that shows up regularly, but relatively infrequently, in coastal southern California (Navo, 1998; pers. obs.; D. Stokes, pers. comm). The current known range of *M. velifer* in California is along the Colorado River.

Given the age of the majority of bat species records in the vicinity of the Baldwin Hills, the main survey goals of the Baldwin Hills bat surveys were: 1) to develop a current species list for the area (including seasonal variations) and 2) to identify areas of habitat use (roosting and foraging locations).

The behavioral and ecological diversity among bat species precludes the use of a universal sampling method that is adequate for detecting all species (Pierson 1993, Pierson 1998). A combination of techniques – acoustic sampling, mist netting and roost monitoring – generally yields a more complete overall picture of diversity and distribution. However, some sampling techniques are more intrusive than others, and bat populations in southern California have been declining in recent years due to multiple human-induced pressures, particularly on the coast where bat species lose both roosting and foraging habitat regularly to urban development. Roosts of species that can adapt to human presence are frequently disturbed (deliberately or inadvertently) and colonies are often eradicated.

Additional impacts faced by local bat populations are pesticide poisoning (from eating insect prey); severe and extensive light pollution that exposes bats to diurnal predators that otherwise would not be active and disperses insect prey, rather than concentrating it; water pollution and mosquito abatement that also affect prey quality and availability; and increasingly frequent wildfires that reduce the prey base and may kill bats directly.

Bats typically have one pup a year. Their low reproductive rate, high juvenile mortality, and long generational turnover make them even more likely to experience population declines in the face of multiple human-induced pressures.

To minimize the impacts of our study on bats, acoustic techniques — the least intrusive of the above-mentioned sampling techniques — were the primary method used in these surveys.

These surveys were originally intended to include both active and passive (remote) monitoring. However, it was not possible to gain access to rooftops, which are the best locations in highly urban areas with extensive human visitation to place detectors to avoid vandalism and theft of acoustic equipment. The lack of all-night monitoring, which can be extended for days, or weeks, at a time, means that some species were likely missed in our survey (for example, rare species and those that arrive later in the evening, such as those that roost farther away but forage on site).

Four main areas were the focus of these bat surveys (Figure 4-1):

1. Kenneth Hahn State Recreation Area (KHSRA)
2. Culver City Park (CCP)
3. Baldwin Hills Scenic Overlook (BHSO)
4. Ballona Creek (BC)

A portion of the active oil field that is publicly owned was surveyed once in October 2014.

Sites were chosen based on area, potential to provide roosting and foraging opportunities for bats, accessibility, and availability of volunteer observers. Holy Cross Cemetery contains good quality coastal sage scrub in the northeast portion of the property. This habitat is known to support foraging bats (pers. obs.; D. Stokes, pers. comm.), and roosting, as well (pers. obs.). However, getting permission for regular access after dark was not possible at this site. The oil fields contain highly degraded habitat, but cover a large portion of the Baldwin Hills. Regular access was not possible at this site, either.

KHSRA is a large park with a variety of native and non-native tree and shrub habitats, and some water features. CCP contains ball fields and a variety of ornamental trees, shrubs, and grasses. The BHSO contains varied terrain and native habitat restoration is ongoing there. Personnel at all three of these sites were very cooperative in allowing access. As the major waterway in the area, BC was also considered a high value site.

This report summarizes the methods and results of these initial bat surveys of the Baldwin Hills and provides baseline data to support future studies of the bat fauna of this area.

Methods

Bat surveys were conducted once a month between April and October in 2014 at one or more sites each month, and once a month between March and June at three or more sites per month in 2015. All field sites except the oil fields were surveyed at least twice in each year. Surveys were conducted by teams of two or more observers, walking transects while watching for bats and recording ultrasonic calls with an ultrasonic detector – usually an Anabat, but SM2 detectors were also used on one night (Table 4-4 Table 4-5). Here, the term 'transect' refers to a pathway, not necessarily a straight line.

Light pollution is extreme in and around the Baldwin Hills (over much of the area, visibility at night is similar or only slightly darker than on an overcast day), so it was unknown how much effect moon phase would have on bat activity. However, because bat activity is often lower on nights with a full or near-full moon, all but two surveys were conducted on nights when moon phase was at less than half. The April 2014 survey at Ballona Creek was conducted two nights after a full moon, but on that night the moon did not rise until 20 minutes before the end of the survey. In June 2014, another near-full moon rose approximately 1.5 hour after sunset.

Table 4-3. Sampling effort by site and year.

2014	KHSRA	CCP	BHSO	BC	OF
April	X			X	
May		X	X	X	
June	X	X	X		
July		X	X	X	
August	X				
September		X	X		
October	X				X
TOTAL	4	4	4	3	1

2015	KHSRA	CCP	BHSO	BC	OF
March	X	X	X	X	
April		X	X	X	
May	X	X	X		
June	X	X	X		
TOTAL	3	4	4	2	0

Grand Total	7	8	8	5	1

Table 4-4 shows which sites were sampled each month during 2014 and 2015. The totals indicate how many bat surveys were done at each site that year, and the grand total is the number of surveys over both years done at that site. Table 4-5 shows sampling effort in terms of the numbers of observers and ultrasonic detectors deployed at each site.

For example, in April 2014 at Kenneth Hahn State Recreation Area (KHSRA), eight observers divided into three teams to survey the park. Ballona Creek was surveyed by one team of two observers. In this case, the April survey of Ballona Creek was conducted on a separate night, but usually, when multiple sites were surveyed in a particular month, they were done by separate teams of observers on the same night.

Table 4-4. Number of observers and detectors at each site during each month of surveys during 2014–2015.

2014	KHSRA		CCP		BHSO		BC		OF	
	# Obs	# Det	# Obs	# Det	# Obs	# Det	# Obs	# Det	# Obs	# Det
April	8	3					2	1		
May			5	2	2	1	2	1		
June	6	2	3	1	3	1				
July			4	2	4	2	14	3		
August	7	3								
September			6	2	3	1				
October	5	2							2	1
TOTAL	**26**	**10**	**18**	**7**	**12**	**5**	**18**	**5**	**2**	**1**

2015	KHSRA		CCP		BHSO		BC		OF	
	# Obs	# Det	# Obs	# Det	# Obs	# Det	# Obs	# Det	# Obs	# Det
March	3	1	4	1	4	1	4	1		
April			4	2	4	2	4	1		
May	3	1	3	2	2	1				
June	4	1	3	2	3	1				
TOTAL	**10**	**3**	**14**	**7**	**13**	**5**	**8**	**2**		

Grand Total	**36**	**13**	**32**	**14**	**25**	**10**	**26**	**7**	**2**	**1**

Kenneth Hanh State Recreation Area	KHSRA
Culver City Park	CCP
Baldwin Hills Scenic Overlook	BHSO
Ballona Creek	BC
Oil Fields	OF

There were two other exceptions to this rule. In October 2014, the KHSRA survey was conducted on a separate night from the oil fields. And Culver City Park (CCP) and Baldwin Hills Scenic Overlook (BHSO) were surveyed along the same transect line by a single team of observers. An example of a CCP/BHSO transect line is shown in Figure 4-3.

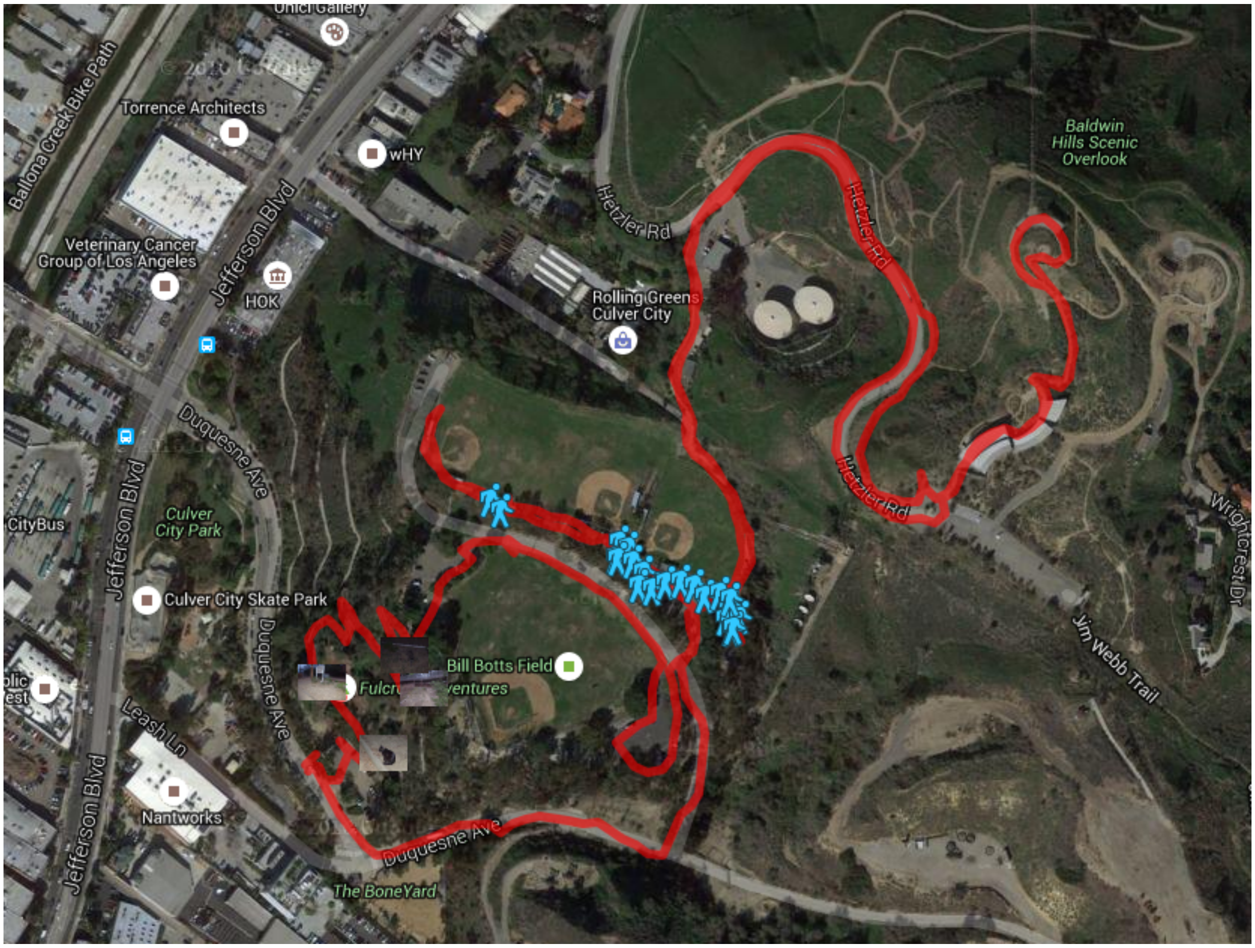


Figure 4-3. An example of a transect (pathway) walked by a team surveying CCP/BHSO.

The tracker app used here takes waypoints every approximately 100 feet (depicted as blue walking figures in Figure 4-3), which can be converted to a record of the path taken that night.

The optimum number of observers per team was three to four – one deploying a detector, one recording data in real time into the ArcGIS Collector App (which was downloaded onto the cell phone of one observer in each group), one taking data on paper (as a backup), and – if present – a fourth observer to help look for flying bats. One or more of the observers frequently had a second duty, such as one of the above tasks (for smaller teams) or of recording GPS points on a hand-held unit for comparison with the GPS readings on the phone app. Some teams had the tracker app, described above, and it was used regularly by one team, but its use was not part of official protocol.

Transect Protocol

After recording the site name, location, and description, as well as sunset time, weather, observer names, and detector identification, transect protocol was to walk until a bat was observed visually and/or detected on an Anabat, then to stop and wait for at least a minute to see if any other bats were seen or recorded. If no bats were seen or recorded, the team resumed walking. If more bats were observed or recorded, then the team stayed at the site for a maximum of ten minutes. During the time stopped, data were entered on the time, location, species (if known), habitat, and behavior (if observed).

All calls were entered into the Collector App (except for occasions when the app was not working or when a last-minute personnel change precluded use of the app for one group) and on paper datasheets.

The detectors were programmed to begin monitoring ½ hour before sunset and were turned off approximately three hours after sunset. 'Bat activity' was measured by the total number of call files recorded on one or more Anabats deployed at a particular site, for a given species or for all species recorded in a night.

Calls were identified to species whenever possible. Timing of calls was used to infer the location of nearby roosts. Calls recorded within an hour of sunset were considered indicators of bats roosting nearby.

Bat Detectors

Because bats are very vocal animals, producing anywhere from one to more than 200 calls per second, often at frequencies inaudible to humans (>20 kHz), ultrasonic detectors are valuable tools for passively monitoring presence-absence and general activity (Fenton 1988, Thomas and LaVal 1988, Pierson 1993).

The microphone of the Anabat detects sounds in both the upper range of human hearing and the ultrasonic range (4-200 kHz). Calls recorded on Anabats are stored on a compact flash card or PDA for later retrieval and download onto a laptop computer, where they can be viewed and analyzed as sonograms. The SM2 detector picks up calls up to 100 kHz. All local bat species can be detected within the frequency range of both detectors. The detection range of the detectors depends on a variety of factors, including the frequency range and intensity of the bat call, air temperature, habitat, relative humidity, and altitude. The SM2 is more sensitive than the Anabat.

Species identification using Anabat recordings is made by comparison with "voucher" calls from known hand-released bats. Interpretation of acoustic data is affected by biases and limitations of the equipment used to collect it. Not all bat species are equally detectable by this method. Its effectiveness depends on the frequency and intensity of a call (Pierson 1993), the habitat and weather conditions in which a bat is foraging (Fenton 1984, Livengood et al, 2001), whether or not a bat is echolocating, and the detector used (Rainey 1995).

The louder bats will be over-represented; Mexican free-tailed bats (*Tadarida brasiliensis*) and western mastiff bats (*Eumops perotis*) emit such loud, low frequency calls that they can be recorded from hundreds of feet away, while "whispering" bats such as Townsend's big-eared bats (*Corynorhinus townsendii)* emit such faint calls, they may not be recorded at all. Pallid bats *(Antrozous pallidus)* also tend to produce lower intensity calls and often hunt without echolocating – detecting prey either visually, by passively listening, or olfactorily (D. Johnston, pers. comm.).

The number of calls recorded can be used as an index of relative bat activity – it is not possible to determine the number of bats from the number of calls recorded.

Although certain calls are diagnostic for a particular species, no "key" to the calls of California bats is available and not all call sequences are identifiable. Different bat species can sometimes use similar signals, and members of the same species can vary the calls they use based on the perceptual task and the surrounding habitat. Calls can also vary regionally. The ability to identify species varies with the experience of the person using the equipment; knowing which bats occur in the area and which are common are important considerations.

Anabat identification in this study follows Stokes' protocol (D. Stokes, pers. comm.). There are similarities and overlap among the calls of several groups of bat species (Table 4-6). To standardize Anabat identifications, a confidence level (high, medium, or low) is assigned to call sequences based on the known range of call characteristics for the group of species occurring in an area (Table 4-7). (See Table 4-8 for the key to species acronyms.)

Table 4-5. Challenges in identifying bat species with similar calls.

Species producing similar calls	Possible additional diagnostic factors
LACI/NYFE	season, elevation
NYFE/TABR	NYFE is audible to some people
TABR/EPFU	visual observation; season (TABR is more likely to be active in the winter)
EPFU/ANPA	visual observation of behavior; ANPA sometimes emits distinctive social calls
ANPA/MYEV	ANPA sometimes emits distinctive social calls
MYCA/MYYU	observe MYYU foraging over water when call is recorded
MYYU/LABL	visual observation of behavior; red bats easily recognized visually with spot-lighting

Table 4-6. Criteria for assigning confidence levels to call sequences.

Criteria	**Confidence Level**			
	High	**Medium**	**Low**	**Reject Call**
Call is diagnostic of a particular species	X			
Call is diagnostic but fragmented		X		
Call is in a species repertoire but is not diagnostic; ID is made in combination with other evidence		X		
Call is not diagnostic and equally likely to be made by 2 or more species; habitat/season/altitude, etc., suggest candidate species			X	
Call is fragmented; no evidence suggests one species over another				X

A high confidence level is assigned only to those calls that appear diagnostic of the species (Table 4-7). A medium confidence level is assigned to calls for either of two reasons: 1) a call is known from the repertoire of two species but there is other evidence (such as habitat, time of year, elevation, etc.) supporting a tentative identification; 2) a call is diagnostic but fragmented. A low confidence rating is given when a call appears equally likely to be from two or more species, but when considered with other evidence, one species is more likely to have produced it than the others.

Table 4-7. Bat species in southern California producing diagnostic calls

Species Producing Diagnostic Calls	**Usually**	**Often**	**Sometimes**
LABL		x	
LACI			x
LAXA			x
PAHE	x		
EPFU			x
ANPA			x
TABR			x
NYFE			x
NYMA			x
EUPE	x		

In this report, bat calls that were identified with a high degree of confidence were used to create the species list. Those that were assigned a medium confidence level are used to indicate species that potentially exist in the area, but are unconfirmed. Bat calls that are fragmentary — and therefore unidentifiable or equally likely to be one of several species — and there is no additional evidence to indicate one over the others, are used only to measure activity levels, and not for identification.

Results and Discussion

On 13 survey nights over both years, 1,208 call files were recorded, 1,072 of which were identifiable to species. Four species were confirmed from the call files [Mexican free-tailed bat (*Tadarida brasiliensis*), Yuma bat (*Myotis yumanensis*), western red bat (*Lasiurus blossevillii*), and hoary bat (*L. cinereus*)] (Figure 4-4, Table 4-8).

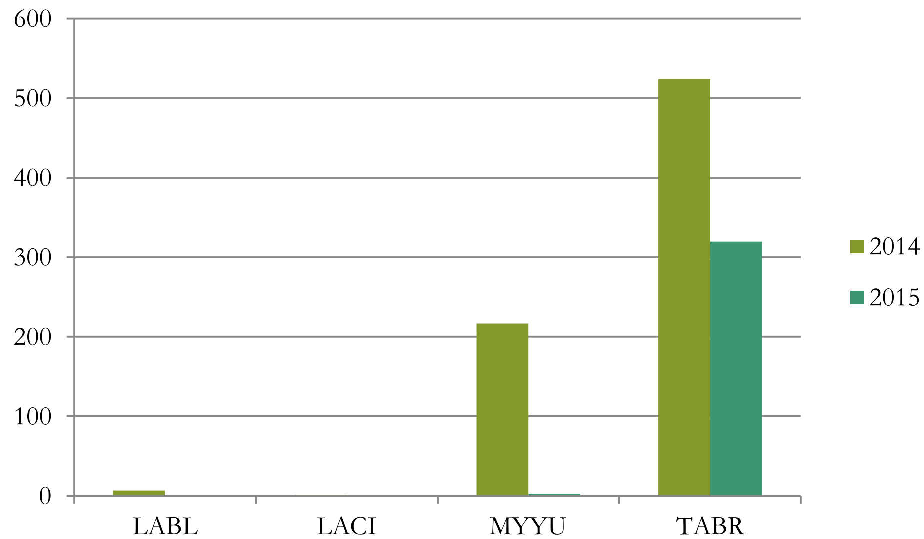


Figure 4-4. Number of bat call files by species in the Baldwin Hills, 2014–2015.

Several call files recorded in May 2015 at KHSRA were possibly made by the western yellow bat (*L. xanthinus*), but identification was not confirmed.

Table 4-8. Species composition in the Baldwin Hills, 2014–2015, with number of call identified per species.

	2014	2015	Total
LABL	7		7
LACI	1		1
MYYU	217	3	220
TABR	524	320	844
Total	***749***	***323***	***1072***

Two species represented 99% of all identifiable call files in 2014: 70% Mexican free-tailed bat (*Tadarida brasiliensis*) and 29% Yuma bat (*Myotis yumanensis*); *T. brasiliensis* represented 99% of identifiable call files in 2015 (Figure 4-4 and Table 4-8), and 79% of total identifiable call files over both years.

The greater number of call files in 2014 is at least partly due to the greater survey effort that year, both in terms of the number of survey nights and number of teams per night (Table 4-3). When the data are standardized by taking an average at sites with multiple teams per night and dividing the resulting annual sum of call files by the total number of survey nights, the resulting ratios for 2014 and 2015 are very similar: 42.1 in 2014 and 41.9 in 2015 (Table 4-9).

Table 4-9. Total bat activity in the Baldwin Hills, 2014–2015, standardized for survey effort.

Month	Site	2014	2015
Mar	BC		2
	CCP		7
	KHSRA		6
Apr	BC	160	3
	KHSRA	6	
	CCP		1
May	BC	36	
	CCP	31	78
	KHSRA		275
Jun	CCP	2	0
	KHSRA	19	5
Jul	BC	27	
	CCP	0	
Aug	KHSRA	23	
Sep	CCP	201	
Oct	KHSRA	0	
	OF	0	
Adjusted Total		**505**	**377**
Total/# survey nights		**42.1**	**41.9**

Three surveys had no bat detections in 2014 (July at CCP and October at both KHSRA and the oil fields (OF). In two of these cases (CCP and KHSRA), the lack of detections was due to accidental changes in the detector sensitivity settings. At CCP, the team recorded bat calls in their datasheets and at KHSRA one of the two teams reported visual sightings of bats early in the evening. If the recording units had functioned properly, it is likely that the 2014 activity ratio from Table 4-9 would have been somewhat higher in 2014.

In April through June, the three months in which surveys were conducted in both years, there were more total calls in 2015 than in 2014, primarily due to *T. brasiliensis* activity in May 2015 (Figure 4-5 and Figure 4-6).

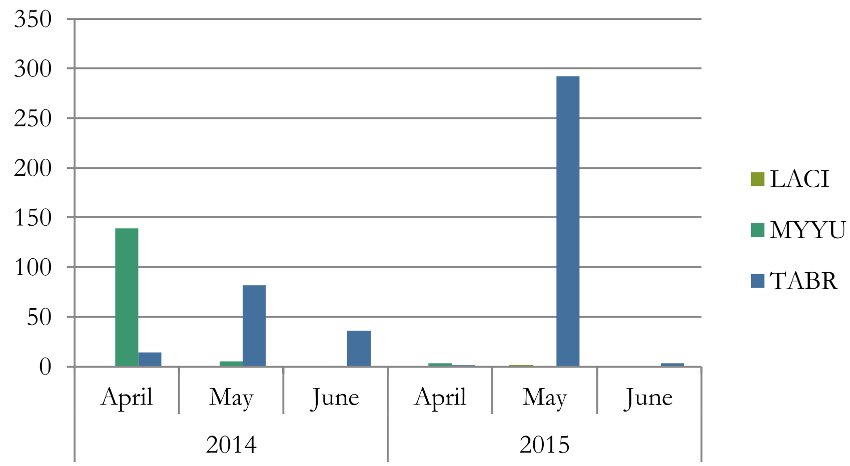


Figure 4-5. Bat activity by species (number of call files) in April–June 2014 and 2015.

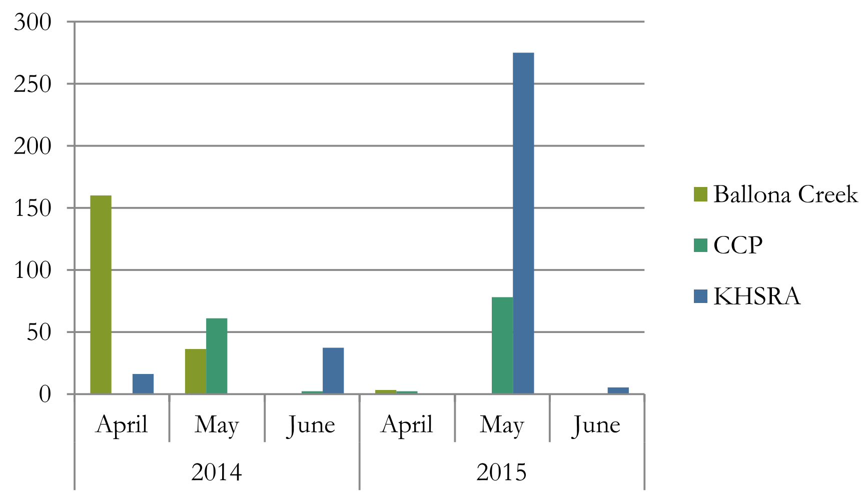


Figure 4-6. Bat activity by site in April–June 2014 and 2015.

In data for all months, *T. brasiliensis* was acoustically dominant at Kenneth Hahn State Recreation Area (KHSRA) and Culver City Park (CCP)(Figure 7) over both years. The bulk of the *T. brasiliensis* activity was recorded on two separate survey nights – one in September 2014 in CCP, and one in May 2015 at KHSRA (Figure 4-7).

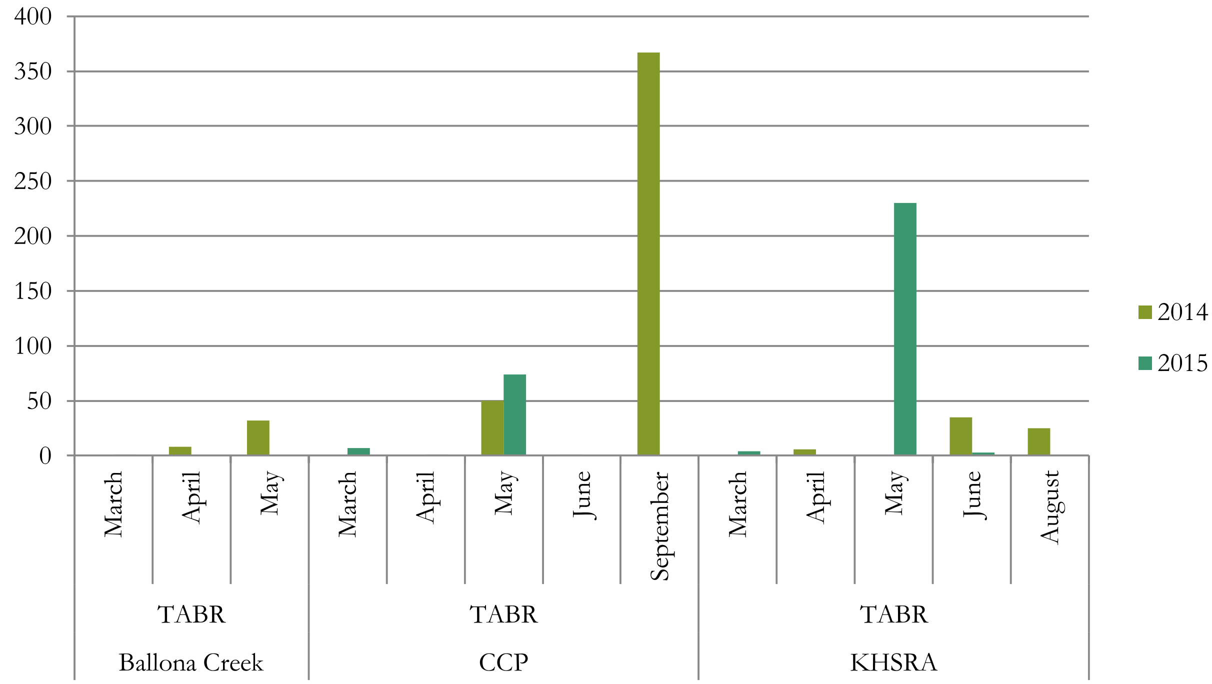


Figure 4-7. T. brasiliensis *activity by site, month, and year in 2014 and 2015.*

M. yumanensis was acoustically dominant at Ballona Creek (BC). There were more call files of this species than any other in both years, despite only three *M. yumanensis* calls being confirmed in 2015. The low number of *M. yumanensis* calls in 2015 was at least partly because there were only half the number of surveys done at this site as the others. The prevalence of *M. yumanensis* (a specialist in the capture of aquatic emergent insects whose geographic range is highly associated with the distribution of permanent water sources) at Ballona Creek was expected. It was not detected at any other sites, however, including KHSRA (Figure 4-8), which has three ponds of varying size. There are a few potential explanations, none of which are mutually exclusive, for the lack of *M. yumanensis* detections at KHSRA. It is possible that this species exists at the park in relatively low numbers and/or tends to arrive later in the night and would have been detected at KHSRA with long-term monitoring. It could also be related to an acoustic bias related to the physics of sound transmission. As mentioned previously, acoustic recording is biased in favor of species (like *T. brasiliensis*) that produce relatively low-frequency echolocation calls. *T. brasiliensis* can be recorded hundreds of feet away, while *M. yumanensis*, which produces calls more than an octave higher (and, therefore, attenuate more quickly in the atmosphere), can only be recorded when they are much closer to the detector.

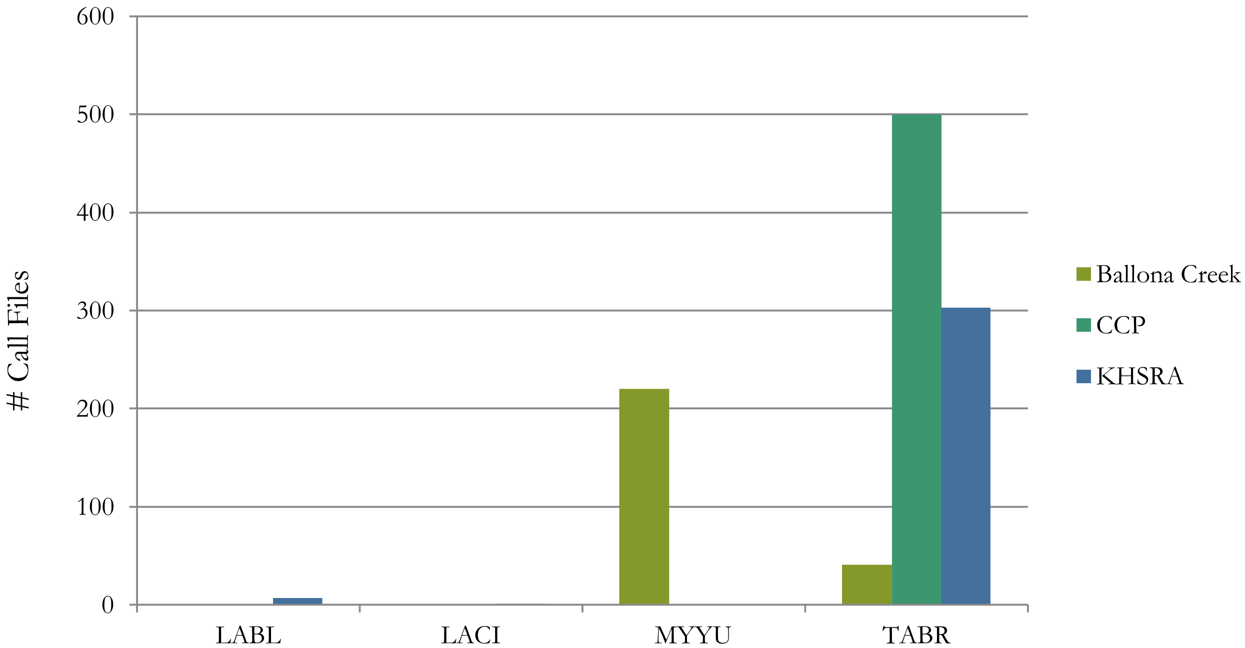


Figure 4-8. Bat activity at each site over both years (2014–2015).

It is also possible that an aggressive mosquito abatement program (at a park with very high human visitation) results in very low abundance of aquatic emergent insects. Flight and echolocation are each very energetically demanding; bats can eat a large proportion of their body weight in insects on a given night. Lactating females, with a particularly high-energy budget, may consume more than their body weight in a night. A suppressed prey base could result in an insufficient quantity of insects to support many *M. yumanensis* on a regular basis.

The highest species diversity was at KHSRA (3 species) – *M. yumanensis* was the only species not detected there (Figure 4-8). Both of the two other species detected were lasiurines (solitary, migratory foliage-roosting species in the genus *Lasiurus*: western red bat (*L. blossevillii*), and hoary bat (*L. cinereus*). All seven *L. blossevillii* detections were recorded on a single night by both teams surveying the park that night. *L. cinereus* was only confirmed once, in April 2014. Long-term monitoring would very likely result in higher rates of detection for both species.

L. blossevillii was the only California Species of Special Concern (CSSC) confirmed during the survey period. The western yellow bat (*L. xanthinus*) is also a CSSC, but – as mentioned before – was unconfirmed. *L. blossevillii* distribution is strongly associated with mature riparian vegetation for both roosting and foraging, which is mostly lacking throughout the Baldwin Hills. An exception is a small patch of native riparian vegetation near the north end of the park, and adjacent to the pond at KHSRA where they were recorded in August 2014. KHSRA was the only site where this species was recorded. Long-term monitoring may have resulted in detections along Ballona Creek, but given the degraded quality of riparian vegetation in and along most portions of the creek in the survey area, it is unlikely to support large numbers of *L. blossevillii*.

The only bat species confirmed at CCP was *T. brasiliensis*. This species foraged extensively over the ball fields – both lighted and unlit, but more heavily toward the lights during the surveys. No bats were detected at the Baldwin Hills Scenic Overlook (BHSO). This may be partly due to the large proportion of the site that is sparsely vegetated or un-vegetated. Although native habitat restoration is ongoing there, work on restoring vegetation at this site is relatively recent in its inception. It may also be due to the paucity of physical or biological features that would funnel or concentrate bat activity (e.g. trees, riparian areas, drainages). It may also have resulted from surveys of the BHSO being combined with surveys of CCP. So, as with previously mentioned scenarios, if activity was already low due to low vegetation biomass (and the resulting low insect prey base), and few features were present to concentrate existing activity, and survey effort was only half (at most) of what it was at KHSRA, these factors could all have contributed to the lack of detections at this site. There are very likely bats at this site that we did not detect. As the habitat restoration continues and the vegetation matures, bat activity will very likely increase at this site.

The timing of call files indicates that bats roosted relatively nearby at KHSRA, CCP, and BC. *M. yumanensis* were recorded within an hour of sunset at the creek in April and July 2014. *T. brasiliensis* were recorded foraging over the lights at the CCP ballfields within a half hour of sunset in September 2014. Two bats were observed foraging below the canopy (about 15 feet off the ground) for approximately 10 minutes at KHSRA, on the City View Trail near Autumn's Peak, a little over a half hour after sunset. Unfortunately, in the last case there was a detector malfunction and none of the bats there were recorded. These bats almost certainly were roosting in KHSRA, but it is unknown which species they were. Given the description of the location and flight, it was unlikely to have been *T. brasiliensis* – a species with high aspect ratio wings, better designed for speed in open air than extended flight in high clutter.

The *T. brasiliensis* calls recorded early at CCP were search phase calls and feeding buzzes (i.e. made by bats that were already foraging relatively high in the air). They were probably roosting relatively nearby, but this species is a fast flyer, so the roost was not necessarily in the immediate vicinity.

Bright moonlight from a full or near-full moon can have an inhibiting effect on bat activity (Lang et al. 2005). Bats may delay their emergence from their roosts, especially if a potential predator is nearby (pers. obs.). As mentioned previously, nights with bright moonlight were avoided in all but two occasions during the current study. However, extensive light pollution in urban areas has been noted to have a similar effect to bright moonlight (pers. obs.), and this was largely unavoidable. Artificial night lighting in the Baldwin Hills area is extreme, especially along Ballona Creek, where visibility throughout the survey period was similar to that of an overcast day.

The consequences of permanently bright night lighting can be severe (Rydell 2006). Azam et al. (2016) found that artificial night lighting negatively influenced bat activity and occurrence in the four most common bats species in France. The authors attributed this effect to the fact that artificial night lighting affects a range of bat behaviors, including roosting, foraging, commuting, and reproduction. Delayed emergence can cause bats to miss the peak in prey abundance (Downs et al.

2003, Boldogh et al. 2007), which can reduce juvenile growth rates and decrease survivorship of adult females in maternity colonies, as well. Bats may avoid lit areas or even abandon roosts altogether due to lighting (Boldogh et al. 2007). This can cause bats to take sub-optimal roosts and foraging and commuting routes.

The effects of artificial night lighting on high, fast-flying species like *T. brasiliensis* may be different from those on slower species that forage closer to the ground and vegetation (e.g. *M. yumanensis*), but landscape level artificial night lighting may act as barriers to bat movements regardless of foraging strategy (Azam et al. 2016). These two are the most common species in highly urban areas of southern California. This indicates that they may be more light-tolerant than other species formerly recorded more frequently in the area. Stone et al. (2015) postulated that more light-tolerant species could be outcompeting less light tolerant species. Schoeman (2016) found results supporting that conclusion at stadium lights. Stone et al. (2015) also describe attraction of insects away from dark areas, reducing the prey base for bat species that do not forage in lit areas.

Comparison with Historical Records and Species Accounts

Of 21 species documented in museum records for Los Angeles County, eight were collected in the Baldwin Hills area (Table 4-2).

Three of these eight species were detected during the current study: a colonial, crevice and cavity-dwelling species [Mexican free-tailed bat (*Tadarida brasiliensis*) and two solitary, foliage-roosting lasiurines [western red bat (*Lasiurus blossevillii*) and hoary bat (*L. cinereus*). A fourth species, of these eight, the big brown bat (*Eptesicus fuscus*), is a habitat generalist that was possibly detected at KHSRA, but its identification was not confirmed. Two species detected in the current study – one confirmed and one unconfirmed – are not among museum records for the Baldwin Hills: a specialist in the capture of aquatic emergent insects [Yuma myotis (*Myotis yumanensis*)] and another foliage-roosting lasiurine [western yellow bat (*Lasiurus xanthinus*)].

T. brasiliensis is the most common species among museum records from the Baldwin Hills area, comprising 21 of 35 specimens, and it was recorded most often in the current study (Figure 4-9). This species is known to roost in a variety of artificial and natural roost types throughout the region. It tends to congregate in large numbers in suitable roosts, and is known to adapt very well to urban structures, such as roof tiles and highway structures.

T. brasiliensis is a fast-flying species that typically forages over long distances, high above the ground, for moths and other insects, including a variety of pest species. It is considered a year-round resident in southern California, but there is some anecdotal evidence that migratory populations from other locations may arrive in fall and stay for some period of time before leaving again, with spikes in colony sizes observed in both fall and spring (pers. obs.).

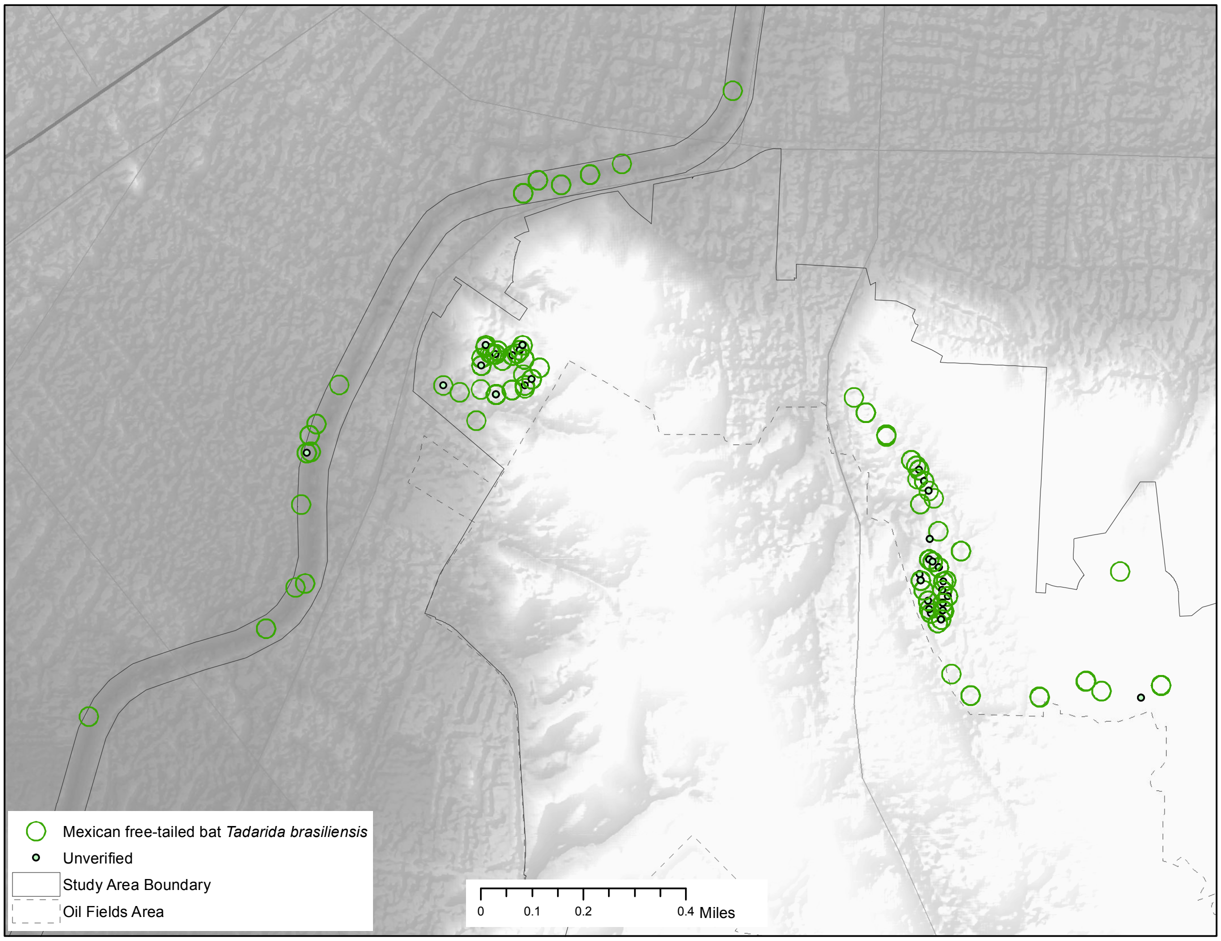


Figure 4-9. Distribution of observations of Mexican free-tailed bat.

This species was recorded within an hour of sunset on five of the 11 survey nights, including two nights in which it was detected early in the evening at two sites. In most cases recordings were of search phase calls, indicating that the individuals producing them were already high in the sky when they were detected. In areas without substantial light pollution, bats sometimes exit the roost within a few minutes of sunset (pers. obs). In areas were light pollution is more extreme, bats may exit the roost a half an hour or more after sunset (pers. obs.), especially when moon phase is full or nearly full. Given the types of call recorded and the speed of this species, individuals recorded within an hour of sunset most likely roosted relatively nearby, but not in the immediate vicinity. There may be one or more roost structures onsite, or they may be located in areas adjacent to survey sites.

When bats are observed early in the evening, it is sometimes possible to find the roost by looking for appropriate structures in the direction from which they came. Although several calls were recorded during this period, none were seen in flight early in the evening.

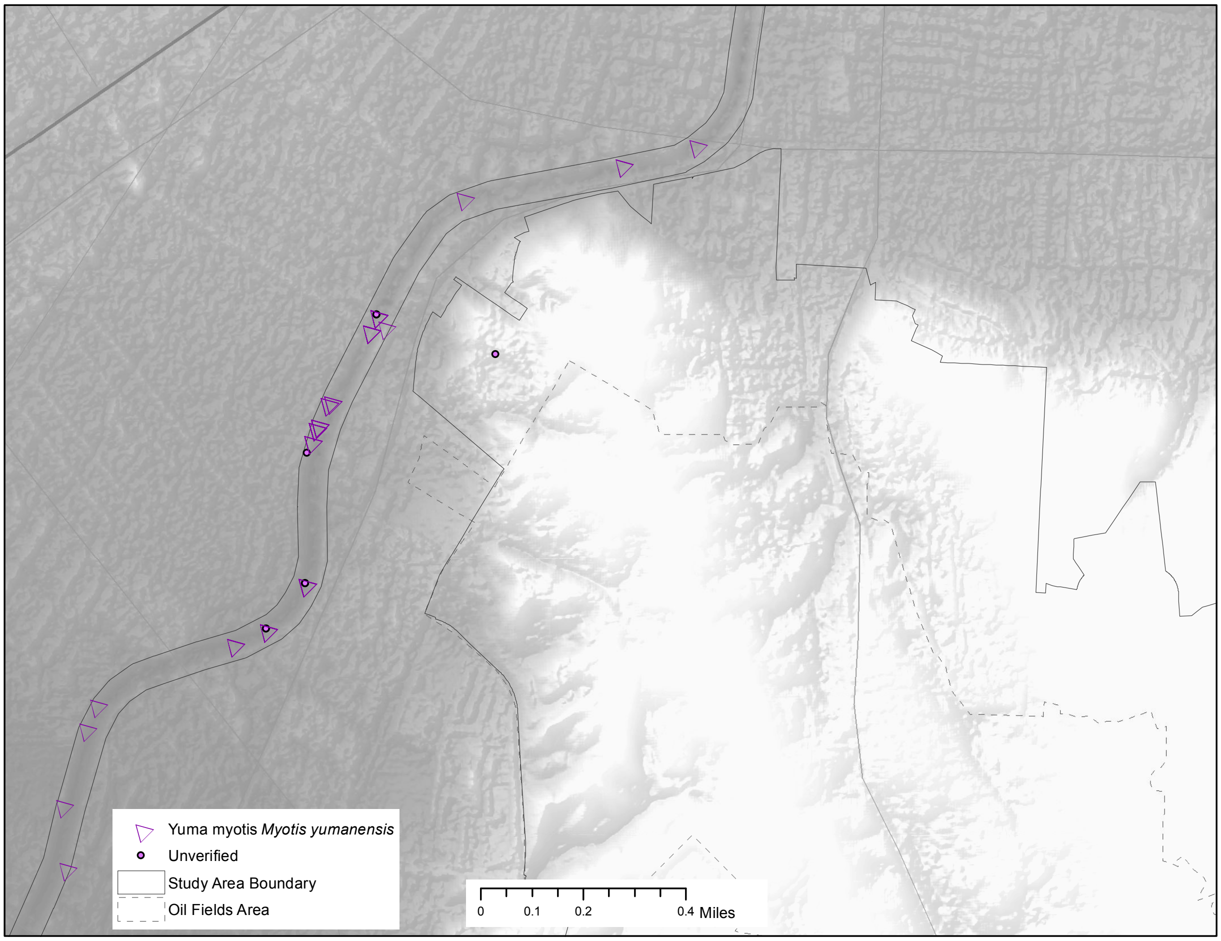


Figure 4-10. Distribution of Yuma myotis observations.

The second most commonly recorded species (Figure 4-10), Yuma myotis (*M. yumanensis*), is not among museum records from the Baldwin Hills area. Of 39 specimens collected in Los Angeles County, between 1906 and 2006, two were collected from within 5 miles of the Baldwin Hills limits – one, collected in 1968 at the Franklin Canyon Reservoir and another collected in 2005 in a residential area in the city of Hawthorne. The next closest specimens, in Downey (2005) and Lakewood (no year recorded), are over 10 miles away, both in commercial areas. Neither distance is insurmountable for a bat to travel, but nightly foraging commutes of this species are usually much shorter than those of *T. brasiliensis*. Typically, when bats commute several miles from a roost to a foraging area, either the roost is high quality, the foraging area is very productive, or both. Highly urban areas often lack diversity in insect populations and small species, such as midges, often dominate the insect fauna along urban creeks and rivers. Although species that forage over long distances, such as molossids (e.g *T. brasiliensis*) and lasiurines (e.g. *L. cinereus*), often include urban areas on their foraging routes (pers. obs.), it would be more likely for highly urban insect populations to support local bat populations of the smaller species, than to draw them in from a long distance.

M. yumanensis is considered a specialist in the capture of aquatic emergent insects whose geographic distribution is strongly associated with the presence of permanent water sources (Bogan, et al., 1998). Its occurrence along Ballona Creek and at the Franklin Canyon Reservoir would be expected. The location noted for the Downy specimen was collected within a mile of the San Gabriel River, where this species was detected within the last three years (pers. obs.), but since the same latitude and longitude is listed for a big brown bat (*E. fuscus*) from the same collector in the same year, this may not be the exact location where either specimen was obtained. The Hawthorne specimen, also listed as collected in a residential area, is located within a couple of miles of a golf course, but may or may not be the actual site of collection.

During the survey period, there was no evidence of bats roosting in the Sawtelle Boulevard, Sepulveda Boulevard, or Overland Avenue bridges over Ballona Creek. It is likely that individuals detected along the creek roosted in the surrounding residential or commercial areas.

The second most common species in museum records, the pallid bat (*Antrozous pallidus*) – 5 records, was undetected in the current study. *A. pallidus* is a CSSC that is sensitive to human disturbance. Individuals of this species can be difficult to detect acoustically because they tend to produce relatively low-intensity calls and sometimes forage without echolocating at all. This species is known to roost in a wide variety of natural and artificial structures including trees, rock crevices, and transportation structures and is known to forage, often for large prey items, in a wide variety of habitats, including grassland, woodland, orchards, and over gravel roads. Despite this species' use of relatively diverse roosting situations, local populations have declined substantially throughout southern California due to habitat loss, sensitivity to disturbance, and a variety of other factors, such as extermination and pesticide poisoning. This species may still occur in the Baldwin Hills, and – if so – would be more likely to be detected by long-term, all-night acoustic sampling than monthly surveys conducted within a few hours of sunset. Locating and protecting local populations is vital to protecting this species (Sherwin 1998, Rambaldini 2005).

Of 127 museum records of *E. fuscus* in Los Angeles County from 1890–2005, there are two from the Baldwin Hills area, both collected in 1935. There is a museum record from 1939 from Exposition Park and another from downtown Los Angeles in 1952. But the most recent museum record from relatively near the Baldwin Hills is the 2005 Downey record. There are recent field records to the north of the Baldwin Hills [Griffith Park (Remington and Cooper, 2014), other sites in the Santa Monica Mountains (Brown, pers. comm., pers. obs.)], but this species was not confirmed acoustically during the current study. It may still occur in the Baldwin Hills at sites such as KHSRA and the Holy Cross Cemetery.

In urban Orange County, *E. fuscus* is occasionally detected in relatively large parks, primarily those near larger tracts of open space, and along Santiago Creek where the vegetation supports relatively high insect populations. However, despite being a relatively adaptable generalist, it is primarily detected in the Santa Ana Mountains and San Joaquin Hills and along their margins (pers. obs.). Recent records in San Diego County show a similar pattern, with occurrences primarily in large open space, but also in suburban areas, housing tracts adjacent to open space (e.g. Camp Pendleton), or in old neighborhoods with a lot of large, old (albeit non-native) trees (D. Stokes, pers. comm.).

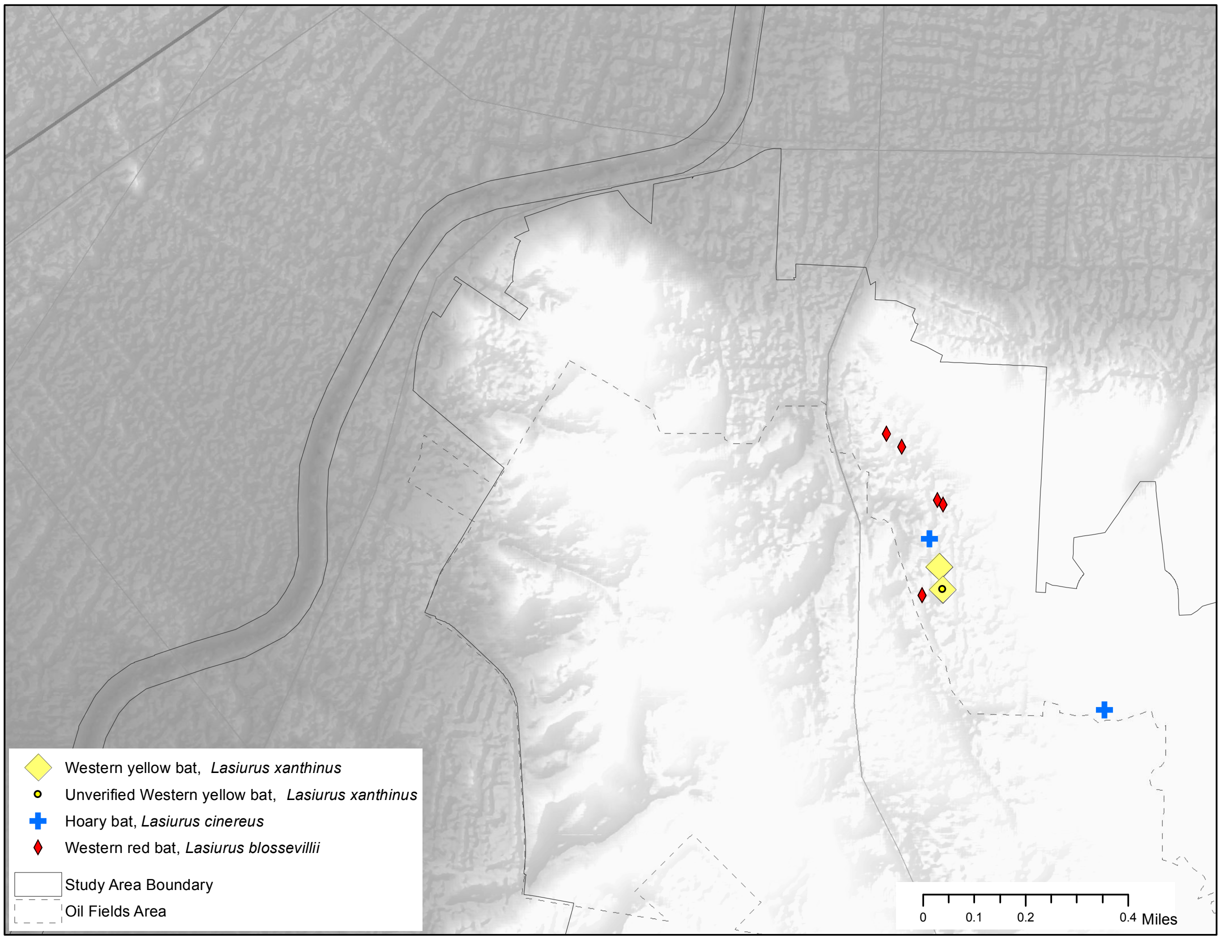


Figure 4-11. Location of Western red bat detections, possible detection of western yellow bat and hoary bats.

Twelve records of *L. blossevillii* exist in Museum records for Los Angeles County (eight are identified as *L. borealis*) between 1889 and 1954. The location closest to the Baldwin Hills was a specimen collected in Exposition Park in 1939. Two others were collected in downtown Los Angeles in 1938 and 1944. Two were collected in the summer, one was collected in spring, and the rest were collected in fall and winter. In Griffith Park, acoustic detections of this species were primarily in the spring and fall. *L. blossevillii* is a solitary foliage-roosting species whose distribution is associated with riparian corridors, particularly areas with mature, intact riparian vegetation, which it uses for both roosting and foraging (Bolster 1998, Pierson and Rainey, 1998). In areas where riparian habitat is less extensive and more fragmented, this species (the only CSSC confirmed during the survey period) also roosts in other trees and shrubs, including orchards – often adjacent to streams, open fields, and urban areas. Roosts are commonly found in edge habitat.

Pierson and Rainey (1998) identified several threats to this species, including conversion or loss of riparian areas, pesticide use (e.g. orchards and golf courses), and fire (in winter it has been observed roosting in leaf litter). This species was considered common in San Diego County from the coastal plain to the foothills of San Diego County in the 1930s and 1940s (Krutzsch 1948). Currently, it is not considered common anywhere in coastal southern California.

There is a small stand of relatively mature native riparian vegetation north of the ponds at KHSRA. *L. blossevillii* was recorded at the pond adjacent to this stand (Figure 4-11). It was only recorded at KHSRA and only on a single night in August. All detections that night were near ponds (including the Japanese garden) and riparian vegetation.

Of 47 *L. cinereus* museum records from Los Angeles County, collected from 1890–1992, there is a single specimen from the Baldwin Hills area (Palms), collected in 1939. The next nearest locations of this species in museum records were Exposition Park (1904), downtown Los Angeles (1942), Hollywood (1928, 1962), and Beverly Hills (1957). Over 80% were collected in spring and fall. As with *L. blossevillii*, *L. cinereus* was detected in Griffith Park most often in spring and fall (Remington and Cooper, 2015) and at other sites in the Santa Monica Mountains (P. Brown, pers. comm., pers. obs.). In Griffith Park, *L. cinereus* was detected more often than *L. blossevillii*. It was the reverse in the current study. Both species were detected on a single night in the current study, but *L. blossevillii* was detected several times on 23 August 2014. There were several call files recorded that could have been *L. cinereus* at all three main sites, but the only call file confirmed as this species was recorded in April 2014 at KHSRA. It very likely occurs at least occasionally throughout the Baldwin Hills area, but This species showed signs of substantial population decline in Orange County from the 1980s through 2000 (Remington, 2000), most likely due in large part to habitat loss. *L. cinereus* is a solitary, migratory, foliage-roosting species that is detected most often in the fall, winter, and spring months in southern California.

Management Recommendations

Based on the observations in the Baldwin Hills and extensive experience with bats and bat conservation in southern California, the following recommendations for management of the Baldwin Hills to promote bat diversity are offered:

- Restore native habitats wherever possible.
- If large scale removal of non-native vegetation is undertaken, conducting the removal in phases, rather than all at once, can prevent total loss of insect fauna over a large area. At the San Joaquin Reserve in Orange County, non-native vegetation was removed all at once from the entire 250-acre property in the mid-1990s. Bat activity had been extensive at the reserve prior to the removal, but dropped to nearly nothing afterwards (non-natives support some insect populations; bare ground does not). The quality of the restoration was excellent, but it took nearly 20 years for bat activity to approach pre-restoration levels.
- Initiate a volunteer program to continue collecting acoustic data on bats. More data are necessary to identify trends.

- Whenever possible, collaborate with entomologists and vector control officials. Knowing when and where mosquito abatement is conducted and what types of compounds and/or organisms are used can help determine the best times to conduct bat surveys. It would be informative to collect and compare data before and after abatement to see if data at any sites indicate the potential for mosquito control by bats.
- Locate, monitor, and protect day (particularly maternity) and night roosts in natural and anthropogenic roosts;
- Engage in outreach (local organizations and individuals, including homeowners) to locate, monitor, and protect local bat colonies.
- Promote adoption of energy-efficient community lighting (similar to the changes made in Tucson, Arizona) or any of the variations described by Stone et al. (2015). In addition to the non-biological benefits of such a program, darker night skies would potentially help increase bat populations by decreasing predation pressures on bats and increasing the amount of dark time available for foraging bats.
- Promote a multi-disciplinary approach, including studies across trophic levels (Stone et al. 2015), to assess the effects of artificial night lighting on ecological communities in the Baldwin Hills.

References

Anderson, V. 2001. Vegetation of the Baldwin Hills. Pages 12–37 in *The biota of the Baldwin Hills: an ecological assessment* (K. C. Molina, ed.). Community Conservancy International and Natural History Museum of Los Angeles County Foundation, Los Angeles.

Azam, C., I. Le Viol, J.-F. Julien, Y. Bas, C. Kerberiou. 2016. Disentangling the relative effect of light pollution, impervious surfaces and intensive agriculture on bat activity with a national-scale monitoring program. *Landscape Ecology*. doi:10.1007/s10980-016-0417-3

Boldogh S, Dobrosi D, Samu P (2007) The effects of the illumination of buildings on house-dwelling bats and its conservation consequences. *Acta Chiropterologica* 9:527–534.

Bogan, M. A., E. W. Valdez, K. W. Navo. 1998. Proceedings of the Western Bat Working Group workshop on ecology, conservation and management of western bat species – species accounts, Yuma myotis (*Myotis yumanensis*). February 9–13, 1998, Reno, Nevada.

Bolster, B. C. 1998. Proceedings of the Western Bat Working Group workshop on ecology, conservation and management of western bat species – species accounts, hoary bat (*Lasiurus cinereus*). February 9–13, 1998, Reno, Nevada.

Brown, P. E. 1980. Distribution of bats of the California Channel Islands. Pp. 751–756 in *The California Channel Islands: proceedings of a multidisciplinary symposium* (D.M Power, ed.). Santa Barbara Museum of Natural History, Santa Barbara, California.

Constantine, D. G. 1998. Range Extensions of Ten Species of Bats in California. *Bulletin of the Southern California Academy of Sciences* 97(2):49–75.

Downs N. C., V. Beaton, J. Guest, J. Polanski, S. L. Robinson, P. A. Racey. 2003. The effects of illuminating the roost entrance on the emergence behaviour of *Pipistrellus pygmaeus*. *Biological Conservation* 111:247–252.

Fenton, M. B. 1984. Echolocation: Implications for ecology and evolution of bats. *Quarterly Review of Biology* 59:33–53.

Fenton, M. B. 1988. Detecting, recording, and analyzing vocalizations of bats. Pp. 91–104 in *Ecological and behavioral methods for the study of bats* (T. H. Kunz, ed.). Smithsonian Institution Press, Washington, D.C.

Grinnell, H. W. 1918. A synopsis of the bats of California. University of California Publications in Zoology, v. 17, no. 12. University of California Press.

Krutzsch, P. H. 1948. Ecological study of the bats of San Diego County, California. Berkeley, University of California; 184 p. M.A. thesis.

Lang, A. B., E. K. V. Kalko, H. Romer, C. Bockholdt, D. K. N. Dechmann. 2005. Activity levels of bats and katydids in relation to the lunar cycle. *Oecologia* 146(4): 659–666.

Livengood, K., R. Drobney, C. Corben, R. Clawson. 2001.What Will a Detector Detect? A Study of the Anabat's Zone of Reception. Platform presentation for the North American Symposium on Bat Research. Victoria, B.C., Canada — October 24–27, 2001. Student Presentations. Friday, October 26, 2001.

Molina, K. C., ed. 2001. *The biota of the Baldwin Hills: an ecological assessment*. Community Conservancy International and Natural History Museum of Los Angeles County Foundation, Los Angeles.

Navo, K. 1998. Proceedings of the Western Bat Working Group workshop on ecology, conservation and management of western bat species – species accounts, big free-tailed bat (*Nyctinomops femorosaccus*). February 9–13, 1998, Reno, Nevada.

Perkins, M. 1998. Proceedings of the Western Bat Working Group workshop on ecology, conservation and management of western bat species – species accounts, silver-haired bat (*Lasionycteris noctivagans*). February 9–13, 1998, Reno, Nevada.

Pierson, E. D. 1993. Survey protocols for California bats. Wildlife Society, Monterey, California. 26 February 1993.

Pierson, E. D. 1998. Tall trees, deep holes, and scarred landscapes. Conservation biology of North American bats. Pp. 309–325 in *Bat biology and conservation* (T. H. Kunz and P. A. Racey eds.). Smithsonian Institution Press, Washington and London.

Rainey, W. E. 1995. Tools for low-disturbance monitoring of bat activity. Pp. 62–71 in *Inactive mines as bat habitat: guidelines for research, survey, monitoring and mine management in Nevada*. Biological Research Center, University of Nevada, Reno.

Rambaldini. D. A. 2005. Updated species account *from* Proceedings of the Western Bat Working Group workshop on ecology, conservation and management of western bat species – species accounts, pallid bat (*Antrozous pallidus*). Original species account from February 9-13, 1998, Reno, Nevada.

Remington, S. 2000. Distribution and diversity of bats in Orange County, California. M.S. Thesis. California Polytechnic University, Pomona.

Remington, S. and Cooper, D. S. 2014. Bat Surveys of Griffith Park, Los Angeles County, California. *The Southwestern Naturalist* 59(4):471–477.

Rydell, J. 2006. Bats and their insect prey at streetlights. Pages 43–60 in *Ecological Consequences of Artificial Night Lighting* (C. Rich and T. Longcore, eds.). Island Press, Washington, D.C.

Schoeman, M. C. 2016. Light pollution at stadiums favors urban exploiter bats. *Animal Conservation* 19(2):120–130.

Sherwin. R. 1998. Proceedings of the Western Bat Working Group workshop on ecology, conservation and management of western bat species – species accounts, pallid bat (*Antrozous pallidus*). February 9–13, 1998, Reno, Nevada.

Stone, E.L., Harris, S., Jones, G. 2016. Impacts of artificial lighting on bats: a review of challenges and solutions. *Mammalian Biology* 80(3): 213–219.

Thomas, D. W., and R. K. LaVal. 1988. Survey and census methods. Pp. 77–89 in *Ecological and behavioral methods for the study of bats* (T. H. Kunz, editor). Smithsonian Institution Press, Washington, D.C.

Vaughn, T. A. 1954. Mammals of the San Gabriel Mountains of California. *University of Kansas Publications. Museum of Natural History* 7(9):513–582.

2016. Special Animals List, Pp. 50–51, *in* California Fish and Wildlife, California Natural Diversity Database (CNDDB), updated in April 2016. https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=109406&inline

2016. State and Federally Listed Endangered & Threatened Animals of California. State of California, The Natural Resources Agency, Department of Fish and Wildlife, Biogeographic Data Branch, California Natural Diversity Database. Pp. 1–12. Updated in April 2016. https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=109405&inline

APPENDIX

A1. Collections with bat specimens from Los Angeles County.

Institution	Acronym
American Museum of Natural History	AMNH
Barcelona Natural History Museum	MCNB
California Academy of Sciences	CAS
Charles R. Connor Museum, Washington State University	CRCM
Cheadle Center for Biodiversity and Ecological Restoration, Santa Barbara	CCBER
Chicago Academy of Sciences	CHAS
Donald R. Dickey Bird and Mammal Collection	UCLA
Humboldt State University Vertebrate Museum	HSU
Kansas University Biodiversity Institute and Natural History Museum	KU
Los Angeles County Museum of Natural History	LACMNH
Louisiana State Museum of Natural Science	LSUMZ
Michigan State University	MSU
Moore Laboratory of Zoology	MLZ
Museum of Comparative Zoology, Harvard	MCZ
Museum of Southwestern Biology, New Mexico	MSB
Museum of Vertebrate Zoology, Berkeley	MVZ
North Carolina Museum of Natural Sciences	NCSM
Puget Sound Museum	PSM
Royal Ontario Museum	ROM
Santa Barbara Museum of Natural History	SBMNH
Smithsonian National Museum of Natural History	USNM
Texas Tech University	TTU
The Field Museum of Natural History, Chicago	FMNH
University of Arizona Museum of Natural History	UAZ
University of Colorado Museum of Natural History	UCM
University of Connecticut	UCONN
University of Florida Museum of Natural History	UF
University of Michigan Museum of Zoology	UMMZ

Chapter 5. Mesocarnivores in the Baldwin Hills

Miguel Ordeñana
Citizen Science Office, Natural History Museum of Los Angeles County

James P. Dines
Section of Mammalogy, Natural History Museum of Los Angeles County

Abstract

Previous surveys for mammals in the Baldwin Hills were limited to small mammals, primarily rodents. Using remotely triggered wildlife cameras, we document the assemblage of mid-sized carnivores currently inhabiting areas comprising the Baldwin Hills, including Kenneth Hahn State Recreation Area and the Baldwin Hills Scenic Overlook. This assemblage includes native and introduced mammal species with generalist habits able to adapt and thrive in human altered environments. Most of these generalists directly or indirectly benefit from subsidized feeding by humans. At least one native carnivore, the gray fox, is apparently suppressed by the presence of the larger coyote. In contrast to generalists, mid-sized mammals suspected to be sensitive to habitat fragmentation were absent from the Baldwin Hills despite records of their occurrence prior to substantial urbanization. We include western spotted skunks and long-tailed weasels in the latter category. The occurrence of feral domestic cats at subsidized feeding stations may attract coyotes to those parts of the Baldwin Hills.

Introduction

Before urbanization, the Los Angeles Basin supported a diverse assemblage of native mammals, including populations of native mice, woodrats, shrews, moles, ground squirrels, weasels, badgers, skunks, bobcats, mountain lions, grizzly bears, coyotes, gray foxes, mule deer, and bats (Willett 1941). Dramatic increases in the human population in the basin beginning in the late 1800s altered the landscape, in turn altering the region's flora and fauna. Native carnivores such as the grizzly bear, mountain lion and coyote increasingly came into conflict with humans and were eliminated from populated areas, with reverberating effects on densities and distribution of subordinate and prey species. Further contributing to the "altered nature" of the region was the introduction of nonnative mammal species such as the eastern fox squirrel (*Sciurus niger*) in 1904 (Becker and Kimball 1947) and the Virginia opossum (*Didelphis virginiana*) in 1906 (Anonymous 1916). The highly transformed Los Angeles Basin of the twenty-first century includes areas such as the Baldwin Hills, with some intact native habitat, that function as "islands" where pockets of native fauna persist. Nevertheless, urbanization and habitat fragmentation are major threats to wildlife populations, in particular mammalian carnivores (Riley et al. 2003).

Ordeñana, M., and J. P. Dines. 2016. Mesocarnivores in the Baldwin Hills. Pp. 102–121 in *Urban Biodiversity Assessment: Baldwin Hills Biota Update* (T. Longcore, ed.). Los Angeles: University of Southern California for Baldwin Hills Conservancy (Proposition 84) and Baldwin Hills Regional Conservation Authority (Proposition A).

The Baldwin Hills comprise a low mountain range in the Los Angeles Basin surrounded by highly urbanized areas. The land encompassing the Baldwin Hills is managed or owned by a mosaic of government agencies and private landowners. Major defined open areas in the Baldwin Hills include Kenneth Hahn State Recreation Area (KHSRA, a 400-acre multi-use park operated by Los Angeles County Department of Parks and Recreation); the Baldwin Hills Scenic Overlook (BHSO, a 58-acre interpretive park under the jurisdiction of the State of California), Culver City Park, Blair Hills, the Stocker Corridor, and large areas owned or leased by petroleum companies. Although sizable swaths of native coastal sage shrub habitat persist, historic oil drilling and human habitation and development in the Baldwin Hills has resulted in substantially degraded habitat throughout. Efforts to restore existing and add native habitat in some areas have been underway, and a better understanding of animal diversity and distribution within the Baldwin Hills can help inform the organizations and agencies involved in restoration efforts.

Previous studies of the mammal fauna in the Baldwin Hills used snap and/or live traps to establish the occurrence of small mammals, and a depauperate community of rodent species was documented using standard trapping methods (Marqua 1978, Dines 2001). Small mammal traps, however, are inherently unsuitable to detect the presence of most non-rodent mammals (e.g., bats and carnivores). Instead, museum specimen records, roadkill records, and indirect evidence such as scat and other sign, were used to develop a list of mammals that potentially inhabit the Baldwin Hills (Dines 2001).

For mammal species other than rodents, contemporary occurrence in the Baldwin Hills has not been robustly investigated. The present study takes advantage of technological advances in remotely triggered trail cameras to document presence of mammalian species, as well as how different species use distinct areas within the Baldwin Hills. The use of trail cameras to monitor wildlife activity has several advantages over older survey methods. Trail cameras monitor a site passively and are therefore a cost-effective way to continuously monitor activity in a location. Cameras are able to capture activity in nocturnal and crepuscular species that may use areas at times not convenient for human monitoring. Moreover, cameras are non-invasive and have the potential to capture images of species that would avoid areas where they can detect human presence (e.g., by smell or sight). Images recorded by trail cameras also provide permanent, verifiable evidence of species presence. Remotely triggered infrared cameras (trail cameras) have successfully been used, for example, to monitor coyote activity (Kays et al. 2015), measure the impacts of human recreation to carnivore activity levels (George and Crooks 2006), and estimate the abundance of large carnivores (Kelly et al. 2008).

From January 2014 to August 2015 we conducted a camera trap survey of multiple habitats within the Baldwin Hills, including areas separated by major roads. The specific objective was to assess carnivore species richness and activity across multiple open areas within the Baldwin Hills with varying sizes and human activity levels.

Materials and Methods

Camera Trail Surveys

From January 2014 to August 2015, we deployed fourteen Bushnell Trophy Cam HD trail cameras (Bushnell Outdoor Products, Overland Park, Kansas) in the study area comprising the Baldwin Hills (Figure 5-1 and Table 5-1). Cameras were securely mounted approximately 30 centimeters above ground level to maximize the chance that mid-sized mammals would trigger the cameras (Figure 5-2). Secure Digital (SD) memory cards with 8 MB to 32 MB memory were used in the cameras to store captured images until they could be retrieved. Eight AA batteries powered each camera setup. Cameras were set on maximum trigger sensitivity and configured to take two consecutive images for each trigger. Daytime photos were full color images; nighttime photos used infrared flash to minimize startling of wildlife. In areas of interest, cameras were occasionally set to video mode for short periods of time to record video of target species. Metadata (date, time, temperature and locality) were recorded with every image and were also maintained in a database.

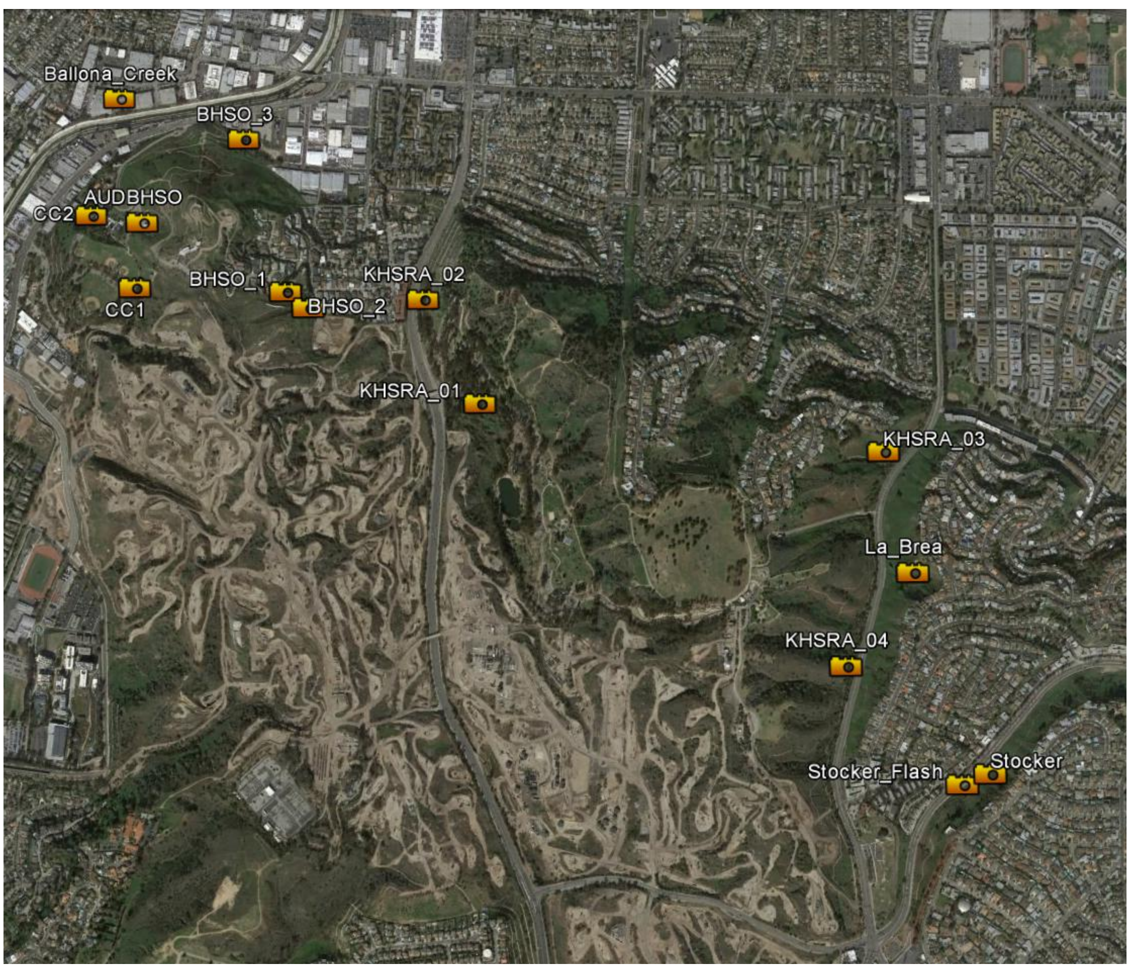


Figure 5-1. Locations of trail cameras deployed in the Baldwin Hills and vicinity.

Camera locations were chosen to give a broad sense of which mammal species use the different parts of the Baldwin Hills, with special attention to the potential use of corridors between areas and the potential of the large boulevards intersecting the Baldwin Hills to act as corridors. Therefore, cameras were installed in KHSRA, BHSO, along the Stocker Corridor, adjacent to La Brea Avenue, and along the Ballona Creek channel (Figure 5-1).

Table 5-1. Location information for the 14 trail cameras used in the study, including camera names (listed in alphabetical order), narrative description of the locations, and GPS coordinates of each location.

Camera Name	Site description	Coordinates
AUDBHSO	Audubon site at Baldwin Hills Scenic Overlook	34.01688°, -118.38110°
Ballona_Creek	Ballona Creek, upland from bike path, across from Hetzler/Jefferson intersection	34.02075°, -118.38491°
BHSO_01	Baldwin Hills Scenic Overlook; Blair Hills Corridor trail at concrete drainage ditch	34.01489°, -118.37859°
BHSO_02	Baldwin Hills S. O.; Blair Hills Corridor trail above former Ohr Eliyahu Academy Property	34.01444°, -118.37779°
BHSO_03	Baldwin Hills Scenic Overlook, lower trail near Jefferson Blvd.	34.01952°, -118.38034°
CC1	Culver City Park, southeast of baseball fields	34.01496°, -118.38394°
CC2	Culver City Park, northwest of baseball fields	34.01711°, -118.38562°
KHSRA_01	Kenneth Hahn State Recreation Area, eucalyptus grove just south of main entrance	34.01174°, -118.37169°
KHSRA_02	Kenneth Hahn State Recreation Area; near concrete ditch west of Japanese Garden	34.01484°, -118.37381°
KHSRA_03	Kenneth Hahn State Recreation Area; trail along west side of La Brea, northern end	34.01052°, -118.3575°
KHSRA_04	Kenneth Hahn State Recreation Area; trail along west side of La Brea, southern end	34.00431°, -118.358823°
La_Brea	La Brea Avenue, east side of road, in wooded ravine	34.00703°, -118.35654°
Stocker	Stocker Corridor Trail, upper trail	34.00134°, -118.35388°
Stocker_Flash	Stocker Corridor Trail, at southern opening of culvert going under lower trail	34.00101°, -118.35482°

Data Analysis

Cameras were checked at 2–3 week intervals during the study period and batteries refreshed as needed. For each camera location, digital images were downloaded from the memory card and stored in a temporary folder on an external hard drive for later sorting. Image sorting and processing were conducted by a trained student worker from the University of Southern California. Image processing and analysis were conducted using freeware developed by Jim Sanderson (Sanderson and Harris 2013). For sorting, image files in the temporary folder were relabeled using the *ReNamer* program, which automatically appends onto the file name the date and time the image was recorded, which facilitates data analysis as described below. Each relabeled image file was opened and the subject that triggered the camera was identified to species when possible. Possible identifications were: empty (no subject, camera possibly triggered by wind); bike; bird; **cat**; **coyote**; **dog**; **fox**; grasshopper; **human**; hummingbird; lizard; mourning dove; **mouse**; **opossum**; owl; **rabbit**; **raccoon**; **skunk**; snake; spider; **squirrel**; **unknown** (subject blurry or otherwise unidentifiable); and vehicle. Only the bolded subjects listed above are reported in the results of this study.

Figure 5-2. Typical camera trap deployment at optimal height (approx. 30 cm) for activation by medium-sized mammals.

Once each image file was identified, it was moved from the computer's temporary folder to a new file architecture according to the following hierarchy:

Location folder (location image was taken, e.g., AUDBHSO, Ballona Creek, etc.)

Species ID (unique species observed at each location, e.g., cat, dog, fox, etc.)

Number-of-individuals of same species in the same image (e.g., 1, 2, 3…)

In the event that two or more species were identified in a single image, a copy of that image file was saved for each species in the appropriate Species/Number-of-individuals folders. This process was repeated until all camera trap images were examined and moved to the appropriate folder(s).

The program *DataOrganize* was used to create an analyzable data file based on the number of image files in each folder. *DataOrganize* creates two editable text files: one that contains a list of all camera locations, the number of species, and a list of species; and one that has a list of all image files labeled with location, species, date and time image was taken, and number-of-individuals. Folders that contained "empty" images were eliminated from subsequent analyses. More than half of captured images were empty (triggered by wind, etc.), and would have been meaningless in the reported results. The program *DataAnalyze* was used to explore the data in the files created. An index of relative activity (RA) was estimated for each camera station by calculating the number of images of a species divided by the number of nights the camera operated at that location (George and Crooks 2006).

Results

More than 15,800 images were captured on the 14 deployed trail cameras with a total effort of 2,633 camera trap days (a camera trap day equals one full day that a camera is active). Of these, 13,768 images were identifiable and were used in the analyses. After excluding images of birds, lizards, snakes, insects, spiders, and vehicles, 11,831 images of mammals remained. Cameras detected a range of small and medium-sized mammals, both native and introduced (Table 5-2).

The assemblage of mammals present in the Baldwin Hills is typical of what is found in natural areas within urban zones: mammals that are generalists and adapted to a range of habitats, including anthropogenically altered habitats. More than 57% of images were of people (n=6774), demonstrating the very high use by humans of most areas in the Baldwin Hills.

The second highest number of image captures were of domestic/feral cats (n=1478). Cats (*Felis catus*) were photographed at every camera location, indicating widespread distribution of domestic/feral cats throughout the study area. With respect to individual camera sites, the highest number of cats (3.01 RA) was detected at site CC1 in Culver City Park, which was the location of a feeding/watering station. Cats encountered at this location would approach us during our regular camera checks, and clearly were not wary of human presence. Further, camera traps temporarily placed at Culver City Park feeding stations documented cats, raccoons, and striped skunks drinking and feeding out of the same bowls alongside one another during the day. The next highest occurrence of domestic/feral cats (1.08 RA) was at KHSRA_3, a location in very close proximity to a neighborhood of single-family homes.

Domestic dogs (*Canis familiaris*) were detected at 9 of the 14 camera locations in the study area, in highest abundance at locations with high human numbers. In fact, the correlation coefficient between observation of humans and observation of domestic dogs is 0.97882. Dogs were typically photographed on leash or otherwise in close association with a human.

We documented the presence of the native gray fox (*Urocyon cinereoargenteus*) on both sides of La Cienega Blvd., a wide and busy boulevard running north-south that essentially bisects the Baldwin Hills (Figure 5-1). The greatest gray fox activity (0.06 RA) was recorded at KHSRA_1, an area just south of the main entrance to Kenneth Hahn State Recreation Area that is a dense, low-lying, brushy habitat dominated by eucalyptus trees. Only one gray fox image was recorded at KHSRA_2, a site approximately 400 meters north-northwest of KHSRA_1, but with much less dense vegetative cover. Gray foxes were not detected at any other sites within Kenneth Hahn State Recreational Area. Gray foxes were detected at three sites in the western Baldwin Hills, although at much reduced abundance: sites CC1 and CC2, at Culver City Park, and the nearby AUDBHSO, recorded 2, 3 and 1 images, respectively, of gray foxes.

Coyotes (*Canis latrans*) were present in low abundance in all major areas of the study area except at the Ballona Creek site and the La Brea Avenue site. Raccoons (*Procyon lotor*) and opossums (*Didephis virginiana*) were both present at every camera site. Striped skunks (*Mephitis mephitis*) were observed at every camera site except Stocker_Flash. Striped skunks were particularly abundant at CC1 and CC2 (540 and 318 images, respectively), sites that were adjacent to the baseball fields at Culver City Park.

Based on museum specimen records, the western spotted skunk (*Spilogale gracilis*) occurred in the Baldwin Hills at least to 1957 (LACM 009954, *Spilogale gracilis* preserved skull, Baldwin Hills, Los Angeles County, California, 09 April 1957). Spotted skunks were not captured on our trail cameras during the study period. Another small carnivore, the long-tailed weasel (*Mustela frenata*) has never been formally documented in the Baldwin Hills, but Willett (1944) discusses long-tailed weasels occurring throughout the Los Angeles basin from "coastal areas to foothills." A museum specimen collected from Playa del Rey in 1957 represents the closest documented long-tailed weasel to the Baldwin Hills (LACM 047297, *Mustela frenata* preserved skin and skull, Del Rey, Los Angeles County, California, 09 June 1957). No long-tailed weasels were captured on our trail cameras during the study period.

In addition to capturing the presence of species, trail cameras document conditions, such as time of day, when the images were recorded. This information can be used to provide a sense of variation in when different species are most active (Figure 5-3). In general, cats were active (caught on camera) during all hours of the day and night, but exhibited peaks in activity during the 8:00 A.M. hour and

5:00 P.M. hour. Ostensibly, this bimodal peak in activity was associated with times the feeding station was replenished by human caretakers.

Other target species showed primarily nocturnal activity patterns, with most activity occurring between 7:00 P.M. and 5:00 A.M. Raccoons (*Procyon lotor*) and striped skunks (*Mephitis mephitis*) occasionally extended activity into twilight and even daylight hours.

Discussion

The most recent previous survey of mammalian fauna in the Baldwin Hills used live-trapping to document several rodent species and indirect observations such as scat and track identifications to infer the presence of larger species (Dines 2001). Using remotely triggered wildlife cameras, the objectives of the current study were to empirically confirm the continued presence of larger mammal species identified in the previous survey as well as document their distribution and movement patterns. An updated checklist of terrestrial mammal species presently occurring in the Baldwin Hills is another result of this effort (Table 5-2).

Notably absent from the study area were the long-tailed weasel (*Mustela frenata*) and the western spotted skunk (*Spilogale gracilis*). Based on the presence of voucher specimens in the Mammalogy collections at the Natural History Museum of Los Angeles, both species were previously proposed as potential inhabitants of the Baldwin Hills (Dines 2001). Both species are primarily carnivorous and rather restricted in their habitat preference, however, making them more sensitive to environmental disturbances associated with human habitation (Crooks 2002). Research in habitat preference for long-tailed weasels and western spotted skunks is insufficient; however, their relative scarcity in urban areas suggests they are sensitive to urbanization. Our evidence suggests that sufficient habitat no longer exists in the Baldwin Hills to support these two specialized carnivore species.

Also absent from the camera trap survey were black-tailed jackrabbits (*Lepus californicus*). Jackrabbits prefer relatively open habitat and may occur in the open oil fields adjacent to KHSRA. The previous mammal survey (Dines 2001) noted a roadkill jackrabbit in the vicinity (intersection of Stocker and Fairfax).

In contrast, the species of mid- to large-sized mammals that were detected in the study area comprise a homogenous assemblage typically found in urban and suburban fringe habitats: mesopredators with generalized habits that easily adapt to human altered environments (McKinney 2006). Mesopredators are small and mid-sized predators that, in the absence of suppression by apex predators such as coyotes, exhibit higher population densities and associated increased levels of predation on smaller prey in a process called “mesopredator release” (Soulé et al. 1988, Ritchie and Johnson 2009). Mesopredators include native and exotic species that typically exhibit generalist habits and are therefore adapted to making a living in urban and suburban settings with fragmented “edge” habitats and abundant food resources.

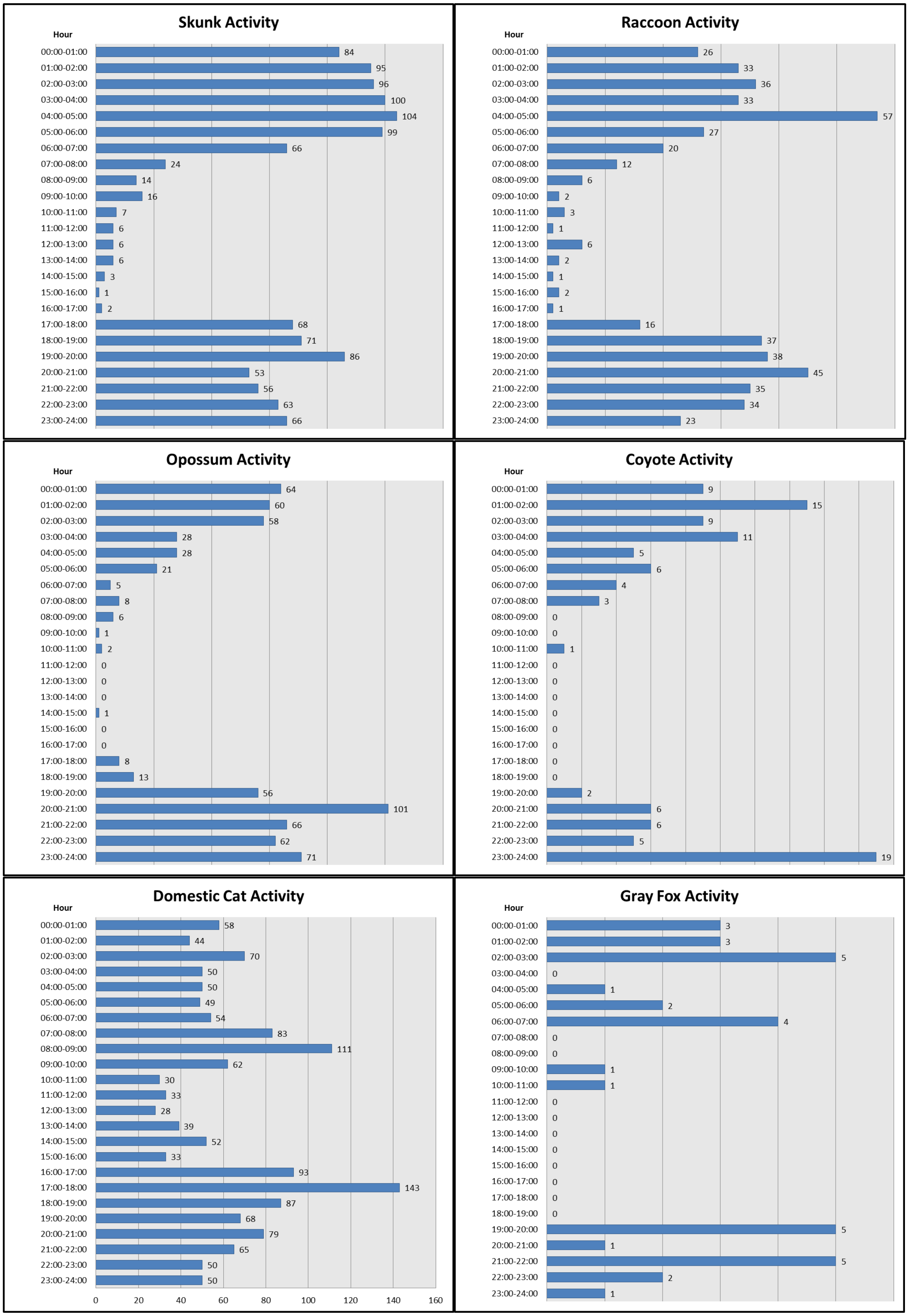


Figure 5-3. Species activity by hour showing diurnal versus nocturnal occurrence of target species.

Table 5-2. Updated list of terrestrial mammals documented as currently inhabiting the Baldwin Hills. Adapted from Dines (2001).

Species	Common Name	LAMC collection	Trapped in 2001	Sign in 2001*	Confirmed this study
Didelphis virginiana	Virginia Opossum	X		X	X
Canis latrans	Coyote	X			X
Canis familiaris	Domestic Dog			X	X
Urocyon cinereoargenteus	Gray Fox	X		X	X
Felis catus	Domestic Cat			X	X
Mephitis mephitis	Striped Skunk	X			X
Procyon lotor	Raccoon			X	X
Sciurus niger	Eastern Fox Squirrel			X	X
Otospermophilus beecheyi	California Ground Squirrel	X			X
Thomomys bottae	Botta's Pocket Gopher	X		X	X
Microtus californicus	California Vole	X		X	X
Mus musculus	House Mouse		X		X
Rattus rattus	Black Rat				X
Neotoma lepida	Desert Woodrat	X	X		
Peromyscus maniculatus	Deer Mouse		X		
Reithrodontomys megalotis	Western Harvest Mouse	X	X		
Sylvilagus audubonii	Desert Cottontail			X	X
Lepus californicus	Black-tailed Jackrabbit			X	

*Sign includes scat, tracks, runways, and roadkill.

As an ecological guild, carnivores vary in their sensitivity to fragmentation and degree of urban development (Crooks 2002; Ordeñana et al. 2010). Carnivores with specialized dietary and habitat needs are most sensitive to fragmentation and tend to disappear as habitat patches shrink and become more isolated. Included in this category are the mountain lion, bobcat, spotted skunk, and long-tailed weasel, all of which occur in the larger remaining expanses of Mediterranean habitat of Southern California but are absent from the present-day Baldwin Hills. Carnivores with more omnivorous habits, such as raccoons and striped skunks, are tolerant of, or may even benefit from fragmentation (Crooks 2002). Domestic cats and opossums are exotic species that actually increase in density in areas with fragmented habitats (Crooks 2002). Although opossums are marsupials and not carnivores taxonomically, they are included here as a mesopredator as they share that ecological niche. Mesopredator species with generalist habits perceive urban and fragmented natural habitats as contiguous (Crooks 2002) and thus readily move through and reside in developed areas.

Similar to the mammalian carnivores detected in other studies of urban habitats in coastal Southern California (Fedriani 2001, Crooks 2002, Ordeñana et al. 2010), the mesopredators we documented in the Baldwin Hills were primarily resource generalists that likely benefit from supplemental food sources available in association with human activities. Included in this group are the Virginia opossum, raccoon, western striped skunk, gray fox, and domestic cat. Similarly, the dominant Southern California urban predator documented in previous studies, the coyote, was distributed widely throughout the Baldwin Hills. Below, we discuss the occurrence and distribution of each of these species.

*Domestic cat (*Felis catus*)*

After humans, domestic cats were the most abundant species captured on cameras in the study area (Table 5-3). Cats were most frequently photographed at site CC1 in Culver City Park, where a feral cat feeding/watering station was observed to have been maintained throughout the study period. Multiple studies suggest that feral cats have a strongly negative impact on native fauna (e.g., Hall et al. 2000, Nogales et al. 2004, Loss et al. 2013) as do inside/outside pet cats (Crooks and Soulé 1999, Kays et al. 2004). Cat activity is known to have a positive relationship with availability of anthropogenic food and habitat resources. In particular, the effects of feral cats that are subsidized (as at feeding stations, for example) are magnified by the fact that subsidized populations grow to as high as 100 times those of native predator population densities (Liborg et al. 2000). Moreover, predation on native fauna is concentrated in areas where subsidized cat populations exist (Schmidt et al. 2007). Previous studies have documented the displacement of cats from natural areas by coyotes (Gehrt et al. 2013; Kays et al. 2015) and direct predation of cats in urban areas (Grubbs and Krausman 2009), however, a combination of human-subsidized resources and potentially lower coyote densities in the Baldwin Hills allow cats to persist beyond the urban edge. The negative effects of exotic cats have occasionally been presented as equivocal (see discussion in Baker et al. 2010), but Longcore et al. (2009) and Loss et al. (2013) present clear evidence that urban cats kill large number of prey animals.

Table 5-3. Results of camera trap study, showing camera trap effort (trap nights) for each location, number of observations at each locality, and the Relative Abundance of each species (RA, in parentheses) at each locality. See Table 5-1 for location details.

		AUDBHSO	Ballona_Creek	BHSO_01	BHSO_02	BHSO_03	CC1	CC2	KHSRA_01	KHSRA_02	KHSRA_03	KHSRA_04	La_Brea	Stocker	Stocker_Flash	Total
Trap Nights		**146**	**41**	**146**	**87**	**106**	**183**	**204**	**465**	**228**	**322**	**180**	**240**	**133**	**152**	**2633**
Species	**Cat**	**16** (0.11)	**12** (0.29)	**3** (0.02)	**51** (0.59)	**51** (0.48)	**551** (3.01)	**63** (0.31)	**9** (0.02)	**13** (0.06)	**347** (1.08)	**135** (0.75)	**136** (0.57)	**88** (0.66)	**4** (0.03)	**1479** (0.56)
	Coyote			**4** (0.03)	**7** (0.08)	**4** (0.04)	**21** (0.11)	**9** (0.04)	**7** (0.02)	**1** (0.01)	**40** (0.12)	**4** (0.02)		**4** (0.03)		**101** (0.04)
	Dog				**15** (0.17)	**1** (0.01)	**3** (0.02)	**4** (0.02)		**2** (0.01)	**92** (0.29)	**298** (1.66)		**48** (0.36)	**1** (0.01)	**464** (0.18)
	Gray fox	**1** (0.01)					**2** (0.01)	**3** (0.01)	**27** (0.06)	**1** (0.00)						**34** (0.01)
	Human	**3** (0.02)	**6** (0.15)	**5** (0.03)	**411** (4.72)	**127** (1.20)	**141** (0.77)	**1** (0.01)		**13** (0.06)	**1871** (5.81)	**4041** (22.5)		**155** (1.17)		**6774** (2.57)
	Mouse		**1** (0.02)			**1** (0.01)		**2** (0.01)		**1** (0.00)	**10** (0.03)	**1** (0.01)	**22** (0.09)	**3** (0.02)		**41** (0.01)
	Opossum	**6** (0.04)	**35** (0.85)	**6** (0.04)	**2** (0.02)	**29** (0.27)	**50** (0.27)	**150** (0.73)	**12** (0.03)	**19** (0.08)	**84** (0.26)	**28** (0.16)	**234** (0.98)	**1** (0.01)	**3** (0.02)	**659** (0.25)
	Rabbit				**6** (0.07)						**4** (0.01)	**10** (0.06)				**20** (0.01)
	Raccoon	**11** (0.08)	**11** (0.27)	**6** (0.04)	**2** (0.02)	**18** (0.17)	**116** (0.63)	**99** (0.49)	**131** (0.28)	**4** (0.02)	**72** (0.22)	**11** (0.06)	**5** (0.02)	**15** (0.11)	**6** (0.04)	**507** (0.19)
	Skunk	**29** (0.20)	**30** (0.73)	**9** (0.06)	**24** (0.28)	**141** (1.33)	**540** (2.95)	**318** (1.56)	**13** (0.03)	**15** (0.07)	**91** (0.28)	**6** (0.03)	**4** (0.02)	**1** (0.01)		**1221** (0.46)
	Squirrel	**1** (0.01)		**1** (0.01)			**109** (0.60)	**67** (0.33)	**34** (0.07)	**12** (0.05)	**79** (0.25)	**40** (0.22)		**4** (0.03)		**347** (0.13)
	Unknown		**1** (0.02)	**2** (0.01)	**18** (0.21)	**8** (0.08)	**53** (0.29)	**18** (0.09)	**35** (0.08)	**1** (0.00)	**15** (0.05)	**5** (0.03)	**23** (0.10)	**3** (0.02)	**2** (0.01)	**184** (0.07)

*Gray fox (*Urocyon cinereoargenteus*)*

Gray foxes are relatively small canids that are widely distributed in North America and generally considered adaptable due to an omnivorous diet and behavioral plasticity (Riley et al. 2003). Gray foxes were present in low density and at limited sites in the current study, seemingly in contrast to previous studies that found gray foxes to be tolerant of—even thriving in—urban areas in Southern California (Riley 2006) and actually more abundant in small urban fragments (Crooks 2002). However, coyotes have been shown to limit the number and distribution of gray foxes by competitive dominance in the nearby Santa Monica Mountains (Fedriani et al. 2000). In the urbanized chaparral canyons of San Diego, gray fox populations are also controlled by coyotes (Soulé 1988, Crooks and Soulé 1999). Indeed, predation by coyotes is an important source of mortality for gray foxes, and gray foxes will avoid areas with high predation risk by coyotes (Farias et al. 2005). In the Baldwin Hills, the highest level of fox activity was in the western portion of KHSRA at site KHSRA_1, in habitat characterized by dense brush and trees. Coyotes were detected at the same site (n=27 for gray foxes, n=7 for coyotes, over 465 trap nights), although less frequently than at other sites in the study area. Fedriani (2000) also showed that gray foxes were restricted to brushy habitat in the Santa Monica Mountains, ostensibly to avoid the abundantly present coyotes. Gray foxes have the unique ability to climb trees to evade predators such as coyotes (Nowak and Paradiso 1999), so the dense brush and trees at site KHSRA_1 possibly provide cover and refuge from coyote activity. It is also possible that the dense cover of that site minimizes contact with humans and domestic dogs, which can also negatively influence gray fox activity.

*Striped skunk (*Mephitis mephitis*)*

The striped skunk is an opportunistic omnivore, in the wild feeding primarily on insects such as beetles and crickets, but also frogs, earthworms, snails, mice, bird eggs, fruit, carrion, and garbage. Like other mammalian resource generalists, the striped skunk is resilient to habitat fragmentation (Crooks 2002). Essentially, for species such as the striped skunk, the mosaic of urban habitats and fragmented pockets of natural habitats in suburban areas form a continuum of suitable territory for foraging and denning. In the present study, striped skunks were most abundant at sites CC1 and CC2 (2.95 RA and 1.56 RA, respectively), in close proximity to the baseball fields in Culver City Park (Figure 5-1). The turf on baseball fields comprise prime foraging grounds for striped skunks, as they are especially fond of grubs and are known to dig up lawns searching for them. Notably, the highest numbers of striped skunk images were captured at site CC1, the location of the feral cat feeding station. Striped skunks are attracted to outdoor feeding of pet cats and dogs (Rosatte et al. 2010). Our camera traps detected striped skunks using the cat feeding stations, demonstrating that the higher density of striped skunks at the Culver City Park sites is unequivocally a result of supplemental feeding. Notably, site CC_1 is adjacent to property with largely undisturbed native coastal sage shrub habitat that would provide skunks with suitable vegetative cover. Previous studies have suggested that when striped skunks occur in proximity to urban areas, they prefer patches of natural habitat for cover and den sites that are adjacent to human-altered landscapes with bountiful food resources (Crooks 2002, Ordeñana et al. 2010).

*Raccoons (*Procyon lotor*)*

Highly proficient at exploiting human structures and food sources, raccoons are resource generalists (Hadidian et al. 2010). Previous studies identified raccoons as tolerant of, or even enhanced by urbanization (Crooks 2002, Crooks and Soulé 1999, Ordeñana et al. 2010). Raccoons also appear to be less impacted by the presence of coyotes than other mesopredators, such as the gray fox (Crooks and Soulé 1999). Consistent with these studies, raccoons were ubiquitous in our study area and were detected at every camera site (Table 5-3). They were most frequently detected at sites KHSRA_1 (n=131) and CC1 (n=116). With its associated dense cover, KHSRA_1 provides natural denning habitat, one possible reason for the high detection rate at that site. Raccoons are readily attracted to feeding stations (Hadidian 2010) and were observed using the cat feeding stations near our site CC1.

*Virginia Opossum (*Didelphis virginiana*)*

Taxonomically, the opossum is a marsupial, not a carnivore, but like the other mid-sized mammals successful in urban settings, the opossum has a fairly generalist diet. Among food items found in an analysis of urban opossum stomachs are earthworms, snails, insects, fruit, bird eggs, small mammals, pet food and garbage (Hopkins and Forbes 1980). Native to the eastern United States, the Virginia opossum was introduced into the Los Angeles region as early as 1906 (Little 1916). Widespread introductions elsewhere in California, coupled with a high fecundity and generalized habits, led to broad occurrence in the state by the 1940s (Ingles 1965), particularly in agricultural and suburban areas. Previous studies of the Virginia opossum in urbanized habitats of California detected opossums near edges of habitat fragments within the urban matrix (Crooks 2002) and even within habitat surrounded by intense development (Markovchick-Nicholls et al. 2008). Although opossums are common in urbanized settings, they may need nearby natural areas for vegetative cover and den sites (Ordeñana et al. 2010). The current survey documented the opossum widely throughout the Baldwin Hills, with individuals detected at every camera site (Table 5-3). Opossums were most frequently detected at the La_Brea camera site (0.98 RA), a location with dense vegetative cover but in very close proximity to human residential developments (Figure 5-1).

*Coyote (*Canis latrans*)*

Well-known for its versatility, the coyote is widespread throughout North America. Prior to the persecution of larger competitors such as the mountain lions and wolf, the coyote was most common in grassland and desert habitats. The removal of larger competitors, however, allowed the coyote to significantly expand its range throughout the continent (Laliberte and Ripple 2004). Indeed, the remarkable behavioral plasticity of the coyote has allowed it to extend its range into metropolitan areas and quickly become a "denizen of the city" (Gehrt and Riley 2010). In southern California, coyotes are able to exploit urbanized areas due to their highly adaptable behavior and omnivorous diet, especially where garbage, cultivated fruit, pet food, and domestic animals are available as food subsidies (Crooks 2002, Fedriani et al. 2001, Riley et al. 2003). Coyotes in human-impacted areas can have densities of up to eight times higher than in natural areas (Fedriani et al.

2001). On the other hand, Ng et al. (2004) found that coyotes related positively with human activity but negatively with urban development, suggesting a tolerance threshold for urbanization.

Coyotes were not detected at every camera site in our study area. They were absent from all camera sites that lacked an obvious trail or path (i.e., La_Brea, Stocker_Flash, and AUDBHSO) and from the Ballona_Creek site, which was located on a path but detected low activity in general. Similarly, previous Southern California studies found positive relationships between coyotes and corridor width, natural habitat, and fragment area (Crooks 2002; Crooks and Soule´ 1999; Tigas et al. 2002), suggesting an overall preference by coyotes for established corridors and natural habitat. The coyote is the dominant predator in the Baldwin Hills and although widespread, is not particularly abundant. We documented the greatest coyote activity at the two sites where domestic cat activity was also the greatest: site CC1, with 3.01 RA for cats and 0.11 RA for coyotes; and site KHSRA_03, with 1.08 RA for cats and 0.12 RA for coyotes. The relatively high activity of cats at feeding stations potentially attracts coyotes, but the overall low density of coyotes in the Baldwin Hills may limit the top-down control of cat populations.

In the Baldwin Hills, parks and other open spaces are extensively used by humans for recreational activities. Studies elsewhere have shown that areas in urban parks frequented by humans and their pet dogs are less diverse in native carnivores (Mathewson et al. 2008, Ordeñana et al 2010). Increased human activity and recreation associated with urbanization may lead to the behavioral displacement of carnivores (Mathewson et al. 2008, Riley et al. 2003, Tigas et al. 2002; George and Crooks 2006). Although fragmentation-sensitive species are absent from the Baldwin Hills, more adaptable generalist species are ubiquitous at certain sites. The presence of this diverse assemblage of species presents challenges and opportunities.

Further development of proposed recreational trails and other areas within the Baldwin Hills will increase human contact with the urban wildlife inhabiting the remaining secluded habitats, leading to potential conflict. Sources of conflict include increased possibility of the transmission of zoonoses such as rabies, distemper, toxoplasmosis, and roundworms, as well as direct conflict with pets. Additionally, previous research indicates that increased recreation and human activity alters the circadian activity of carnivores, either displacing them from an area entirely or narrowing their window of activity that they use to hunt, patrol territories, and find mates (Tigas et al. 2002; George and Crooks 2006). Land managers and community leaders will need to weigh the benefits of securing more space for traditional recreational activities, such as hiking trails, against the cost of eliminating natural habitat necessary for cover and den sites of native fauna. Wildlife viewing opportunities, for mammals as well as birds and other taxa, have their own inherent recreational benefits, particularly in a society with limited access to nature (Louv 2008).

Regardless of increased development, the operation of feeding stations should be addressed. Supplemental feeding artificially increases populations of carnivores. In the case of domestic cats, that means more cats are killing more native fauna such as songbirds, native mice, and reptiles. The current study echoes the results of previous studies: whether intended or not, feeding stations lead to increased populations and habituation of raccoons, skunks, and opossums, which increases conflict (Gehrt and Riley 2010). Increased densities of these mesopredator species may also lead to increased possibility of disease transmission, both between wildlife species and between domestic animals and wildlife.

Many major boulevards divide the Baldwin Hills into discrete areas. Roads can act as physical and social barriers to carnivores (Riley et al. 2006, Tigas et al. 2002). Our study showed that all of the carnivore species that inhabit the Baldwin Hills are found in KHSRA and in the Baldwin Hills Scenic Overlook/Blair Hills properties. Creating wildlife corridors that allow safe movement between those areas (e.g., wildlife overpasses and underpasses) would decrease vulnerability to mortality associated with crossing La Cienega Blvd, and potentially increase gene flow in the populations inhabiting those two areas. While the camera at the Ballona_Creek site did not detect the presence of significant numbers of carnivores, connectivity of the Baldwin Hills to Ballona Creek should be explored, particularly in light of Ballona Creek potentially being used as a wildlife corridor to and from the Ballona Wetlands to the west.

Conclusions

The Baldwin Hills have a long history of use by humans, including early Native American settlements, location of Rancho land grants during the Mexican era, suburban housing developments as Los Angeles developed into a major urban center, discovery of oil and development of petroleum operations, and most recently as recreational space. With some patches of native habitat remaining, the Baldwin Hills are essentially an "island" of habitat surrounded by the "sea" of the urbanized flatlands. As such, the Baldwin Hills support certain species, such as the native gray fox, that do not occur in the adjacent flatlands. Even so, urbanization has impacted the overall mammal fauna within the Baldwin Hills. Available habitats in the Baldwin Hills are typical of the "altered nature" found in similar urban recreation areas of the Los Angeles Basin (e.g., Ernest E. Debs Park and Elysian Park). Wildlife most able to co-exist in human-influenced environments is most abundant. Meanwhile, species that are sensitive to habitat fragmentation, in particular the long-tailed weasel and spotted skunk, have likely been extirpated. Despite the adaptive nature of the mammal species that endure, challenges remain. The large boulevards transecting the Baldwin Hills act as barriers and as a source of mortality, especially for more wide-ranging species such as the coyote. The abundant recreational use and associated presence of humans and their pet dogs, in the Baldwin Hills likely displaces the natural activities of wild animals. Paradoxically, those same wild species benefit from human presence to supplement their natural foraging activities. Finally, the density of generalist mammals in urban habitats, and their close proximity with humans and their pets, raises the potential for transmission of zoonotic diseases and conflict.

Acknowledgements

Travis Longcore provided GIS support, arranged access to properties under the jurisdictions of multiple agencies, and provided valuable comments to this report. Shawn McAdory provided permission to install camera traps in Kenneth Hahn State Recreation Area. Benjamin Banet provided data support, including image data sorting and organization, and manually identifying species in each image. Stevie Kennedy-Gold and Bennett Hardy assisted with camera checks and data downloads.

References

Baker, P. J., C. D. Soulsbury, G. Iossa and S. Harris. 2010. Domestic cat (*Felis catus*) and domestic dog (*Canis familiaris*). Pp. 157–171 in *Urban Carnivores: Ecology, Conflict, and Conservation* (S. D. Gehrt, S. P. D. Riley, and B. L. Cypher, eds.). Johns Hopkins University Press, Baltimore, Maryland.

Becker, E. M. and M. H. Kimball. 1947. Walnut growers turn squirrel catchers. *Diamond Walnut News* 29(3):4–6.

Crooks, K. R. 2002. Relative sensitivities of mammalian carnivores to habitat fragmentation. *Conservation Biology* 16(2):488–502.

Crooks, K. R., and M. E. Soulé. 1999. Mesopredator release and avifaunal extinctions in a fragmented system. *Nature* 400(6744):563–566.

Dines, J. P. 2001. Mammals of the Baldwin Hills. Pp. 127–141 in *The Biota of the Baldwin Hills: An Ecological Assessment* (K. C. Molina, ed.). Community Conservation International and Natural History Museum of Los Angeles County.

Fahrig, L., J. H. Pedlar, S. E. Pope, P. D. Taylor and J. F. Wegner. 1995. Effect of road traffic on amphibian density. *Biological Conservation* 73(3):177–182.

Farias, V., T. K. Fuller, R. K. Wayne and R. M. Sauvajot. 2005. Survival and cause-specific mortality of gray foxes (*Urocyon cinereoargenteus*) in southern California. *Journal of Zoology* 266(3):249–254.

Fedriani, J. M., Fuller, T. K., Sauvajot, R. M., & York, E. C. 2000. Competition and intraguild predation among three sympatric carnivores. *Oecologia* 125(2):258–270.

Fedriani, J. M., T. K. Fuller, and R. M. Sauvajot. 2001. Does availability of anthropogenic food enhance densities of omnivorous mammals? An example with coyotes in southern California. *Ecography* 24(3):325–331.

Gehrt, S. D. and S. P. D. Riley. 2010. Coyotes (*Canis latrans*). Pp. 80–95 in *Urban Carnivores: Ecology, Conflict, and Conservation* (S. D. Gehrt, S. P. D. Riley, and B. L. Cypher, eds.). Johns Hopkins University Press, Baltimore, Maryland.

Gehrt, S.D., E.C. Wilson, J.L. Brown, and C. Anchor. 2013. Population ecology of free-roaming cats and interference competition by coyotes in urban parks. *PLoS ONE* 8(9):e75718.

George, S. L and K. R. Crooks. 2006. Recreation and large mammal activity in an urban nature reserve. *Biological Conservation* 133:107–117.

Grubbs S.E. and P.R. Krausman. 2009. Observations of coyote-cat interactions. *Journal of Wildlife Management* 73:683–685.

Hadidian, J., S, Prange, R. Rosatte, S. P. D. Riley, and S. D. Gehrt. 2010. Raccoons (*Procyon lotor*). Pp. 35–48 in *Urban Carnivores: Ecology, Conflict, and Conservation* (S. D. Gehrt, S. P. D. Riley, and B. L. Cypher, eds.). Johns Hopkins University Press, Baltimore, Maryland.

Hall, L. S., M. A. Kasparian, D. Van Vuren and D. A. Kelt. 2000. Spatial organization and habitat use of feral cats (*Felis catus* L.) in Mediterranean California. *Mammalia* 64(1):19–28.

Hopkins, D. D. and R. B. Forbes. 1980. Dietary patterns of the Virginia opossum in an urban environment. *The Murrelet* 61(1):20–30.

Ingles, L. G. 1965. Mammals of the Pacific states: California, Oregon, and Washington. Stanford University Press.

Kays, R. W. and A. A DeWan. 2004. Ecological impact of inside/outside house cats around a suburban nature preserve. *Animal Conservation* 7(3):273–283.

Kays, R., R. Costello, T. Forrester, M. C. Baker, A. W Parsons, E. L. Kalies, G. Hess, J. J. Millspaugh and W. McShea. 2015. Cats are rare where coyotes roam. *Journal of Mammalogy* 96(5):981–987.

Kelly, M. J., and E. L. Holub. 2008. Camera trapping of carnivores: trap success among camera types and across species, and habitat selection by species, on Salt Pond Mountain, Giles County, Virginia. *Northeastern Naturalist* 15(2):249–262.

Laliberte A. S. and W. J. Ripple. 2004. Range contractions of North American carnivores and ungulates. *BioScience* 54(2):123–38.

Liberg, O., M. Sandell, D. Pontier, and E. Natoli. 2000. Density, spatial organisation and reproductive tactics in the domestic cat and other felids. Pages 119–147 in *The Domestic Cat: the Biology of its Behaviour* (D. C. Turner and P. Bateson, eds.) Cambridge University Press, Cambridge, United Kingdom.

Little, E. V. 1916. The opossum in Los Angeles County. *California Fish and Game* 2:46–47.

Longcore, T., C. Rich and L. M. Sullivan. 2009. Critical assessment of claims regarding management of feral cats by trap–neuter–return. *Conservation Biology* 23(4):887–894.

Loss, S. R., T. Will and P. P. Marra. 2013. The impact of free-ranging domestic cats on wildlife of the United States. *Nature Communications* 4(1396):1–7.

Louv, R. 2008. Last child in the woods: Saving our children from nature-deficit disorder. Algonquin Books.

Mader, H. J. 1984. Animal habitat isolation by roads and agricultural fields. *Biological Conservation* 29(1):81–96.

Markovchick-Nicholls, L., H. M Regan, D. H. Deutschman, A. Widyanata, B. Martin, L. Noreke, and T. Ann Hunt. 2008. Relationships between human disturbance and wildlife land use in urban habitat fragments. *Conservation Biology* 22(1):99–109.

Marqua, D. 1978. Animal life: Baldwin Hills project. County of Los Angeles Department of Parks and Recreation.

Mathewson, P. D., S. N. Spehar, and D. S. Cooper. 2008. An initial carnivore survey of Griffith Park, Los Angeles, California. *Bulletin of the Southern California Academy of Sciences* 107:57–67.

McKinney, M. L. 2006. Urbanization as a major cause of biotic homogenization. *Biological Conservation* 127(3):247–60.

McLaughlin, C. A. 1959. Mammals of Los Angeles County, California. *Los Angeles County Museum Science Series* 21:1–35.

Nogales, M., A. Martín, B. R. Tershy, C. J. Donlan, D. Veitch, N. Puerta, B. Wood, and J. Alonso. 2004. A review of feral cat eradication on islands. *Conservation Biology* 18:310–319.

Nowak R. M. and J. L. Paradiso. 1999. Walker's Mammals of the World, vol. I. John Hopkins University Press, Baltimore, Maryland. 6th edition.

Ordeñana, M. A., K. R. Crooks, E. E. Boydston, R. N. Fisher, L. M. Lyren, S. Siudyla, D. D. Haas, S. Harris, S. A. Hathaway, G. M. Turschak, and A. K. Miles. 2010. Effects of urbanization on carnivore species distribution and richness. *Journal of Mammalogy* 91(6):1322–1331.

Riley, S. P. 2006. Spatial ecology of bobcats and gray foxes in urban and rural zones of a national park. *Journal of Wildlife Management* 70:1425–1435.

Riley, S. P., R. M. Sauvajot, T. K. Fuller, E. C. York, D. A. Kamradt, C. Bromley, & R. K. Wayne. 2003. Effects of urbanization and habitat fragmentation on bobcats and coyotes in southern California. *Conservation Biology* 17(2):566–576.

Riley, S. P., J. P. Pollinger, R. M. Sauvajot, E. C. York, C. Bromley, T. K. Fuller, and R. K. Wayne. 2006. A southern California freeway is a physical and social barrier to gene flow in carnivores. *Molecular Ecology* 15(7):1733–1741.

Ritchie, E. G., and C. N. Johnson. 2009. Predator interactions, mesopredator release and biodiversity conservation. *Ecology Letters* 12(9):982–998.

Rosatte, R., K. Sobey, J. W. Dragoo, and S. D Gehrt. 2010. Striped skunks and allies (*Mephitis* spp.). Pp. 97–106 in *Urban Carnivores: Ecology, Conflict, and Conservation* (S. D. Gehrt, S. P. D. Riley, and B. L. Cypher, eds.). Johns Hopkins University Press, Baltimore, Maryland.

Sanderson, J. and G. Harris. 2013. Automatic data organization, storage, and analysis of cameratrap pictures. *Journal of Indonesian Natural History* 1(1):11–19.

Schmidt, P. M., R. R. Lopez, and B. A. Collier. 2007. Survival, fecundity, and movements of free–roaming cats. *Journal of Wildlife Management* 71(3):915–919.

Soule, M. E., D.T. Bolger, A.C. Alberts, J. Wrights, M. Sorice and S. Hill. 1988. Reconstructed dynamics of rapid extinctions of chaparral-requiring birds in urban habitat islands. *Conservation Biology* 2(1):75–92.

Tigas, L. A., D. H. Van Vuren and R. M. Sauvajot. 2002. Behavioral responses of bobcats and coyotes to habitat fragmentation and corridors in an urban environment. *Biological Conservation* 108:299–306.

Willett, G. 1941. Faunal changes in Los Angeles County. *Los Angeles County Museum Quarterly* 1(4):19–23.

Willett, G. 1944. Mammals of Los Angeles County, California. *Los Angeles County Museum Science Series* 9:1–34.