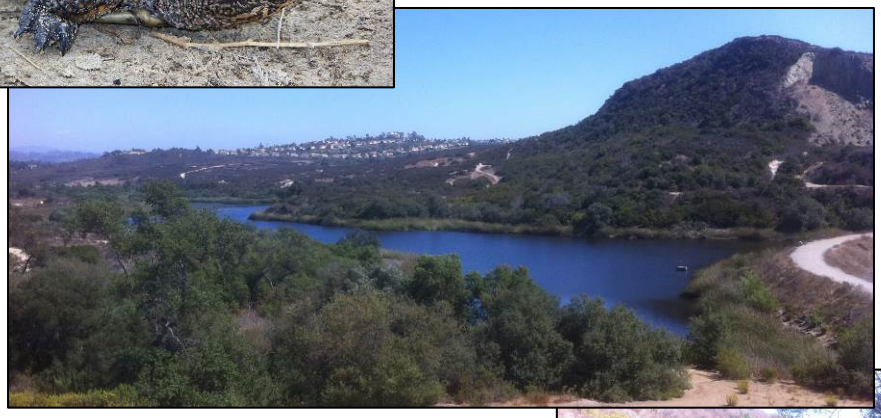
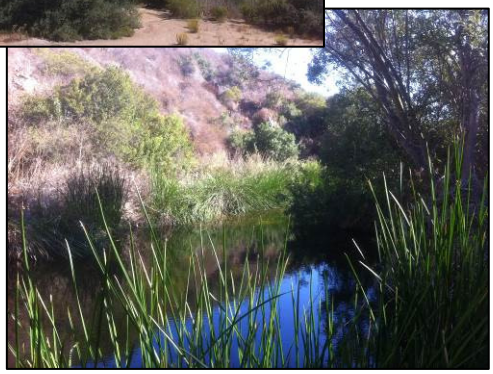
Western Pond Turtle (*Emys marmorata*) Study for the TransNet Environmental Mitigation Program Grant Agreement 5001976, 2012-2014

Data Summary





Prepared for:

SANDAG

TransNet Environmental Mitigation Program

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY
WESTERN ECOLOGICAL RESEARCH CENTER

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By: Chris Brown, Melanie C. Madden, Stacie A. Hathaway, and Robert N. Fisher

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Cover Photographs: Western pond turtle (*Emys marmorata*) from Lake Calavera, Lake Calavera, and Rancho La Costa Preserve, Box Canyon (photos by C. Brown).

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Introduction

The western pond turtle (*Emys marmorata*; hereafter referred to as pond turtle) is California's only native freshwater turtle and was once widespread and common in southern California. Based on recent work, three out of four genetically distinct lineages of pond turtles occur in southern California (Spinks & Shaffer 2005). The remaining lineage occurs from central California north to Washington. This high genetic diversity in southern California is the result of a long and complex genetic history, heightening the need for conservation in the south coast region (Spinks & Shaffer 2005). Furthermore, genetic diversity in San Diego County south of Marine Corps Base Camp Pendleton (MCBCP) is high relative to other areas in the pond turtle's range analyzed to date (Markert et al. 2011; Spinks & Shaffer 2005). The San Diego Multiple Species Conservation Program (MSCP) and North County Multiple Habitat Conservation Program (MHCP) have recognized the conservation need for pond turtles in San Diego County by including it in their habitat conservation plans, giving legal protection to the pond turtle (AMEC & CBI 2003).

This species is heavily impacted by fragmentation, recreation, and the introduction of nonnative aquatic species which compete with and directly predate upon it (e.g. nonnative turtles, bullfrogs, largemouth bass, sunfish and crayfish) (Holland 1991; Brattstrom & Messer 1988; Bury & Germano 2008). Recent (2002-2003) studies in the MSCP region of San Diego detected only six pond turtle localities (of which only three had females), the largest population estimated to be between 30-81 individuals and no populations showing recruitment (Madden-Smith et al. 2005). Very few stable populations still exist elsewhere in San Diego County and little is known regarding pond turtles in many of the coastal areas outside of the MSCP (Brattstrom & Messer 1988; Madden-Smith et al. 2005). In and around San Luis Rey River, pond turtles were historically abundant; however, very few pond turtles have been observed in recent years (K. Merkel, personal communication, 2008; Fisher et al. 2012). Outside of Sycuan Peak Ecological Reserve (SPER) where there is ongoing restoration and headstarting for pond turtles, there has been no documented recent recruitment of pond turtles within the MSCP and MHCP regions and there is less knowledge of turtle populations (native or not) in the MHCP area (Madden-Smith et al. 2005; Brown et al. 2012). As a result, the pond turtle is one of the rarest species covered by habitat conservation plans in San Diego County.

Many of the watersheds in northern coastal San Diego County south of MCBCP are severely impacted by aquatic nonnative species and pond turtles are at high risk of extirpation in these drainages, if they are not already extinct in most locations. Similar to the restoration for pond turtles at SPER, the removal of nonnative aquatic species can release this pressure on extant pond turtle populations or prepare a site for reintroduction of pond turtles (Brown et al. 2012). However, in the MHCP region, the extent to which nonnative species are impacting pond turtle populations and habitat is unknown. Before successful active management can be implemented in the northern coastal drainages of San Diego County, the distribution and status of pond turtles and aquatic nonnatives must be determined and suitable habitat must be identified. In 2012, USGS began work on the TransNet Environmental Mitigation Program grant agreement 5001976 regarding the western pond turtle in order to assess the distribution of native and nonnative turtles and suitable habitat for pond turtles in coastal northern San Diego County south of MCBCP.

Study Area

The focal area of this study consists of riparian areas along the coastal streams of northern San Diego County south of Marine Corps Base Camp Pendleton and north of the city of Solana Beach (Figure 1). Within this region, there are seven coastal watersheds which had limited or no data for pond turtles. These include the San Luis Rey River, Loma Alta Creek, Buena Vista Creek, Agua Hedionda Creek, Canyon de las Encinas Creek, San Marcos Creek, and Escondido Creek (Figure 2, Table 1). We focused on public, quasi-public, and conserved lands within these watersheds. For the assessment for habitat suitability and potential trapping locations, we examined ponds, wetted areas, streams and adjacent upland habitat in these watersheds. A total of 62 sites were surveyed in the seven watersheds combined (Appendix A; Figure 2). Sites were divided into 250 meter reaches, resulting in a total of 118 reaches surveyed throughout the study area. Defining and selecting stream reaches was an iterative process. Initially 186 predefined stream reaches were mapped to the 2012 conserved lands database. During field reconnaissance, many of these predefined sites were found to be unsuitable based on anthropogenic land cover alterations, lack of any defined stream channel, lack of pooling habitat, or lack of a wetted stream channel. As additional potentially occupiable sites were identified in the field, the streams associated with these sites were mapped in their entirety and divided into 250 meter reaches. Newly conserved parcels were also added to the SANDAG Conserved Lands Database during the study (SanGIS 2014). As of this writing, USGS has 462 mapped 250 meter stream reaches within conserved lands, both on public and private lands (SanGIS 2014).

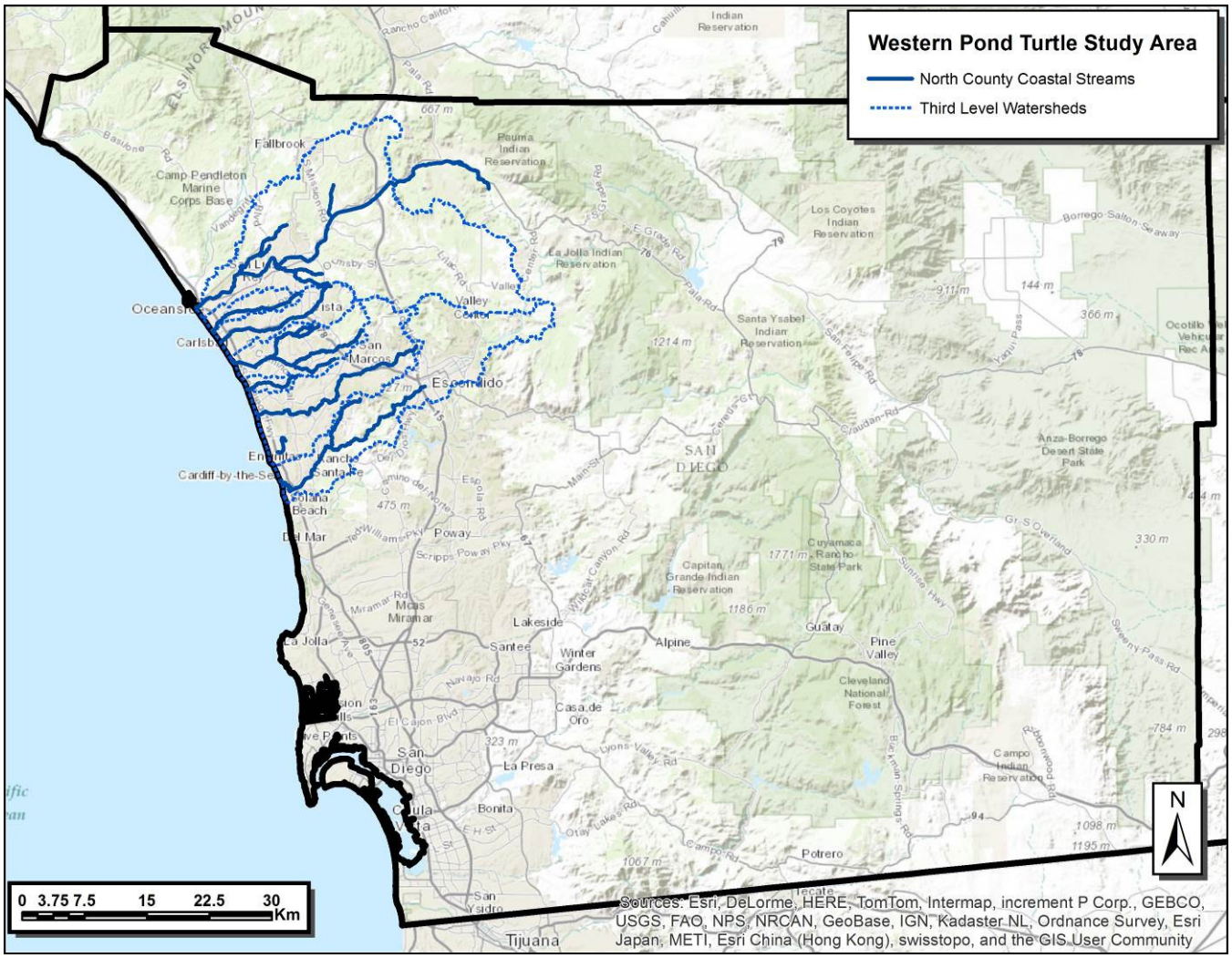

Figure 1. Overview of the seven north county streams within the study area. The main stems of the streams lie south of Marine Corps Base Camp Pendleton and north of the City of Solana Beach. This region occupies much of the northwest corner of San Diego County.

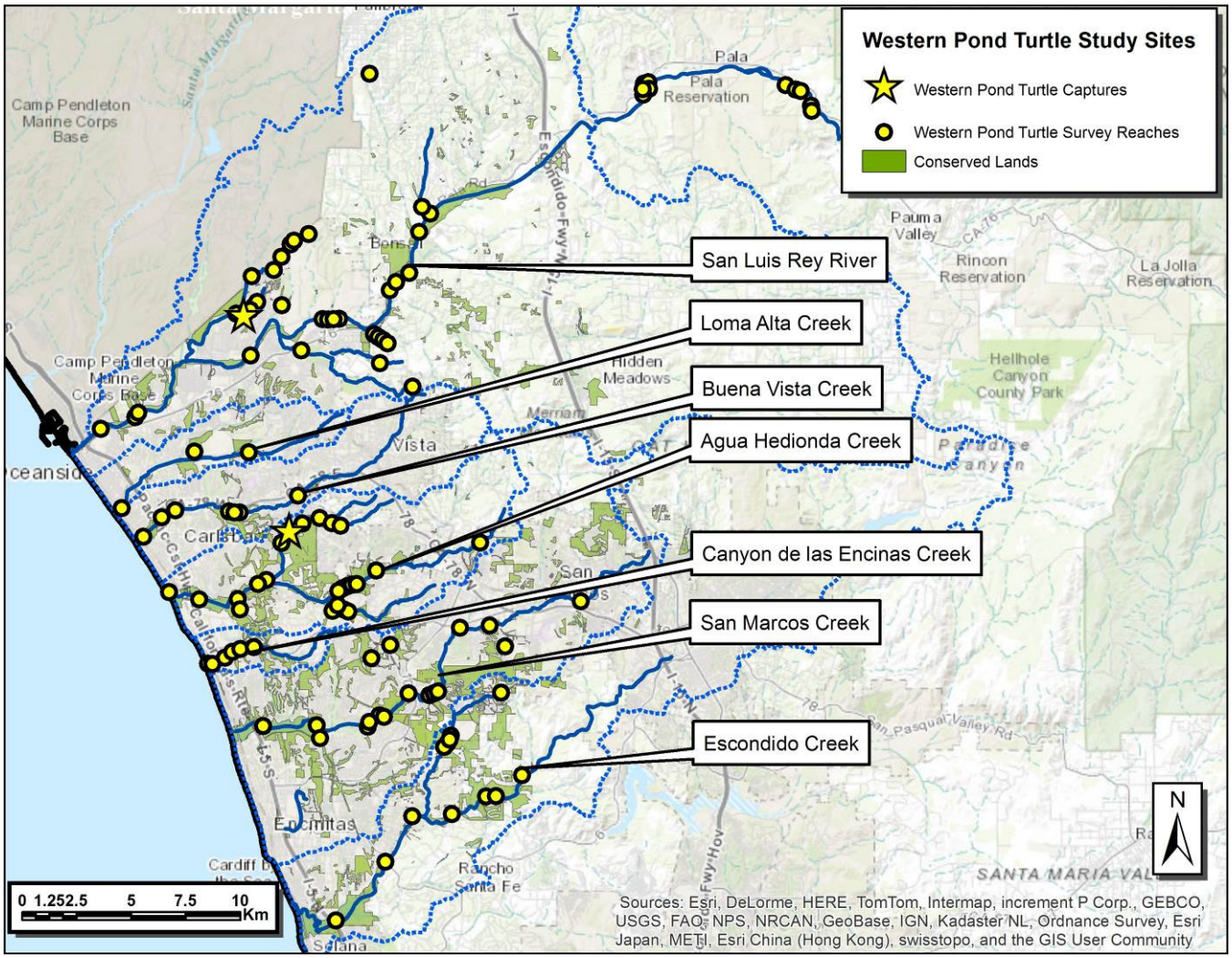

Figure 2. Map of potential habitat for pond turtles. Reaches surveyed for habitat suitability (118 total) within the seven watersheds in the study area, 2012-2014. Sites were divided into 250 m reaches. Larger study sites comprised more than one 250m reach and are represented by multiple survey reach locations. Study sites include conserved lands within the seven main coastal watersheds in northern San Diego County south of Marine Corps Base Camp Pendleton and north of the city of Solana Beach. Watersheds include the San Luis Rey River, Loma Alta Creek, Buena Vista Creek, Agua Hedionda Creek, Canyon de las Encinas Creek, San Marcos Creek and Escondido Creek. The two starred locations indicate where pond turtles were observed during the study.

Table 1. Watersheds from north to south with approximate area in hectares and percent conserved for the seven watersheds within the study area.

Watershed	Total Area (Ha)	Conserved Area (Ha)	Conserved (%)
San Luis Rey	45,686	1,653	4
Loma Alta Creek	2,540	165	6
Buena Vista Creek	5,842	200	3
Agua Hedionda Creek	7,623	1,466	19
Canyon de las Encinas Creek	3,434	82	2
San Marcos Creek	15,469	1,126	7
Escondido Creek	21,898	1,872	9

Site Descriptions

Below are brief discussions of each of the 62 sites surveyed, broken down by watershed and listed and described from north to south, including landowners and managers, approximate locations, habitat descriptions, and level of access/disturbance. Sites are included in the SANDAG Conserved Lands Database (SanGIS 2014), unless otherwise noted. Sites not included in the SANDAG Conserved Lands Database ((SanGIS 2014) were sites with public or quasi-public ownership that were identified as potentially suitable habitat during field reconnaissance but have non-conservation oriented management. These are mostly sites managed for recreation in or around riparian habitat, including local and regional parks. Site photographs are located in Appendix B (some sites do not have photographs).

San Luis Rey River Watershed

The San Luis Rey River winds through the northernmost region of our study area and is surrounded by development at the lower reaches and US Forest Service and tribal lands in the upper reaches with approximately 1,650 hectares conserved along the main stem and flowing tributaries (SanGIS 2014). In addition to sites along the main stem of the San Luis Rey River, we surveyed sites along the following tributaries: Los Jilgueros Creek, Pilgrim Creek, and Guajome Creek, as well as several off-channel ponds, for a total of 16 sites (Appendix A). Most of our surveys were conducted on conserved lands, however, lands not included in the SANDAG Conserved Lands Database (SanGIS 2014; water district property, regional park lands, etc.) were surveyed if they provided suitable habitat for pond turtles and access could be obtained. The open space land managers within the watershed are California Department of Fish and Wildlife (CDFW), California Department of Transportation (Caltrans), Center for Natural Lands Management (CNLM), City of Oceanside, County of San Diego, Fallbrook Land Conservancy, Pala Band of Mission Indians, San Diego Audubon Society, and residential homeowners associations (HOA's).

Wilderness Gardens Preserve

Wilderness Gardens Preserve is a San Diego County Park located along the main stem of the San Luis Rey River and downstream from Pauma Valley near the community of Pala. This section of the San

Luis Rey River is characterized by a sandy wash with seasonal flow of water. A permanent pond lies adjacent to the main stem of river, providing a year-round water source. Recreation is limited to hiking within the 6.4 kilometers of trails surrounding and bordering the San Luis Rey River.

Hanson Ponds

The Hanson Ponds are located along the main stem of the San Luis Rey River in the community of Pala and fall within the tribal lands of the Pala Band of Mission Indians. The ponds are the remains of a former sand and gravel mining operation conducted by Hanson Aggregates Pacific Southwest, Inc. Mining ceased within the last 13 years and over time the quarry pits have filled with sediments and become lined with dense riparian vegetation. The ponds provide a valuable year-round water source for wildlife. The ponds are not open to the public and access is restricted. At this time, the ponds are not included in the SANDAG Conserved Lands Database (SanGIS 2014).

San Luis Rey River Park

This San Diego County Park contains a large section of conserved riparian along the main stem of the San Luis Rey River. Part of this site is also owned and managed by Caltrans. Much of the riparian habitat consists of an ephemeral wash with a thick canopy. There is a large pond approximately 750m upstream from Camino del Rey which has water and structure sufficient enough for pond turtles. Public access and recreation are very high, and includes bicycling, camping, and paintball and archery target shooting in the riparian habitat.

San Luis Rey River Trail

This portion of the San Luis Rey River is owned by the City of Oceanside. Water in this section of the San Luis Rey River becomes more permanent below Whelan Lake and the confluence with Pilgrim Creek. The habitat is characterized by thick riparian vegetation, sandy banks and upland, and deep channels and pools. The canopy is thick over much of it, but with occasional sunny pools. This section of the creek was trapped by CDFW for USGS in 2010 (USGS, unpublished data) and only nonnative turtles, including red-eared sliders and spiny softshell turtles were captured.

Rosemary Mountain Quarry-North River Unit

This section of the San Luis Rey River is owned by Granite Construction and managed by CNLM. This site is located approximately three kilometers downstream from the Mission Road bridge and has been impacted historically by nonnative vegetation. It was undergoing active riparian restoration, including removal of nonnative vegetation and planting of native vegetation, at the time of the surveys. Water flow in this section is seasonal, and while the site may provide suitable habitat in the future, it was dry during all surveys for this project. The presence of large, damp, vegetation free depressions in the main channel indicate that the site has the potential to hold surface water in decent sized pools during wet years. Access to this site is restricted.

Los Jilgueros Preserve

Los Jilgueros Preserve is located in the heart of the city of Fallbrook and is owned by the Fallbrook Land Conservancy. Los Jilgueros Creek runs through the preserve and there are two larger permanent

ponds and a series of smaller, more ephemeral ponds that could provide adequate water and basking sites for pond turtles. This preserve is highly accessible and popular among walkers, joggers, birders and bikers. At this time, the preserve is not included in the SANDAG Conserved Lands Database (SanGIS 2014).

Wilmont Ranch/Morro Hills/Arrowhead Golf Course

The riparian habitats within Wilmont Ranch, Morro Hills and Arrowhead Gold Course are jointly managed by CNLM. These areas fall within the city of Oceanside and contain two small tributaries of Pilgrim Creek and the San Luis Rey River. These areas were characterized by ephemeral pools that had little to no pooling water. It was undergoing restoration at the time of the surveys, including removal of nonnative vegetation and planting of native riparian vegetation. Public access varies within these areas, but is mostly restricted.

Foss Lake Preserve, Pilgrim Creek Tributary

This tributary of Pilgrim Creek runs along the southern border of the Foss Lake Preserve in the city of Oceanside and is managed by CNLM. It is characterized as a narrow riparian corridor with small, permanent pools in the channel. The channel and associated pools are relatively well isolated and hidden along the bottom of a slope providing for very low access given the proximity to housing. The small permanent pools with excellent cover and structure currently support pond turtles and both male and female pond turtles have been observed. The nonnative red-eared sliders have also been found here, but in small numbers. Public access is not permitted in this area.

Foss Lake Preserve, Lake

Foss Lake Preserve is managed by CNLM and is located along a tributary of Pilgrim Creek in the City of Oceanside. Foss Lake is one of the only inland alkali marshes in San Diego County. The lake is a large (approximately 25.7 hectares), mostly permanent pool with a silt/mud shoreline and thick cattails. In fall of 2014, this pool dried down considerably and was too shallow to support pond turtles. Public access is not permitted in this area.

Pilgrim Creek Ecological Reserve

Pilgrim Creek Reserve is a CDFW reserve along Pilgrim Creek near Foss Lake Preserve in the City of Oceanside. During our surveys, this section of Pilgrim Creek was mostly dry with little to no suitable habitat for pond turtles. The reserve is open to the public for wildlife viewing.

Anstine-Audubon Preserve

This San Diego Audubon Society preserve is located along a tributary to Guajome Creek in the city of Vista and is surrounded by mixed land use including residential and nearby City and homeowners association open space. There is a large pond with adequate water and structure for basking and foraging for pond turtles. Habitat restoration is ongoing and many of the nonnative aquatic species have been removed, but some bullfrogs remain on site. Public access is limited to Saturdays, from October through June between 8:00 am until 12:00 pm.

Guajome County Park, Guajome Lake

This County Park, located in the city of Oceanside, contains Guajome Lake, a small lake maintained for recreation and a portion of intact riparian along Guajome Creek. The lake is home to a large number of nonnative aquatic species, including red-eared sliders, predatory fish, and bullfrogs and also supports a small population of pond turtles (Morrison et al. 1994; Silbernagel et al. 2012, 2013). The lake is adjacent to campgrounds and has high public access and heavy recreational usage. At this time, Guajome Lake is not part of the SANDAG Conserved Lands Database (SanGIS 2014).

Guajome County Park, Ponds

Within the County Park and adjacent to the lake, campground and recreation areas, ponded areas occur within thick willow scrub and cattail dominated riparian habitats. The ponds have much less available water than the main lake itself, but also have less access. Access is limited to a series of dirt paths that parallel the stream channel and cross only in four locations. At this time, Guajome County Park ponds are not part of the SANDAG Conserved Lands Database (SanGIS 2014).

Libby Lake Park

Libby Lake Park, located off of the main stem of the San Luis Rey River, is a recreational park for the City of Oceanside with high access and visitation. Much of the lake and surrounding park area are artificial with concrete shoreline, mowed lawns, and park benches. The northern end of the park contains some marshland with cattails that is adjacent to conserved coastal sage scrub. Libby Lake Park is not part of the SANDAG Conserved Lands Database (SanGIS 2014).

Talone Lake

This small lake off of the main stem of the San Luis Rey River is owned by Talone Conservancy Group and is bordered by Highway 76, Frazee Road, College Ave, and Town Center/Town Center Drive in the city of Oceanside. The nine hectare lake is surrounded by isolated wetland ponds and a series of artificial channels feed into the lake through large stands of dense cattails. Created by a natural depression in the land, the lake has filled in with sediments and dense riparian vegetation over the years. Although the area is closed to the public, there is a network of trails that run through the uplands at the west end of the property that are used frequently by trespassers. This property could not be trapped due to high public use of the site, but does contain more surface water than many other sites surveyed.

Santa Fe Pond

Privately owned and managed by the Vista Sandalwood Owners Association in the city of Vista, this pond is utilized for recreation by the residents of the Sandalwood community. Until recently, this pond was lined with thick vegetation including thick stands of cattails; however, the vegetation was removed in recent years to make improvements to the pond. Currently there are no aquatic or riparian refugia, but future management or restoration may allow for suitable habitat. This site is not part of the SANDAG Conserved Lands Database (SanGIS 2014).

Loma Alta Creek Watershed

The Loma Alta Creek watershed is mostly urban with approximately 165 hectares conserved along the main stem and flowing tributaries (SanGIS 2014). We surveyed two sites along the main stem of this drainage (Appendix A). The open space land managers within the watershed are CNLM, City of Oceanside, and North San Diego County Transit Development Board (NSDCTDB). Much of the public and quasi-public lands consist of recreational parks or drainage systems. The majority of the 11 kilometers of stream is lined with artificial paths (Carlsbad Watershed Network 2002).

Rancho del Oro Preserve

The Rancho del Oro Preserve, owned by NSDCTDB and managed by CNLM, is approximately 8 hectares of riparian habitat along Loma Alta Creek in the city of Oceanside. This isolated fragment is characterized by thick canopy riparian with consistent low flow and occasional shallow to medium pools. The preserve is currently closed to the public but still gets much foot traffic.

Loma Alta Slough

Loma Alta Creek flows into artificial drainages downstream from the Rancho del Oro Preserve and enters the Loma Alta Slough approximately 0.75 kilometer from the Pacific Ocean. The slough, a mostly freshwater marsh, has been heavily impacted historically and is opened to the ocean seasonally. It is owned and managed by City of Oceanside for water quality and recreation. The slough is heavily recreated for fishing, walking, biking, bird watching, picnicking. The Loma Alta Slough is not in the SANDAG Conserved Lands Database (SanGIS 2014).

Buena Vista Creek Watershed

The Buena Vista Creek watershed mouth is an open and recently restored estuary/lagoon and the creek stretches upstream through urban areas then water district and county open space with approximately 200 hectares conserved along the main stem and flowing tributaries (SanGIS 2014). We surveyed three sites along the main stem of this drainage (Appendix A). Most of the conserved riparian habitat in this watershed is owned by CDFW, the City of Vista is the other major landowner and private conserved lands make up approximately 10 hectares. Much of the upper portions of the creek have been modified, including lined and fully encased channels. The creek receives large inputs from urban and agricultural runoff and heavy sediment and nutrient loads (Carlsbad Watershed Network 2002). Due to streambed alterations, increased runoff, and increased sediment associated with the large amount of urbanization, the main creek channel largely consisted of shallow stream with constant flow.

Buena Vista Creek Channel

This channelized section of Buena Vista Creek is owned by the City of Vista and is located upstream from the Buena Vista Ecological Reserve. The creek channel is surrounded by urbanization and thus has constant flow and is highly sedimented from urban runoff. The creek channel is not designated for recreation, but the proximity to urbanization makes access moderate.

Buena Vista Creek Ecological Reserve

The best habitat observed on conserved lands in this watershed is within the CDFW owned and CNLM managed Buena Vista Creek Ecological Reserve. The 60 hectares reserve, located in the city of Carlsbad, includes Diegan coastal sage scrub, southern arroyo willow riparian forest, coastal and valley freshwater marsh, and nonnative grassland habitats. The reserve contains multiple deep pools along the stream, ample upland habitat, and two large off channel pools. Habitat restoration has been ongoing. Recreation at the reserve is limited to wildlife viewing and site access is moderate.

Buena Vista Lagoon Ecological Reserve

This 80 hectares reserve owned by CDFW is located in the cities of Carlsbad and Oceanside. The reserve is mostly coastal freshwater lagoon habitat that is highly suitable for pond turtles. Public access and recreation, mostly hiking and fishing, is very high and major roads surround and pass through the lagoon.

Agua Hedionda Creek Watershed

Agua Hedionda is the third largest watershed in the study area with approximately 7,600 hectares. The Agua Hedionda Creek mouth is an open estuary/lagoon similar to Buena Vista Creek and the creek stretches upstream through urban areas then water district and county open space with approximately 1,466 hectares conserved along the main stem and flowing tributaries (SanGIS 2014). In addition to sites along the main stem of Agua Hedionda Creek, we surveyed sites along Calavera Creek and several unnamed tributaries, for a total of 12 sites (Appendix A). Agua Hedionda contains the largest percentage (19%) of its riparian habitat conserved relative to the other six watersheds examined in this study. Even with this high degree of conservation, fragmentation, sedimentation, and invasive species are continuing threats to the watershed. Most of the open space land managers of this watershed are water districts, University of California San Diego, San Diego County, CNLM, CDFW, and the cities of Carlsbad, San Marcos and Escondido.

North Las Posas Pond

Near the top of Agua Hedionda Creek in the City of San Marcos, this pond is owned and managed by Vista San Marcos Ltd. This moderate-sized pond is lined with bulrush and cattails and surrounded by disturbed coastal sage scrub. Public access is high and during wet years the pond supports recreational fishing, however, the pond was completely dried during our surveys. At this time, the pond is not part of the SANDAG Conserved Lands Database (SanGIS 2014).

Las Posas Pond

This lower pond along Agua Hedionda Creek is a recreational pond managed by the Rancho Santalina Homeowners Association in the city of San Marcos. This moderate-sized pond is lined with bulrush and cattails and is surrounded by disturbed coastal sage scrub. The pond usually stays wet and provides the basking and foraging habitat necessary for pond turtles; however, there is heavy recreational use of the area. At this time, the pond is not part of the SANDAG Conserved Lands Database (SanGIS 2014).

Dawson Los Monos Reserve

Dawson Los Monos Reserve is owned and managed by the University of California San Diego Natural Reserve System and is located in the city of Vista. Here, Agua Hedionda Creek flows under a canopy of sycamores, oaks and willows that opens up over large boulder strewn pools. There is permanent water, a large number of deep pools, structure for basking, and extensive upland habitat. Public access is limited.

Buena Vista Pond

Buena Vista Pond, located in Buena Vista Park in the City of Vista, is an artificial recreational pond along a small tributary of Agua Hedionda Creek. It is located near conserved lands owned by City of Vista and neighboring homeowners associations. The cattail lined pond has permanent water and has heavy recreational use. At this time, the pond is not part of the SANDAG Conserved Lands Database (SanGIS 2014).

Village Pond

This small, roadside pond in the Agua Hedionda drainage is located in the City of Carlsbad. It is owned by the Calavera Hills Homeowners Association, but managed by CNLM. This site contains a small patch of oak scrub at the base of a coastal sage scrub hillside. The pond receives runoff from the hillside and adjacent residential area and irrigation. The pond is very close to main roads, but access is restricted. The pond dried during our study.

Agua Hedionda Creek Mouth

This section of Agua Hedionda Creek is located in the city of Carlsbad and is owned by San Diego Gas and Electric (SDGE). It consists of coastal sage scrub uplands with some riparian along the creek as it flows into Agua Hedionda Lagoon. During our surveys, the riparian was dry excepting tidal influences. Public access to the site is moderate.

Agua Hedionda Lagoon

The Agua Hedionda Lagoon, located in the city of Carlsbad, is owned and managed as conserved land by SDGE and CDFW. There are nearly 80 hectares of riparian and marsh, with most of the suitable habitat falling within the CDFW Agua Hedionda Lagoon Ecological Reserve. Through the reserve, Agua Hedionda Creek has predominately silt or sand bottom and banks with the upper 1 kilometer of stream meandering through dense riparian with few pools but good structure and the lower 0.5 kilometers of stream has a much more stable, silted channel offering less structure for pond turtles. While major roads are nearby, human access is low.

Upper Calavera Creek

This site, located in the cities of Carlsbad and Oceanside, consists of approximately 1.3 kilometers of Calavera Creek riparian habitat upstream from Lake Calavera. The conserved riparian is owned by either City of Carlsbad (managed by CNLM) or City of Oceanside. Calavera Creek meanders through nearly 75 hectares of conserved riparian with urban residential development on three sides, then drains

into a marsh at the northeast end of the lake. The creek has a mixed canopy, scattered deep pools, and ample structure for basking. There is little public access at the site.

Lake Calavera Preserve

Lake Calavera is located in the middle of the nearly 35 hectares Lake Calavera Preserve owned by City of Carlsbad. Lake Calavera is a reservoir that provides recreation and fishing for the surrounding community, and thus human access to the site is high. The western half of the reservoir, with the dam, is heavily impacted by recreation with picnicking, bathing, and fishing along the shorelines. The eastern half of the reservoir provides much more structure with more emergent vegetation and channels through shallow marsh where the creek flows into the reservoir.

Carlsbad Oaks Preserve, Faraday Pond

Faraday Pond is located in the CNLM Carlsbad Oaks Preserve in the city of Carlsbad. The approximately 30m diameter pond is located on a slope above an ephemeral tributary to Agua Hedionda Creek and is shown as a spring on the San Luis Rey, CA USGS Topographic Quadrangle 7.5 minute series (USGS 1997). Although there is little connectivity to Agua Hedionda Creek, this pond has sufficient water, ample structure for foraging and basking, and managed upland habitat. Public access to the pond is restricted.

Carlsbad Oaks Preserve, Agua Hedionda Creek Tributary

This tributary to Agua Hedionda Creek runs 6 kilometers through nearly 160 hectares of conserved lands managed by CNLM as part of the Carlsbad Oaks Preserve in the City of Vista. The habitat is a mix of chaparral, sage scrub, and riparian. Major roads bisect the stream in three locations, with the upper half of the tributary being isolated and dry during our surveys. The lower section of the tributary, managed by CNLM, has low access, more natural riparian, but lacked the pooling water suitable for pond turtles that was found in the adjacent Dawson Los Monos Preserve. Public access to this area is restricted.

Agua Hedionda Creek Falls

This site is a series of exposed bedrock pools along a tributary to Agua Hedionda Creek in conserved lands within the footprint of the City of Carlsbad Municipal Golf Course (The Crossings) owned by City of Carlsbad and managed by CNLM. Historically holding water, this site was dry during our surveys. Despite being next to a golf course, there is little public access to this area.

Canyon de las Encinas Creek Watershed

The Canyon de las Encinas Creek watershed is a small, mostly urban, watershed with approximately 82 hectares conserved (SanGIS 2014). In addition to the main channel of the creek, we surveyed three artificial impoundments along the upper portion of the creek, for a total of five sites (Appendix A). Most of the open space land managers are homeowners associations, private landowners, or CNLM. (CWN 2002).

Palomar Oaks Pond

This highly modified natural pond off of Canyon de las Encinas Creek is located in the Palomar Oaks Business Park in the City of Carlsbad and is part of the conserved lands managed by the Palomar Oaks Business Center Association. The pond borders the business park to the east and a roadway to the west and only a few small pooling areas exist along Palomar Airport Road. The upland habitat to the south of the pond is intact, but the pond is managed for aesthetics and recreation, providing trails and picnic benches. Public access is high due to the location and nature of the pond.

Upper Canyon de las Encinas Creek

West of the Palomar Oaks pond, Canyon de las Encinas Creek runs through conserved land managed by the Mar Brisa Homeowners Association in the City of Carlsbad. The creek in this area is characterized by thick riparian and shallow flow. The creek runs along a main thoroughfare, Palomar Airport Road, and although not designated for recreation, public access is moderate.

Lower Canyon de las Encinas Creek

Downstream from the Mar Brisa Homeowners Association land and West of Hidden Valley Road, Canyon de las Encinas Creek runs through a mitigation bank managed by CNLM in the city of Carlsbad. The riparian along this section has two small pools that hold enough water to sustain pond turtles. Along this section, the creek also runs along Palomar Airport Road and public access is moderate although it's not designated for recreation.

Canyon de las Encinas Palms

West of the CNLM managed property, Canyon de las Encinas Creek runs through conserved lands owned and managed by Costco Wholesale Corporation in the City of Carlsbad. This highly disturbed riparian and adjacent upland has ongoing restoration efforts, but the stream channel is still heavily silted, very few pools exist and those present are small and lack permanent water. Although the creek in this area is not designated for recreation, public access is high.

Canyon de las Encinas Marsh

This section of Canyon de las Encinas Creek, located between Avenida Encinas and Carlsbad Blvd in the City of Carlsbad, contains freshwater marsh habitat owned by NSDCTDB and private landowners. Not included in the SANDAG Conserved Lands Database (SanGIS 2014), this habitat has clear, fresh flowing water and good structure for basking. Access is high and there are major roads on either side.

San Marcos Creek Watershed

The San Marcos Creek watershed is the third largest watershed in the study area at approximately 15,500 hectares with approximately 1,126 hectares conserved along the main stem and flowing tributaries (SanGIS 2014). In addition to sites along the main stem of San Marcos Creek, we surveyed sites along the following tributaries: an unnamed tributary that runs through Carrillo Ranch and the community of Rancho Carrillo and Cottonwood Creek, as well as two off-channel ponds, for a total of 16 sites (Appendix A). The open space land managers include CNLM, CDFW, and the City of San

Marcos. Lake San Marcos is a private, recreational lake near the middle of the watershed. Above the lake, upper San Marcos Creek has very little associated conserved land (less than 50 hectares along the stream). Below the lake, CNLM manages over 5 kilometers of stream with lush riparian, large boulder strewn pools, and restricted access before the creek enters the La Costa Resort and Spa. The creek then enters Batiquitos Lagoon with over 50 hectares of mixed freshwater and brackish marsh. The tributary of Cottonwood Creek runs through the city of Encinitas and discharges into the Pacific Ocean at Moonlight State Beach through a storm drain and hence is often referred to as its own watershed as opposed to part of the San Marcos Creek watershed (CWN 2002). Similar to the San Luis Rey River, there are several large off channel ponds in the San Marcos Creek watershed which are highly modified or completely artificial and are isolated from the riparian habitat of the river or its tributaries.

Jacks Pond

Isolated from the San Marcos Creek main channel by Highway 78 and residential communities, Jacks Pond is a recreational pond located in a City of San Marcos park. The pond is bordered with dense stands of cattails and bulrush and is surrounded by conserved coastal sage scrub and mixed riparian habitat. Managed for recreation and conservation, public access at this site is high.

San Marcos Creek Ponds I

These ponds fall within conserved lands in upper San Marcos Creek and are owned and managed by the City of San Marcos. These small parcels have sage scrub uplands with patchy riparian which was dry during our survey visits. Access to the ponds is moderate.

San Marcos Creek Ponds II

This section of riparian habitat along the upper portion of San Marcos Creek is owned and managed by City of San Marcos, but is not yet conserved. This parcel is mostly sage scrub uplands with willow scrub riparian running through it. The channel has thick cattails and pampas grass. This area has potential to hold water in wet years, but was dry during our survey visits. Access to the ponds is moderate

Upper San Marcos Creek

This section of San Marcos Creek runs between a private golf course and San Marcos High School and is above and adjacent to Lake San Marcos in the City of San Marcos. It's privately owned and managed by the Citizen's Development Corporation for recreation of the residents of Lake San Marcos and is not in the SANDAG Conserved Lands Database (SanGIS 2014). The creek and has dense riparian vegetation and permanent water flow, mostly from urban runoff. The area is heavily recreated.

Lake San Marcos

Lake San Marcos is an artificial lake located in the City of San Marcos. It is also privately owned and managed by the Citizen's Development Corporation for recreational purposes, mainly boating and fishing, and is not in the SANDAG Conserved Lands Database (SanGIS 2014). There is little riparian habitat along the shoreline, except in the lower portion of the lake above the dam. The lake and surrounding area is heavily recreated.

Rancho La Costa Preserve, San Marcos Creek Quarry

This former quarry near the communities of San Elijo Hills and Old Creek Ranch in the City of San Marcos is now owned and managed by CNLM as part of the Rancho La Costa Preserve. With abundant sage scrub upland, the riparian area is being restored to willow/sycamore riparian and has many large boulder lined pools. There are nearby hiking trails for the neighboring communities and access to the site still remains moderate even though there is active habitat restoration and CNLM is trying to prevent human disturbance to the riparian habitat.

Rancho La Costa Preserve, Middle San Marcos Creek

Downstream from the quarry site, this portion of stream is also part of the Rancho La Costa Preserve that is owned and managed by CNLM. It runs mostly through the city of Carlsbad near the community of La Costa Oaks. Here the creek is mostly shallow with a silt and sand bottom, dense riparian vegetation and mostly coastal sage scrub uplands. There are nearby hiking trails for the neighboring communities, but access to the site still remains moderate.

Rancho La Costa Preserve, Box Canyon

This large section of San Marcos Creek is also part of the Rancho La Costa Preserve in the city of Carlsbad and is owned and managed by CNLM. Here the habitat is considered valley foothill riparian. The stream is lined with boulders and bedrock and has many sunny pools and suitable structure for basking and hiding. Access to this area is restricted.

Rancho La Costa Preserve, Lower San Marcos Creek

This small section of San Marcos Creek, between Box Canyon and the La Costa Resort and Spa in the city of Carlsbad, is also part of the Rancho La Costa Preserve and is owned and managed by CNLM. Habitat in this section is similar to that of Box Canyon. Access to this area is restricted

Batiquitos Lagoon Ecological Reserve

Batiquitos Lagoon Ecological Reserve, located in the cities of Carlsbad and Encinitas, is owned and managed by the California Department of Fish and Wildlife as a nature reserve and a designated Marine Protected Area. Before opening up into the lagoon, San Marcos creek is a fast flowing, low gradient, shallow wash with few pools. Brackish emergent marsh exists where San Marcos Creek and Encinitas Creek enter the lagoon and there is some suitable structure along the edge of the marsh, but the freshwater habitat is limited. Access by to this area of the lagoon is moderate.

Carrillo Ranch

The Carrillo Ranch site is owned and managed by CNLM and borders Leo Carrillo Ranch Historic Park in the City of Carlsbad. An unnamed tributary of San Marcos Creek runs through the site and consists of ephemeral to dry willow scrub habitat surrounded by coastal sage scrub uplands. While dry during our surveys, some depressions without vegetation existed along the stream channel indicating the potential for pooling water in wetter years. Although in close proximity to Leo Carrillo Ranch Historic Park, public access to the site is only moderate.

Rancho Carrillo

The Rancho Carrillo open space is located in the City of Carlsbad, directly downstream from CNLM's Carrillo Ranch, and is managed by the Rancho Carrillo Homeowners Association. Vegetation in the open space includes riparian woodland, freshwater marsh, Baccharis scrub, and nonnative grasslands. There is a large permanent pool that appears to be fed by the groundwater. Although designated for recreation for the community of Rancho Carrillo, public access to the site is only moderate.

Cottonwood Creek Park

Cottonwood Creek Park is managed by the City of Encinitas as a recreational park. Cottonwood Creek runs along the edge of the park and the only pooling water is an artificial pond created by the storm drain system. The pond is mostly lined with willows, cottonwoods, and sycamores, and the creek leading into the pond is full of cattails with some shallow running water. There is high recreational use of the pond and surrounding park.

Moonlight State Beach

Moonlight State Beach is owned by the State of California and managed by the City of Encinitas. Here, Cottonwood Creek runs through the surrounding park and beach, and then discharges into the Pacific Ocean. The only pooling water on the property is two ponds artificially created by the storm drain system. A trail passes by the larger, willow-lined upper pond and the lower pond is mostly open with some bulrush and nonnative vegetation along the edges. The creek between the ponds is narrow with shallow flowing water. Due to the popularity of this beach, access to the ponds is considered high.

Discovery Lake Park

Discovery Lake Park is a recreational park for the City of San Marcos with easy access and heavy recreational use. The lake is managed as a catch and release bass fishery and is surrounded by hiking trails. While natural riparian and coastal sage scrub habitat remains on site, much of the area has been planted with nonnative trees and shrubs for aesthetics and recreation. A paved trail surrounds the lake and connects with urban and soft-surface trails that connect the adjacent residential area with the coastal sage scrub and chaparral covered uplands surrounding the lake. There are abundant basking areas and refugia.

South Lake

South Lake is an earthen dammed reservoir owned by Vallecitos Water District that has been leased to the City of San Marcos to be developed into a recreational park including fishing, boat rentals, picnic areas, a playground and developed trails. Similar to Discovery Lake, South Lake supports a bass fishery, is lined with natural riparian, and is surrounded by coastal sage scrub uplands. At this time access is still limited.

Escondido Creek Watershed

Escondido Creek is the second largest watershed in the study area and largest in the Carlsbad Hydrologic Unit. The watershed is approximately 22,000 hectares with approximately 1,872 hectares

conserved along the main stem and flowing tributaries (SanGIS 2014). In addition to sites along the main stem of Escondido Creek, we surveyed along Copper Creek, a tributary of Escondido Creek, for a total of 8 sites (Appendix A).Open space land managers include Olivenhein Municipal Water District, San Diego County, CNLM, Escondido Creek Conservancy (ECC), CDFW, and Cities of San Diego and Escondido. There has been ongoing restoration of the creek by the Escondido Creek Conservancy. The creek provides ample upland, large, deep permanent pools, and good structure for basking and hiding.

Harmony Grove

This section of Escondido Creek is located in the community of Harmony Grove in the City of Escondido and is owned and managed by ECC. This section of low gradient, wide, boulder lined stream has a relatively closed canopy of sycamore with scattered openings of sunlight to enter for basking. However, these open areas also supported historical recreational use and there were signs of past picnicking and fishing. Even though the creek parallels the main road for the adjacent community, under current management by ECC, recreation appears to be limited to established trails nearby and there were no visible signs of recent recreational impacts.

Elfin Glen

Downstream from Harmony Grove site, the Elfin Glen site is located off of Elfin Glen Road in the community of Elfin Forest in the City of Escondido and is owned and managed by ECC. This section of the creek contains more heterogeneous riparian habitat with more large, sunlit pools and opportunities for basking. This stretch of stream is also more isolated from the main roads and the only access is through a small network of trails that cross the stream in a few locations, but mostly stay away from the main watercourse, keeping access low.

Wildflower Estates

This section of Escondido Creek is located in the City of Encinitas near the Wildflower Estates community and is owned and managed by ECC. The site was restored approximately 10 years ago, with hopes of creating more pond turtle habitat and now has more open pooling. There is a network of trails surrounding the creek, but access appears to remain low.

Little Oaks

This section of Escondido Creek borders the Little Oaks Equestrian Park in the City of Encinitas and is jointly managed by City of Encinitas and the San Elijo Lagoon Conservancy. Here the stream is shallow and silt lined under a thick canopy of willow and sycamore with some off channel open pooling surrounded by cattails. In wetter years, water can fill the pools and provide structure and foraging and basking habitat. During this study, the pools were dry or too shallow. Access to this site is high.

Lower Escondido Creek

This section of Escondido Creek is downstream from the Little Oaks site and is owned and managed by the San Elijo Lagoon Conservancy. This reach is characterized by sycamore/willow riparian, a shallow, sand/silt braided stream channel with wide sandy benches, and a dense canopy. During our surveys, this

area contained little to no water with only a few muddy pools remaining. Access to this site is moderate.

El Mirlo Ponds

The section of Escondido Creek, located near El Mirlo Road in the city of Encinitas, has mixed private and conserved ownership. It contains open, pooling areas that have the potential to support pond turtles. The largest, most permanent pond, is an off channel pool that has recently changed ownership and become part of County of San Diego's Escondido Creek Preserve. Historically, this pond had high access, but as the management of the property has changed, access to this section of the creek has decreased. Other ponds in this area are on private property and access is low.

San Elijo Lagoon Ecological Reserve

San Elijo Lagoon Ecological Reserve, located in the city of Encinitas, is owned and managed by the California Department of Fish and Wildlife as a nature reserve and a designated Marine Protected Area. By the time Escondido Creek approaches the San Elijo Lagoon, it becomes eutrophic and full of sediments, largely from urban runoff and nearby agricultural use (CWN 2002). Most of the channel lacks structure for pond turtles, with the only habitat for basking and hiding being the emergent vegetation along the large pools near the nature center. This area is heavily recreated, mostly by hikers, joggers and bird watchers.

Copper Creek

Copper Creek, a tributary of Escondido Creek, runs downstream from the recently closed and restored San Marcos Landfill through the cities of San Marcos, Carlsbad, and Encinitas, until it reaches Escondido Creek. The creek flows through mostly conserved land owned and managed by CNLM and a segment falls within the Rancho La Costa Habitat Conservation Area. Most of the creek is surrounded by large, intact sage scrub uplands. The creek channel goes from modified and restored at the upper end to a more natural state at the lower portion of the reserve with several bedrock pools, an open canopy, and good structure for foraging and basking. The creek eventually flows onto private lands and drains into Escondido Creek. The remoteness of much of this drainage keeps public access low.

Methods

Following the USGS aquatic species and habitat assessment protocols for the south coast region (USGS 2006a, 2006b), the coastal drainages of northern San Diego County were mapped and divided into 250 meter survey segments. Ponding areas outside of the stream channels were also mapped using areal imagery, historic data, previous surveys, and topographic maps. These features were combined with parcel information from the SANDAG Conserved Lands Database (SanGIS 2014), the Center for Natural Lands Management's Consolidated Preserve Boundaries, and parcel maps for the County of San Diego to identify suitable aquatic habitat within conserved, public and quasi-public lands.

These features were assessed in the field for potential suitability for pond turtle trapping. Aquatic species observations and water and habitat characteristics were recorded electronically utilizing the USGS aquatic species protocols and forms and were entered into the USGS Multi-Taxa database server.

Date, time, location, species, and age class were recorded for all aquatic animals observed. Water conditions, native and nonnative vegetation, and stream morphology were also collected to identify potential pond turtle habitat and trapping locations.

Visual Surveys

Visual surveys were conducted at most sites to determine whether a site was potentially suitable for pond turtles, to visually search for turtles, to make a qualitative assessment of habitat quality, and to determine whether a site was trappable for pond turtles. Pond turtles are habitat generalists and can occupy a wide range of aquatic habitats, thus the most limiting factor of habitat suitability is the presence of water. Therefore, the only criterion that was used to determine whether a site had potential for pond turtles was whether there was slow moving, pooled water (Holland 1991; Jennings & Hayes 1994; Reese 1996). In addition, for a site to be considered trappable there had to be water at least 0.25 meter deep which is the minimum depth required to effectively use our smallest trap. After sites were determined to be trappable, trapping surveys were then prioritized based on the extent of potentially suitable habitat at a site and the presence of pond turtles (if known). If it could be determined a priori that potential habitat existed and a site was trappable, as was the case for some reservoirs, the visual assessment stage was skipped and a site was elevated to the trapping phase. However, when opportunities to preview the site before trapping were available, visual surveys were usually conducted to plan trap placement for subsequent trapping surveys and to search for turtles. During all visual surveys the aquatic habitats were searched, with and without binoculars, for the presence of basking or underwater pond turtles.

Two types of visual surveys were conducted, visual encounter surveys and reconnaissance surveys. Visual encounter surveys were more intensive and entailed walking an entire riparian reach in search of pond turtles, potential pond turtle habitat and trapping locations. Reconnaissance surveys were less intensive and were conducted when a full visual assessment was either not necessary or not possible. Reasons for conducting a reconnaissance survey rather than a visual encounter survey include the presence of water was known (e.g., reservoirs and ponds), access for trapping surveys was known, and in rare instances, suitability of a site could be ruled out for pond turtles without conducting a full visual assessment. Reconnaissance surveys were also conducted when it was determined upon arrival to a site that there was no aquatic habitat in the portion of land to be surveyed, as this was not always apparent through maps because of uncertainty of property boundaries. In other instances, safety concerns (e.g., homeless camps, dangerous terrain) precluded a full visual assessment from being conducted. Additionally, at the end of the study with future pond turtle studies in mind, reconnaissance surveys were conducted in some drainages within the study area to determine whether potentially suitable habitat existed and whether water was present.

Since 2012 and 2013 were below normal rainfall years, some sites failed to meet the basic criteria of potential pond turtle habitat (the presence of water), some sites did not have water deep enough for trapping, and some sites were given a lower priority for trapping because the potential habitat was very limited (i.e., only one or two isolated pools of water existed and no turtles were observed during visual survey). Pond turtles will usually remain in the water until it disappears (B. Bury, personal communication, 2002), so if pond turtles were concentrated in these small pools of water, there would have been reasonable opportunity to detect them when the sites were visited. At the sites assigned low priority for trapping due to limited aquatic habitat, pond turtles were not observed during visual surveys.

The length of time a pond turtle can survive in the upland habitats without water is not known, therefore some of the sites determined to be low priority in 2012 were revisited in 2013 to determine if there was enough precipitation to create more suitable habitat. All resurveyed sites deemed unsuitable in 2012 were also found unsuitable in 2013 due to dry conditions from low rainfall and the failure to detect pond turtles.

In addition to deeming a site potentially suitable or not suitable based on the presence of water, a qualitative habitat assessment was conducted at most sites. The data collected during the habitat assessment were later used to rank the quality of the habitat. The habitat assessment was usually done on the first visit during a visual encounter or reconnaissance survey and included collection of data on characteristics associated with the presence of pond turtles, including water feature type, estimates of water feature size and flow, presence of pond turtle habitat characteristics (e.g., basking sites, upland nesting habitat), estimates of vegetation cover, general riparian species composition, upland habitat types, presence of nonnative plant species, possible impacts observed and global positioning system (GPS) locations of water features (e.g., pools, ponds) and possible trap locations.

Habitat Quality Rating

Based on literature (Bury 1972; Holland 1991; Jennings & Hayes 1994; Reese 1996; Reese & Welsh 1998; Hays et al. 1999), in addition to the presence of deep pools and slow moving water, the following general characteristics are associated with pond turtle habitat: 1) basking sites, 2) aquatic refugia, 3) streamside refugia and 4) upland nesting habitat. During habitat assessment each of these characteristics was evaluated for the overall site. These values were recorded as “None”, “Few” or “Many” and later during analysis the qualitative descriptions were given a numeric value: None = 0, Few = 1, and Many = 2. The values for each of these four characteristics were then tallied (ranging from 0-8) and sites were given a habitat quality rating according to the following scoring system: “High” = 7- 8, “Good” = 5-6, “Marginal” = 3-4, and “Poor” = 0-2. In addition, a site was automatically ranked as “Poor” if water was not present or water 0.5 meter or deeper was not present. Pond turtles require some deep water (> 1 m) and 2012 through 2014 were low rainfall years, thus it was assumed that during wetter years, pools that were > 0.5 meter during this study would be sufficiently deep for pond turtles under normal rainfall conditions and due to limited resources (e.g., water), pond turtles may be confined to the deepest pools available. Some level of water permanency is most likely necessary for southern California pond turtles to persist under extended drought conditions, but this and the amount of time that pond turtles can withstand drought by aestivating in the uplands is poorly understood and requires further study. Pond turtles are habitat generalists, thus these ratings only represent the potential for suitable pond turtle habitat and pond turtle occupancy and cannot be used as definite indicators of pond turtle presence or absence from a site. Additionally, these quality ratings are based solely on habitat characteristics and do not take into consideration threats or disturbances that may render the site less suitable for pond turtles overall.

Level of Human Access and Naturalness of Sites

In addition to the qualitative habitat assessment and habitat quality rating, sites were ranked according to the level of human access they receive and according to their level of naturalness following Madden-Smith et al. 2005. The ratings of human access and naturalness were done to assess potential for pond turtle suitability according to the following conditions:

1. As the level of human access increases and the level of naturalness decreases, the likelihood of pond turtles being present decreases.
2. The opposite is true for nonnative turtles. As the level of human access increases and the level of naturalness decreases, the likelihood of nonnative turtles being present increases.

Pond turtles are found to be more abundant where habitat is less disturbed and less human contact occurs due to decreased chance of collection, killing, disturbance (including disturbance of nesting females or nest sites), introduction of nonnative species, predation by scavengers (e.g., opossums, skunks, raccoons, and dogs), etc. Nonnative turtles are found to be more abundant in more urbanized and/or heavily recreated areas due to the increased likelihood of unwanted pet turtles being released and because modified or artificial systems tend to be located in more urbanized areas.

The level of human access at a site was categorized as high, moderate and low according to the following criteria and did not take into consideration human disturbance or pressures outside of the individual study sites:

Low: Remote sites or sites with restricted or limited access (e.g., wilderness area, ecological reserve).

Moderate: Sites with restricted or limited access, but with a moderate frequency of trespassing (e.g., private reservoirs), sites with access less restricted (e.g., CDFW Wildlife Area) or sites with only limited restrictions on access that have only moderate use (e.g., parks imbedded in low density housing, parks in a developing area with only moderate use at this time).

High: Sites with few restrictions on access, usually designated recreational areas (e.g., fishing/boating reservoirs, parks imbedded in high density housing, designated recreational areas).

The level of site naturalness, the amount of natural or fairly undisturbed wetland habitat, was categorized as natural, modified natural, or artificial according to the following criteria and did not take into consideration the habitat quality or pressures outside of the individual study sites:

Natural: Sites with 10% or less modification of the natural habitat (e.g., mostly natural river or stream channel).

Modified Natural: Sites with greater than 10% artificial modification of the natural habitat (e.g., dammed or channelized river or stream).

Artificial: Sites that were completely artificial and occur outside of a natural channel or wetland (e.g., artificial ponds in a park setting, agricultural ponds).

Trapping Surveys

If a site was considered potentially suitable and trappable during a visual survey, surveys using baited traps were conducted in attempt to capture pond turtles. Because pond turtles are habitat generalists and the habitat quality ratings only represent the potential for suitable pond turtle habitat and pond turtle presence, a site was considered potentially suitable for trapping solely on the presence of water deep enough to set traps. Pond turtles were captured using commercial turtle traps baited with canned sardines (Holland 1994; Reese 1996; Ashton et al. 2001; Lovich & Meyer 2002; Rathbun et al. 2002).

Traps were set parallel to shore in most cases and anchored to shore with a rope (tied to the center top of the trap) so that the traps did not drift or sink. The top of the traps were raised above the water's surface with floats to allow captured turtles (and other animals) to surface for air. The traps were baited with punctured cans of fish which prevented consumption by the turtles; the bait simply served as an attractant to the trap. Baited traps were set for 2-4 days and were checked daily to remove any captured animals.

Each new pond turtle captured was sexed, measured, tissue-sampled (for genetics), and marked. Sex was determined based on morphological traits (Holland 1991). Before being released, all females were palpated to determine the presence of shelled eggs. Measurements included weight, carapace length, carapace width, carapace height, and plastron length. Upon initial capture, a small (approximately 3-5mm) tail-tip tissue sample of each turtle was collected and stored in 95% ethanol. Tail tips were not taken from animals with damaged tail tips. Pond turtle tissue samples are being collected for future pond turtle genetics studies. All turtles were tagged with an AVID passive integrated transponder (PIT) tag (encoded with a unique identification number) and marked with a single triangular notch on the right femoral scute to indicate that the turtle had been PIT tagged. The PIT tag was inserted inside the body cavity anterior to the rear right leg and the notch was made with a small triangular file following methods of Rathbun et al. (1993) and Buhlmann and Tuberville (1998). Both methods will assist in future recognition of the individual. Pond turtles were released near the point of capture immediately following processing, usually within 15 minutes of capture. If multiple turtles were captured at the same time, turtles were placed in a bucket containing water in the shade until they could be processed. All captured nonnative turtles were processed similarly to the pond turtles except they were not implanted with a PIT tag nor were they released. All nonnative turtles removed from the wild went to the San Diego Turtle and Tortoise Society to be adopted by members of the society. All turtle and other animal species observed on visual, reconnaissance, and trapping surveys were recorded and are included in the results. Most sites were only trapped once.

Results

Visual Surveys

A total of 118 visual surveys were conducted at the 62 sites during the summer and fall of 2012, the winter of 2013, and the summer and fall of 2014 (Appendix C). Some sites were visually surveyed more than once, in most cases to determine if sites deemed unsuitable to trap in 2012 had improved in 2013 or 2014. At the time of our initial surveys, 48 sites had surface water and out of those, only 43 sites had pooling water adequate to support pond turtles (Appendix A). Of the 43 sites found to have adequate pooling habitat (water $\leq$ 0.5m), 11 were in the San Luis Rey River watershed, 7 were in the Loma Alta Creek watershed, 2 were in the Canyon de las Encinas Creek watershed, 4 were in the Agua Hedionda Creek watershed, 13 were in the San Marcos Creek watershed, and 6 were in the Escondido Creek watershed (Appendix A).

One pond turtle was visually detected at the Foss Lake Preserve along the Pilgrim Creek tributary during trapping surveys. No other pond turtles were visually detected. The only other native species observed was Pacific tree frog (*Pseudacris regilla*). In spite of low water levels, many nonnative aquatic species were also observed during visual surveys, including crayfish (*Procambarus* spp.), sunfish (*Lepomis*

spp.), American bullfrogs (*Lithobates catesbeianus*) and red-eared sliders (*Trachemys scripta*) (Appendix A).

Habitat Quality Rating

Habitat suitability was assessed at 60 of the 62 sites during visual surveys (Appendix A; Figure 3). Sites were ranked based on the presence of habitat characteristics associated with pond turtle presence and the presence of slow moving, pooled water. Fourteen sites were ranked as *high quality*, 17 sites were ranked as *good quality*, 10 sites were ranked as *marginal quality*, 19 sites were ranked as *poor quality*, and 2 sites were not given a habitat quality rating (North Las Posas Pond and Talone Lake). North Las Posas Pond was completely dry and filled with sediment and we were unable to obtain access to Talone Lake for the duration of the study.

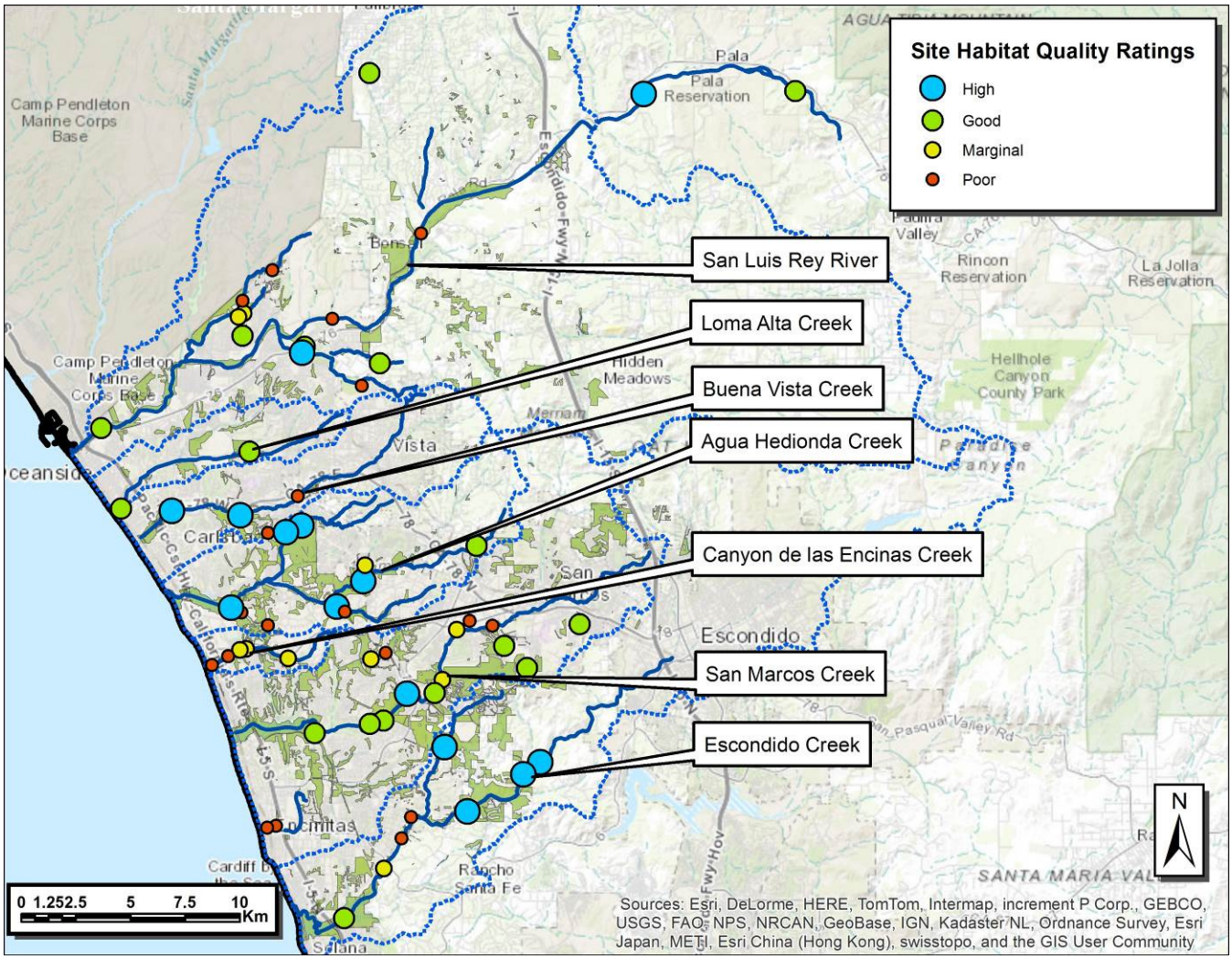

Figure 3. Map of sites with habitat quality ratings for pond turtles. Fourteen sites were ranked as *high quality*, 17 sites were ranked as *good quality*, 10 sites were ranked as *marginal quality*, 19 sites were ranked as *poor quality* based on presence of basking sites, refugia, and upland nesting habitat.

Trapping Surveys

Of the 62 sites surveyed, 12 sites were trapped for pond turtles for a total of 16 trapping surveys (Appendix C). Sites that were not trapped had either been deemed unsuitable for pond turtles (e.g., no water), unsuitable for trapping (e.g., water not deep enough for traps) or unsafe for trapping (e.g., high human access) during visual surveys. Four of the sites were trapped multiple times because pond turtles had been detected at or near the site in 2013 and the site was resurveyed to get more data on population size and status. Trapping effort included a total of 536 trap days or 12,867 trap hours and resulted in the detection of pond turtles at two sites: Foss Lake Preserve, Pilgrim Creek Tributary and Lake Calavera Preserve (Table 2; Appendix A).

Four individual pond turtles were captured and marked during the trapping surveys (Table 2). One adult male was captured at the Foss Lake Preserve, Pilgrim Creek Tributary and two adult males and one adult female was captured at Calavera Lake (Figure 2, Table 2). As mentioned above, an additional adult pond turtle of unknown sex was visually detected at Foss Lake Preserve, Pilgrim Creek Tributary. We could not estimate population size at either site because too few individuals were captured, however, we can postulate that the populations are small based on the low numbers captured.

Table 2. Capture records for western pond turtle within study area, 2012-2014.

Site	Date	Age	Sex	Method	AVID ID	Lat	Long
Foss Lake Preserve, Pilgrim Creek Tributary	7/24/2013	Adult	Male	Trap	013527877	33.260855	-117.30676
	7/23/2013	Adult	Unknown	Visual	--	33.26103	-117.30715
Calavera Lake Preserve	7/8/2013	Adult	Male	Trap	004512052	33.171615	-117.28227
	8/20/2013	Adult	Male	Trap	013529534	33.170757	-117.28238
	8/20/2013	Adult	Female	Trap	013331784	33.171405	-117.2821

Pond turtles were not detected at any sites with known historical records within or near (within 6 kilometers) our study area, including sites previously surveyed by USGS (CDFG 1989; Madden-Smith et al. 2005; K. Merkel personal communication, 2008; Clark et al. 2010; Shuster et al. 2010; Silbernagel et al. 2012, 2013; M. Madden, personal communication, 2015; Table 3). Of the two locations where pond turtles were found, one was ranked as *high quality* (Lake Calavera Preserve) and one location was ranked during our surveys as *marginal quality* (Foss Lake Preserve, Pilgrim Creek Tributary).

Table 3. Historic records for western pond turtle within the current study area and for the nearest locations outside of study area.

Site	Watershed	Conserved Lands Database?	In Study Area?	Presumed Status[a]	Date	Age	Number and Sex	Lat	Long	Method	Source	Notes
Alturas Creek	Santa Margarita River	No	No	Extant	12 July 2011	Adult	1 Female	33.37431	-117.25755	Visual	Schuster et al. 2010	Approximately 2 km from Los Jilgueros Preserve in the San Luis Rey River watershed.
West Fork San Luis Rey River	San Luis Rey River	No	No	Extant	2010 to 2015	Adult	2 Female, 4 Male	33.2935	-116.75943	Trapping	Clark et al. 2010	Above Lake Henshaw. Current USGS restoration for western pond turtle and arroyo toad
Guajome Lake	San Luis Rey River	No	Yes	Extant	April 2012	Adult	1 Unknown Sex	33.24666	-117.27544	Trapping	Silbernagel et al. 2012, 2013	5 red-eared sliders (RES) were also captured
Pilgrim Creek	San Luis Rey River	No	No	Unknown	30 April 2009	Adult	1 Unknown Sex	33.277167	-117.30283	Hand Capture	M. Madden, personal communication, 2015	Found in uplands above Pilgrim Creek; most likely female.
Buena Vista Lagoon	Buena Vista Creek	Yes	Yes	Unknown	1988	Unknown	Unknown	33.17833	-117.3438	Visual	CDFG 1989	From Buena Vista Lagoon Draft Interim Management Plan of 1989
Buena Vista Creek at Emerald Ave	Buena Vista Creek	No	Yes	Unknown	1988	Unknown	Unknown	33.18553	-117.27991	Visual	K. Merkel, personal communication, 2008	
Escondido Creek Wildflower Estates	Escondido Creek	Yes	Yes	Extant	9 Sept 2003	Adult	2 Female, 2 Male	33.05359	-117.20419	Trapping	Madden-Smith et al. 2005	No largemouth bass or RES observed in 2003
Lusardi Creek	San Dieguito River	Partial	No	Extant	2003 to 2011	Adult	1 Female, 11 Male	32.99962	-117.10209	Trapping	Madden-Smith et al. 2005	Approximately 6 km south of Escondido Creek. Estimate population size was estimated to be 15 individuals.

[a]Presumed status is prior to current study.

Level of Human Access and Naturalness of Sites

All 62 sites were ranked according to the level of human access they received and according to their level of naturalness (Appendix A; Figure 4). Twenty-two sites were ranked as low human access, 17 sites were ranked as moderate, and 23 sites were ranked as high. For naturalness, 11 sites were ranked as natural, 37 sites were ranked as modified natural, and 14 sites were ranked as artificial. Of the two locations where pond turtles were found, Lake Calavera Preserve was ranked as artificial with high human access and Foss Lake Preserve, Pilgrim Creek Tributary was ranked as modified natural with low human access. We could not correlate whether pond turtle presence was related to human access or naturalness of site for our study area because too few pond turtles were captured.

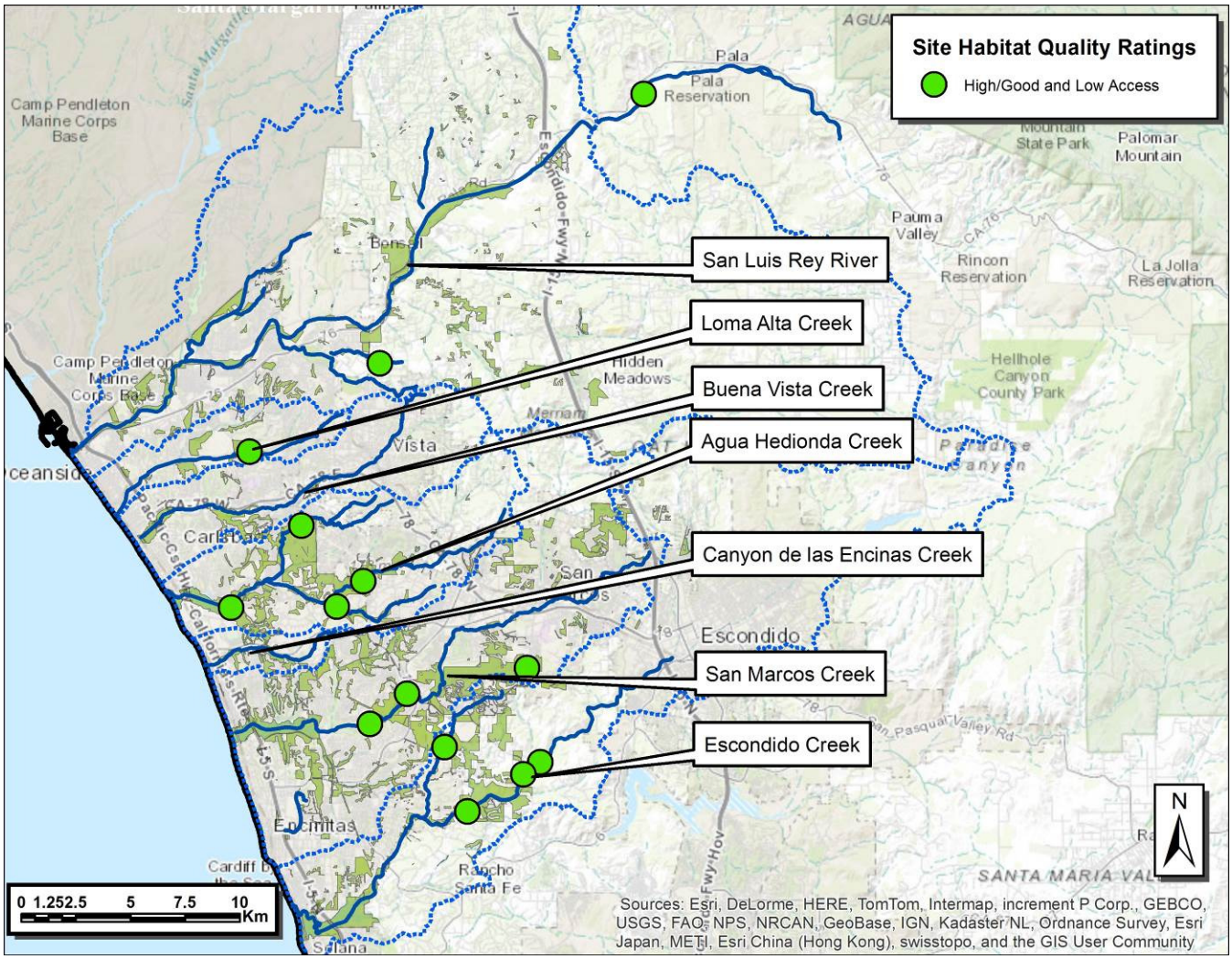

Figure 4. Map of suitable habitat for pond turtles. Fourteen sites were rated as either high or good quality for pond turtles and had low human access based on recent land management, 2012-2014.

Nonnative Aquatic Species

Nonnative turtles were more abundant than pond turtles within the study area. In contrast to the two sites where pond turtles were detected, nonnative turtles, specifically the red-eared slider, were detected at 18 sites (Appendix A; Figure 5). Red-eared sliders were more likely to be detected at sites with high human access (11) than those with low (5) or moderate human access (2), and they were more likely to be detected at sites considered modified natural (9) than artificial (5) or natural (4). In addition, red-eared sliders were also detected at the two sites where pond turtles were detected. At the Foss Lake Preserve, Pilgrim Creek Tributary site, red-eared sliders were visually detected but not captured and at the Lake Calavera Preserve site, 33 red-eared sliders were captured, compared to the three pond turtles that were captured here. Similar to Lake Calavera, a high number of red-eared sliders (35) were captured at the Buena Vista Lagoon Ecological Reserve. Both sites with the highest number of red-eared sliders are considered to have high human access, and were either artificial (Lake Calavera Preserve) or modified natural (Buena Vista Lagoon Ecological Reserve).

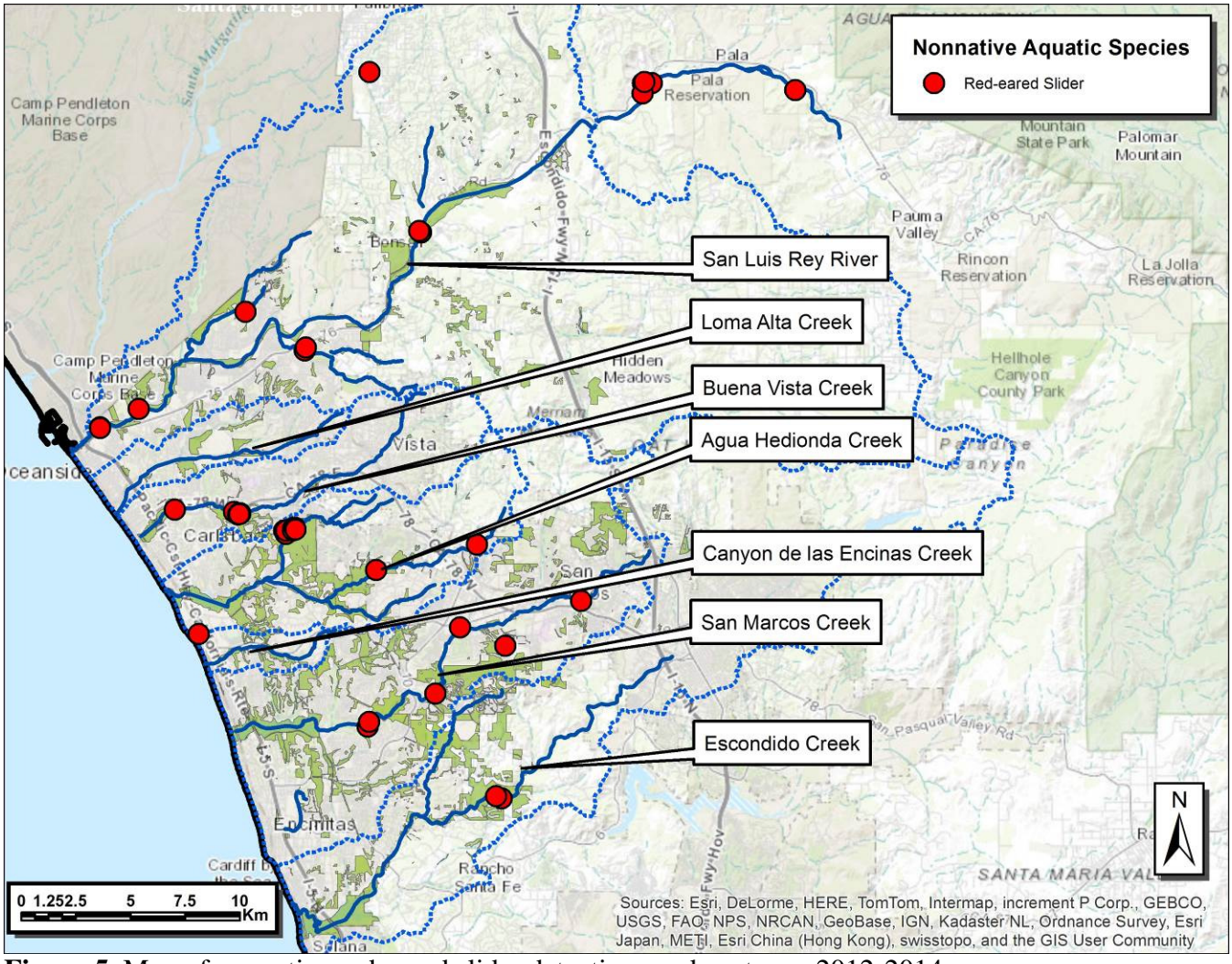

Figure 5 Map of nonnative red-eared slider detections and captures, 2012-2014.

Nonnative centrarchid fishes were detected at 16 sites (Appendix A; Figure 6). These include the predatory largemouth bass (10 sites) and competitive bluegill or green sunfish (8 sites). The largemouth bass was observed at these sites in large numbers and was the most frequently observed aquatic species in Escondido Creek. American bullfrogs were detected at 12 of the sites (Appendix A; Figure 7). Red swamp crayfish were detected at 12 of the sites (Appendix A; Figure 8).

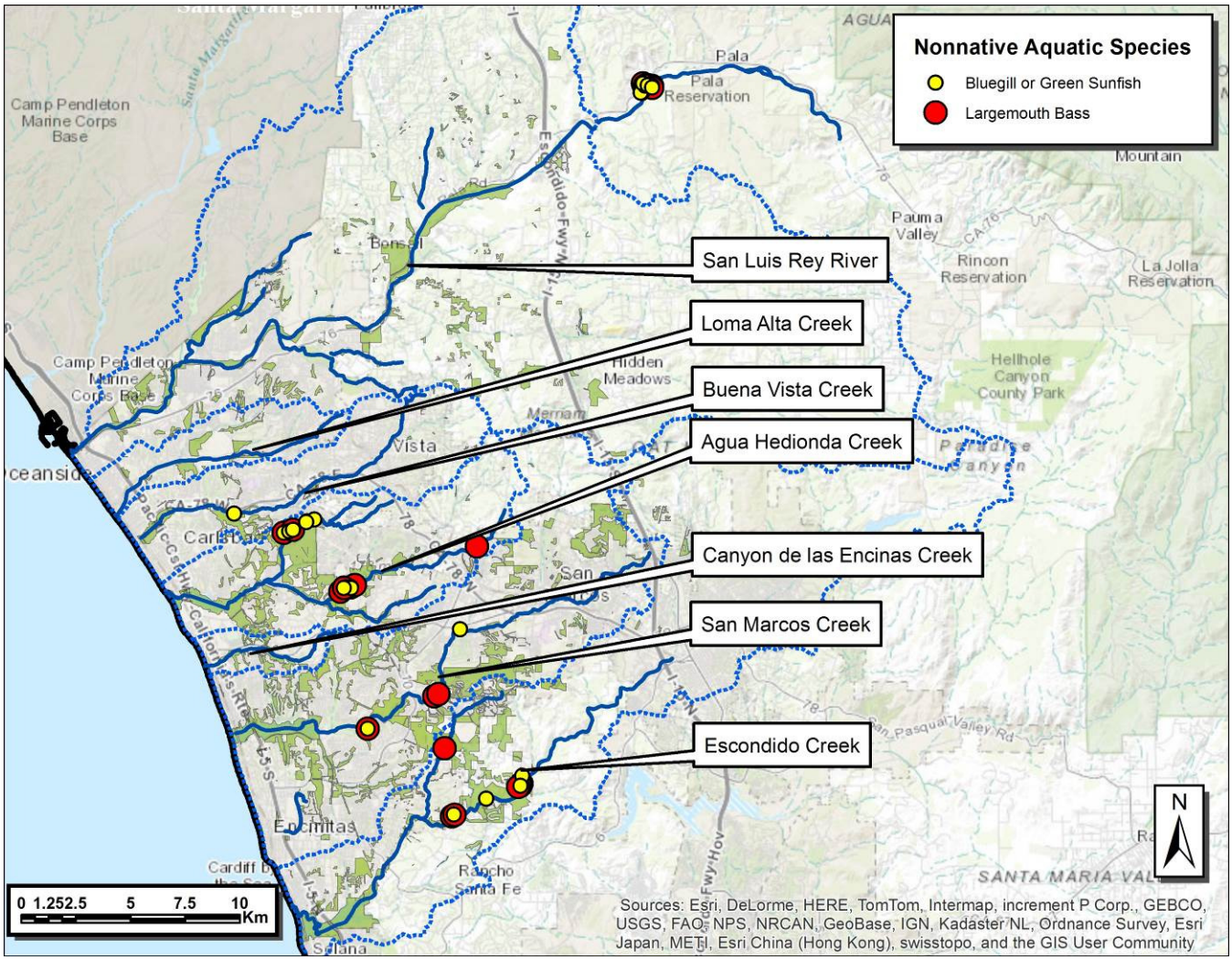

Figure 6. Map of nonnative centrarchid fishes (largemouth bass , bluegill or green sunfish) detections, 2012-2014.

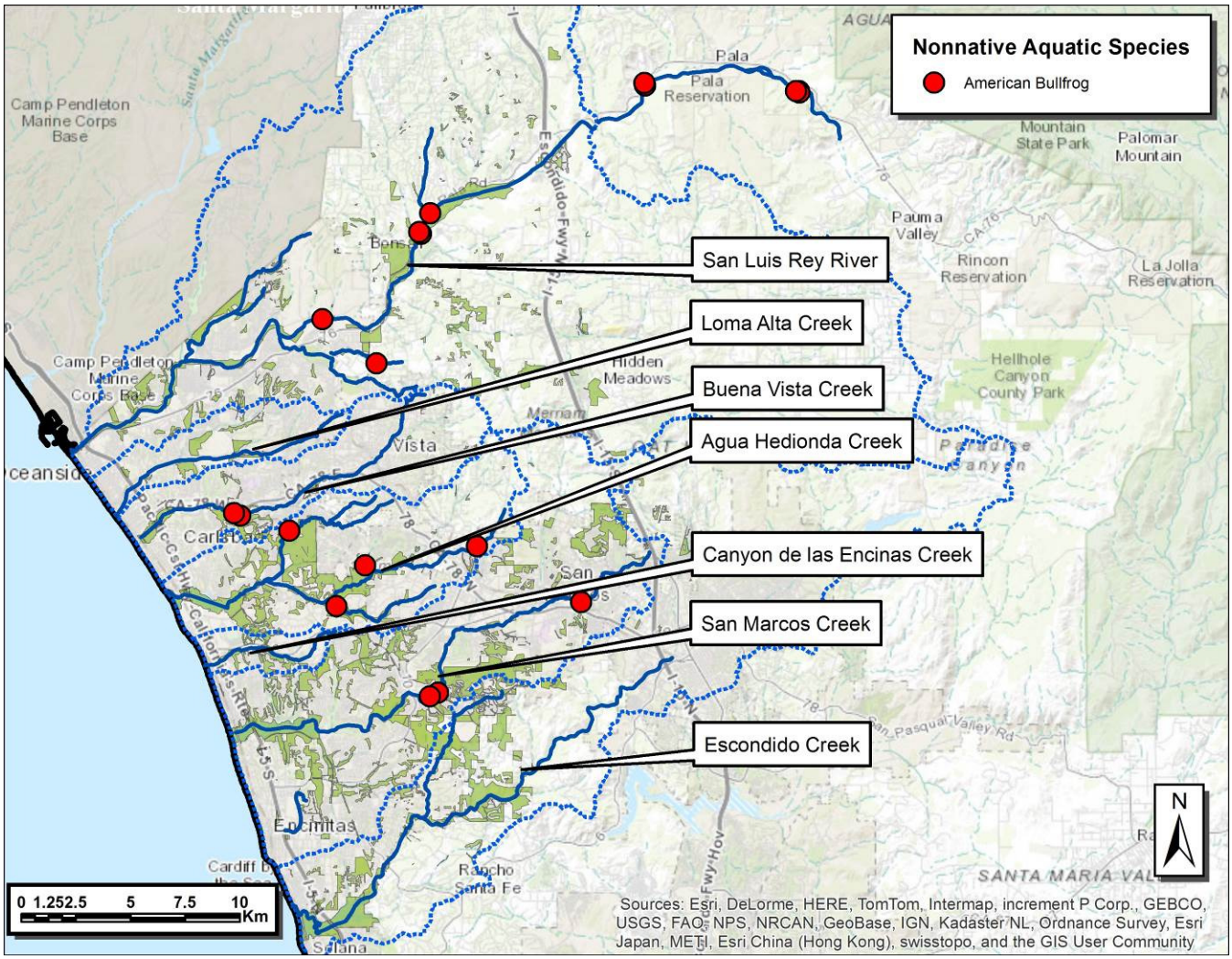

Figure 7. Map of American bullfrog detections, 2012-2014.

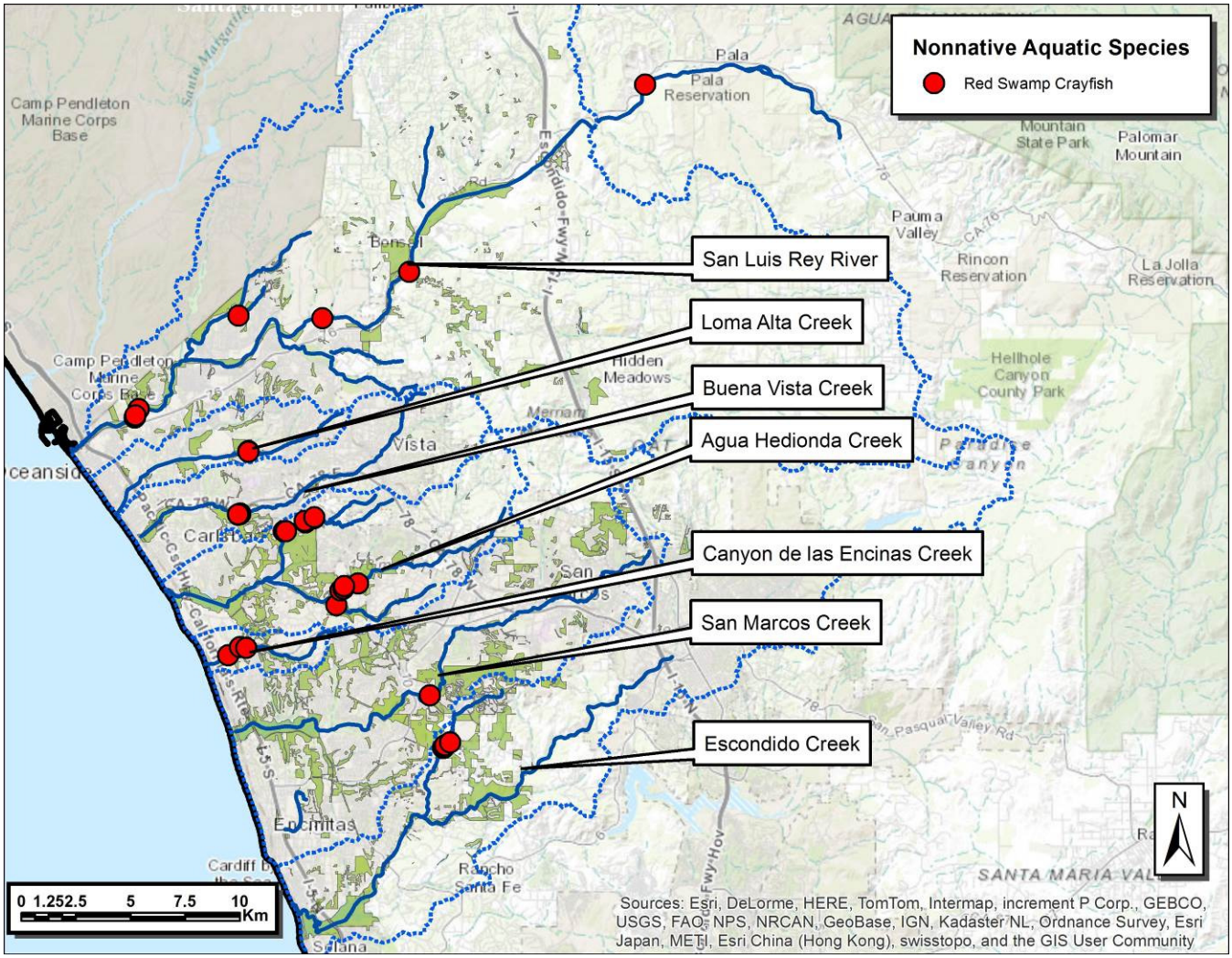

Figure 8. Map of red swamp crayfish detections, 2012-2014.

Discussion

A significant finding of this study is the number and distribution of the nonnative red-eared sliders within the coastal streams of northern San Diego County. In contrast to the two sites where pond turtles were detected, red-eared sliders were detected at 18 of the 62 sites surveyed (Appendix A). The red-eared slider has been a common turtle in the pet trade for decades and either by release or escape has managed to establish populations throughout the world (Iverson 1992). Red-eared sliders have established large populations in many areas throughout San Diego County (Madden-Smith et al. 2005). The direct and indirect effects of the red-eared slider on the pond turtle are summarized in Madden-Smith et al. (2005) and include: acting as vectors for disease and parasites that can be spread to pond turtles (see also Silbernagel et al. 2012, 2013), out-competing pond turtles for food and basking resources, and having higher fecundity than pond turtles.

In addition to the red-eared slider, 6 other nonnative aquatic species were detected, including predatory species such as the American bullfrog and large-mouth bass (Appendix A). In contrast, only one other native species beside the pond turtle was detected, the Pacific tree frog (Appendix A). Nonnative aquatic species were detected at a total of 37 sites compared to the 5 sites where natives were detected (Appendix A). Dawson Los Monos Reserve had the highest number of nonnative species detected, 6, most of which were nonnative fish (Appendix A). Introduced predators, especially bullfrogs and largemouth bass, pose potential threats to pond turtles, especially young turtles (Holland 1991; 1994; Lovich & Meyer 2002). As a result of the threats nonnative predators pose to population recruitment and because recruitment rates appear low or absent within the coastal North County San Diego pond turtle populations, nonnative predatory species should be removed from locations to be managed for pond turtles, the effectiveness of eradication techniques should be monitored and the benefits to pond turtles should be measured. In addition, although sunfish and mosquitofish do not predate on turtles, they are threats to pond turtles and should be controlled where pond turtle populations exist. Sunfish are suspected of competing with pond turtles for food (Holland 1991; Jennings & Hayes 1994; Hayes et al. 1999) and sunfish and mosquitofish are known paratenic hosts of turtle parasites in the genus *Falcaustra* (Moravec et al. 1995).

Below are brief discussions for each watershed, focusing on the sites with known or historic populations of pond turtles or those with the most potential for pond turtle restoration.

San Luis Rey River Watershed

Pond turtles were detected at one location in the San Luis Rey River watershed at the Foss Lake Preserve (Pilgrim Creek tributary) and were not detected at a known historical location, Guajome Lake (Table 3; Appendix A). In contrast the nonnative red-eared slider was detected at seven of the 16 sites surveyed and other nonnative aquatic species were detected at 11 sites (Appendix A). In addition to Foss Lake Preserve and Guajome County Park, other locations suitable for pond turtle restoration include Hansen Ponds and Anstine-Audubon Preserve.

Hansen Ponds, while not in the SANDAG Conserved Lands Database (SanGIS 2014), have low human access and habitat highly suitable for pond turtles. However, only nonnative fish, bullfrogs, and red-eared sliders were detected at this location and red-eared sliders were detected throughout most of the site. With the management of nonnative aquatic species this site could possibly support pond turtles in the future.

Even though the small tributary of Pilgrim Creek within the Foss Lake Preserve contains only marginal habitat with small permanent pools and is surrounded by housing, it currently supports a small population on pond turtles. However, only adult pond turtles were detected, further indicating an impacted population (Brattstrom & Messer 1988, Holland 1991). The channel and associated pools are relatively well isolated and hidden along the bottom of a slope providing for very low access given the proximity to housing. Red-eared sliders were also detected here, but in small numbers, as well as mosquitofish. Management of nonnative aquatic species and continued monitoring of the pond turtles will be necessary to maintain this population.

The tributary of Pilgrim Creek opens up into Foss Lake, a large, mostly permanent, off channel pool with a silt/mud shoreline and thick cattails. This pool initially looked like it would support pond turtles, although none were detected here, only red swamp crayfish were detected. In fall of 2014, this pool dried down considerably and was too shallow to support pond turtles. Because of its close proximity to

the small pond turtle population in the tributary of Pilgrim Creek within the preserve, this site should be managed in the same way to help maintain the population.

The Anstine-Audubon Preserve is another candidate for pond turtle restoration because of the conservation status of the property, high habitat quality, and active management of the preserve. The only nonnative species detected was bullfrog. This preserve could be made suitable for housing populations at risk or for headstarting efforts with removal of and management for bullfrogs.

While no pond turtles were observed during our surveys at Guajome County Park, there was a single pond turtle detected in the lake during 2012 surveys (Silbernagel et al. 2012, 2013). We detected a large number of nonnative aquatic species in the lake, including red-eared sliders, mosquitofish, and red swamp crayfish, but the lake is also known to support bullfrogs and is stocked with largemouth bass and other nonnative fish. Red-eared sliders and red swamp crayfish were also detected in Guajome Creek. The lake and the two less accessible ponds along Guajome Creek should be trapped more extensively to prove the presence or absence of pond turtles at this location.

Loma Alta Creek Watershed

No native species were detected at either of the two sites in the Loma Alta Creek watershed, however, neither were red-eared sliders (Appendix A). The only other nonnative aquatic species detected in this watershed was red swamp crayfish. Both sites have low potential for utilization by pond turtles. The Loma Alta Creek site has no adjacent conserved riparian and very little conserved lands nearby within the watershed and restoration and species specific management would be intensive and costly. Loma Alta Slough, while seemingly void of nonnative aquatic species and similar in size to less disturbed coastal marshes that support pond turtles, is not considered conserved nor is it managed accordingly.

Buena Vista Creek Watershed

No native species were detected at any of the three sites surveyed in the Buena Vista Creek watershed and were not detected at a known historical location, The Buena Vista Lagoon Ecological Reserve (Table 3; Appendix A). Red-eared sliders and other aquatic nonnative species were detected at the two locations most suitable for pond turtles, Buena Vista Creek Ecological Reserve and Buena Vista Lagoon Ecological Reserve. Red-eared sliders were observed in high numbers at both locations. The other nonnative aquatic species detected were red swamp crayfish and sunfish.

The best pond turtle habitat observed within this watershed was at the Buena Vista Creek Ecological Reserve. However, we observed a large amount of disturbance including recreation, litter, and transient/vagrant habitation, but onsite restoration efforts are helping reduce these impacts and with continued management and restoration this site may become suitable for pond turtles. In addition, Buena Vista Lagoon Ecological Reserve has large amounts of suitable habitat for pond turtles. They were known to inhabit the lagoon as recently as 1988 and were included in the Buena Vista Lagoon Draft Interim Management Plan of 1989 (R. Fisher, personal communication, 2008; CDFG 1989). In the Buena Vista Lagoon Land Management Plan Elements Biological Study, the bullfrog was also reported as the “most common amphibian” and the red-eared slider was reported as the “most visible reptile at the lagoon,” likely replacing the pond turtle (Coastal Environments 2000). High human access

and the large number of red-eared sliders and bullfrogs present pose major threats to pond turtles and must be managed before the lagoon can possibly support pond turtles again.

Agua Hedionda Creek Watershed

Pond turtles were detected at one location in the Agua Hedionda Creek watershed at the Lake Calavera Preserve. Red-eared sliders were also detected at one site out of the 12 sites surveyed, Las Posas Pond (Appendix A). The pond turtle was included in management plans for this region (AMEC & CBI 2003) even though their presence had not been verified prior to this study. In addition to Lake Calavera Preserve, other sites highly suitable for pond turtle restoration include Dawson Los Monos Reserve, Agua Hedionda Lagoon, and Upper Calavera Creek.

At Dawson Los Monos Preserve, the permanent water, large number of deep pools, structure for basking, extensive upland habitat, limited public access, and high naturalness make the habitat highly suitable for pond turtles. However, the presence of nonnative aquatic species within (more nonnative species were detected at this site than any other site in this study) and near (red-eared sliders and bullfrogs were not observed on site, but were observed in a nearby drainage) the reserve is problematic and would need to be mitigated before the site could possibly be suitable for pond turtles.

At Agua Hedionda Lagoon, most of the suitable riparian and marsh habitat lies within the CDFW Agua Hedionda Lagoon Ecological Reserve. However, Agua Hedionda Creek is highly sedimented and lacks medium to deep permanent pools, particularly in the upper portion of reserve, making this site unsuitable for pond turtles in its current state. Management for silt and sedimentation which has been previously identified as a major concern (CWN 2002) could help create and retain pools which may be suitable for pond turtles. While major roads are nearby, we did not observe the high levels of human impacts found at the other coastal lagoons. Additionally, no nonnative aquatic species were detected.

At Lake Calavera Preserve, the western half of the reservoir (includes the dam) is more heavily impacted by recreation the along the shoreline than the eastern half. Only nonnative aquatic species were observed in the western half, mostly red-eared sliders, largemouth bass, and bullfrogs. The eastern half provides much more structure with more emergent vegetation with channels running through shallow marsh where the creek flows into the reservoir. It is in the eastern half that pond turtles were observed during this study. Only adult pond turtles were captured, indicating an already impacted population (Brattstrom & Messer 1988; Holland 1991), but the presence of both male and female pond turtles makes this a site of high conservation value. Upper Calavera Creek, immediately above Lake Calavera Preserve, has a mixed canopy, scattered deep pools, and ample structure for basking, making the habitat highly suitable for pond turtles; however none were detected outside of the lake. CNLM has been working with City of Carlsbad to restore the upland adjacent to the reservoir, mostly in the eastern half. This restored upland can provide additional habitat for nesting for pond turtles as well as provide additional buffer for human impacts from the adjacent residential areas. With continued upland habitat enhancement and management mitigating human activities, the most pressing threats to pond turtles are the presence of red-eared sliders, largemouth bass, and bullfrogs.

Additional sites to consider for pond turtle restoration, although less ideal than the sites described above, include Faraday Pond in the Carlsbad Oak Preserve and Agua Hedionda Creek Falls. While having little connectivity to Agua Hedionda Creek, Faraday Pond has sufficient water, ample structure

for foraging and basking, and managed upland habitat to support an isolated population of pond turtles. The pond contains nonnative aquatic species, including bullfrogs and red swamp crayfish, but the potential to control these is high given the relatively small size and isolation from the creek channel. With management of the nonnative species, this pond has potential as a receiver or headstarting site for pond turtle restoration efforts in the Aqua Hedionda watershed. Agua Hedionda Creek Falls historically held ponding water, but was dry during our surveys making it unsuitable for pond turtles. If the rapidly changing surrounding land use creates additional inputs and surface water becomes more permanent, the excellent structure for foraging and basking would make this site worth revisiting in the future and worth considering for pond turtle restoration.

Canyon de las Encinas Creek Watershed

Pond turtles were not detected in the Canyon de las Encinas Creek watershed and neither were red-eared sliders (Appendix A). Only two nonnative species were detected in this watershed, red swamp crayfish and mosquitofish, and they were only detected at four sites (Appendix A). All sites had marginal to poor habitat for pond turtles, but two of the sites did support the native Pacific tree frog. In addition, most of these sites had high access and were adjacent to roads making them unsuitable for pond turtle restoration.

San Marcos Creek Watershed

No native aquatic species were detected within the San Marcos Creek watershed (Appendix A). In contrast, 8 of the 16 sites had nonnative aquatic species, including six with red-eared sliders (Appendix A). Because of the lack of suitable habitat, the high number of nonnative species and the high level of recreation and human access, most sites within this watershed would not be suitable for pond turtle restoration or would be too costly to restore. The two most suitable sites for pond turtle restoration are the San Marcos Creek Quarry and Box Canyon sites.

The San Marcos Creek Quarry site has abundant sage scrub upland, is being restored to willow/sycamore riparian, has many large boulder lined pools, and excellent basking opportunities for pond turtles. However, the stream contains larger numbers of nonnative aquatic species, including red-eared sliders, bullfrogs, and largemouth bass. Control of these species is problematic with Lake San Marcos harboring large numbers of nonnative species very close upstream. However, should control of the nonnative species occur, this site would be suitable for pond turtle restoration.

The Box Canyon site contains a large section of San Marcos Creek with high habitat quality- lined with boulders and bedrock, many sunny pools, great structure for basking and hiding, and low access. However, as with the other portions of San Marcos Creek, it too has large numbers of red-eared sliders and largemouth bass. If nonnative aquatic species were controlled in the watershed, this area should be considered for restoration of pond turtles.

Escondido Creek Watershed

No native aquatic species were detected within the Escondido Creek watershed (Appendix A). In contrast, 5 of the 16 sites had nonnative aquatic species, including two with red-eared sliders (Appendix A). Escondido Creek has the most recent historical pond turtle observations prior to this study

(Madden-Smith et al. 2005; Table 3) in the site now known as Wildflower Estates, but none were detected during our surveys. During our efforts, the most frequently captured species was the largemouth bass and the only turtles observed were red-eared sliders. Most of the watershed is conserved and being restored and the creek provides ample upland, large, deep permanent pools, and good structure for basking, thus making most of the sites surveyed within the Escondido Creek watershed great candidates for pond turtle restoration or enhancement. However, the sites with the most potential for pond turtle restoration include Wildflower Estates, because of the recent historical detection, and Copper Creek. Other sites with potential for pond turtle restoration include Harmony Grove, Elfin Glen, and Mirlo Ponds.

Wildflower Estates is where USGS trapped four adult pond turtles in 2003 at the beginning of riparian habitat restoration for this portion of Escondido Creek by the ECC (Madden-Smith et al. 2005). Since the restoration was completed, the site has much more open pooling habitat, but now has more nonnative species. Our surveys detected large numbers of largemouth bass while none were caught in 2003. Recently, red-eared sliders were detected in this reach (L. Wittwer, personal communication, 2014) and were captured just upstream from here in our surveys. Our recent surveys did not detect pond turtles and it is possible that pond turtles no longer inhabit this site. This area needs to be trapped more extensively to prove the presence of pond turtles and nonnative species removal will need to occur if this site is to be managed for pond turtles.

The riparian habitat within Copper Creek and the uplands surrounding it, remain fairly intact due to the isolation of this site. Only one nonnative aquatic species was observed during our surveys. The amount of pooling water, naturalness, low number of nonnative species, and controlled access make this site highly suitable for pond turtles, giving this site high potential for restoration or enhancement for pond turtles.

Harmony Grove and Elfin Glen might also be suitable for pond turtle restoration because of the conservation status of these properties, the high habitat quality, and the ongoing habitat management. Nonnative aquatic species still dominate the stream at both locations and would need to be managed prior to pond turtle restoration. Turtles were observed by the land managers at Elfin Glen prior to our surveys (L. Wittwer, personal communication, 2014) but were not identified.

A portion of El Mirlo Ponds is now part of conserved lands and future management of this area may improve habitat suitability for pond turtles. The ponds are off the main channel of Escondido Creek and have potential for active management for nonnative aquatic species and may provide refugia for pond turtles within the lower part of this watershed. Other potential ponds in this area are on private property.

General Guidelines for Future Pond Turtle Monitoring and Management

Below is a brief summary of monitoring and management guidelines that may be used as a means to sustain and improve pond turtle populations within the coastal watersheds of northern San Diego County. Increasing these populations and expanding them into other suitable areas may be achieved by increasing habitat quality, removing nonnative turtles, nonnative predatory species and nonnative species with the potential to be disease vectors, and restoring a more natural hydrologic regime within the drainages that contain pond turtles. The following suggestions should benefit the pond turtle and

improve the understanding of this declining species within the coastal streams of northern San Diego County. Very few populations of pond turtles remain in these watersheds, thus aggressive actions will be necessary to effectively manage for this species.

Nonnative Bullfrogs

Nonnative bullfrogs were detected at many more locations than pond turtles, thus a management strategy for the pond turtle needs to include studies on the interspecific relationships between pond turtles and bullfrogs and the benefits of bullfrog removal to the pond turtle. Bullfrogs have been documented to predate on juvenile pond turtles (Brattstrom & Messer 1988; Holland 1991, 1994). Bullfrog removal has been part of successful pond turtle restoration projects elsewhere in San Diego County, where nonnative species removal resulted in an increase in pond turtle recruitment (Bury & Germano 2008; Brown et al. 2012). Nonnative bullfrog removal should be high priority at or near locations that support pond turtles or at pond turtle restoration sites.

Nonnative Turtles

Nonnative turtles were detected at many more locations than pond turtles, thus a management strategy for the pond turtle needs to include studies on the interspecific relationships between pond turtles and nonnative turtles and the benefits of nonnative turtle removal to the pond turtle. Pathogen introduction by nonnative turtles has been speculated to be a cause of declining pond turtle populations (Silbernagel et al. 2012, 2013). Nonnative turtle removal should be included with other nonnative species removal and would be beneficial at or near locations that support pond turtles or at pond turtle restoration sites.

Minimize Disturbance and Take:

Coastal northern San Diego County pond turtle populations are at increased risk due to human activities that may lead to disturbance and take of pond turtles (e.g., recreation, collection, and roads). Conserved lands should be managed to prevent or minimize disturbance to pond turtles and/or their habitat resulting from on-site activities (e.g., fishing, releasing nonnative turtles). With increased human access there is a greater possibility of humans encountering pond turtles and collecting them.

Education and Outreach

Educational kiosks or signs should be installed at trailheads to educate and inform the public of any restrictions and the importance of not releasing unwanted pets, especially turtles. This is particularly important at all locations where pond turtles occur, especially those sites heavily recreated or easily accessed by humans.

Recruitment and Population Viability

It appears that successful recruitment is low or possibly not occurring within coastal northern San Diego County pond turtle populations, and it is important that future studies determine: 1) whether recruitment is occurring and at what level, 2) what are the direct and indirect causes of reduced or absent recruitment, and 3) how can the negative pressures on recruitment be reduced or eliminated. This may involve protecting nesting females, finding and protecting nest sites throughout the year (juveniles may overwinter in the nest),

protecting juveniles and assessing juvenile feeding and habitat requirements. In addition, to increase population recruitment headstarting and/or captive rearing may need to be considered.
Radio-telemetry studies can be used to gather more information on the reproductive status of the pond turtle populations within this area. Studies should involve tracking female pond turtles, locating and protecting nests and monitoring juvenile survival.

Mitigate the Effects of Roads

Mitigation measures should be taken to prevent negative effects of roads on pond turtles, and should include monitoring run-off and water quality and creating structures, such as barrier fences or wildlife ecopassages (Boarman et al. 1997; Barichivich & Dodd 2002).

Additional Surveys

In order to get a better understanding of the size, status, and habitat requirements of pond turtle populations occurring within the watersheds of coastal northern San Diego County, surveys using the methods carried out in this study should be repeated and expanded to examine upland habitat use, adult and juvenile wetland habitat requirements, recruitment and population viability. More intensive surveys are necessary to better illuminate the demographic structure and life history requirements of the remaining pond turtle populations in these watersheds. Historic locations or possible historic locations with suitable habitat should also be resurveyed to further verify pond turtles are absent. Additionally, causes for the low number of females and the absence of juveniles should be investigated and measures should be taken to protect and increase the number of females and increase successful recruitment.

Habitat Assessment

At sites with known pond turtle populations, more detailed habitat assessment should be conducted in order to gain a better understanding of the habitat requirements of the coastal northern San Diego County populations. From thereafter, all pond turtle habitat should be periodically assessed to determine the extent and quality of habitat (upland and wetland) and to establish whether it is increasing or decreasing throughout the reserve (every five or more years).

Water Quality Assessment

A specific measure of habitat quality that should be taken into account is water quality. In coordination with cities and water agencies, water quality should be monitored and if necessary, improved in areas where pond turtles occur. Water quality measurements that should be taken during future habitat assessment should at a minimum include: dissolved oxygen, pH, turbidity, nitrate and phosphate levels. In highly urbanized areas lead and aluminum should also be monitored.

Effects of Drought

There was below normal rainfall during this study (2012-2014), thus future pond turtle presence surveys should be conducted during a period of normal rainfall in order to better determine the likelihood of absence of pond turtles at sites with potential pond turtle habitat (rated high and good quality) or sites that

historically supported pond turtles or potential pond turtle habitat, but were too dry to trap or support pond turtles during our study.

Habitat Restoration and Creation

Another management goal should be to expand the abundance and range of known populations of pond turtles through restoration or creation of wetland habitats for both adult and juvenile life stages.

Head Starting, Captive Breeding, or Translocation

After threats to pond turtles have been removed and suitable habitat has been restored or created, a reintroduction or population establishment program (using headstarting, captive rearing or translocation) should be considered to maintain or enhance extant populations or to reintroduce turtles where they have been extirpated within the north coastal San Diego County populations or to introduce new populations.

Acknowledgements

Site Access

The California Department of Fish and Wildlife, Center for Natural Lands Management, County of San Diego, University of California, San Diego's Natural Reserve System, Escondido Creek Conservancy, and the Cities of Carlsbad and San Marcos have provided and coordinated access to the reserves.

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Literature Cited

AMEC Earth and Environmental, Inc. (AMEC) and Conservation Biology Institute (CBI). 2003. Final MHCP Executive summary. Prepared for Multiple Habitat Conservation Program. 30pp

Ashton, D. T., K. E. Schlick, N. E. Karraker, D. A. Reese, A. J. Lind, and H. H. Welsh. 2001. Ecology and sampling methods for the western pond turtle. USDA Forest Service, Redwood Sciences Laboratory, Arcata, California. 60 pp.

Barichivich, W. J. and C. K. Dodd, Jr. 2002. The effectiveness of wildlife barriers and underpasses on U. S. Highway 441 across Paynes Prairie State Preserve, Aluchua County, Florida. Post construction survey: final report. Prepared for the Department of Transportation, contract No. BB-854. 36 pp.

Boarman, W. I., M. Sazaki, and W. B. Jennings. 1997. The effect of roads, barrier fences, and culverts on desert tortoise populations in California, USA. In J. Van Abbema (Ed.), Proceedings: Conservation, Restoration and Management of Tortoises and Turtles- an International Conference (pp. 54-58). New York Turtle and Tortoise Society, N.Y.

Brattstrom, B. H. and D. F. Messer. 1988. Current status of the southwestern pond turtle, *Clemmys marmorata pallida*, in southern California. Final report to California Department of Fish and Game. Contract C-2044. Sacramento, CA. 62 pp.

Brown, C., S. A. Hathaway, and R. N. Fisher. 2012. Data Summary for the TransNet Environmental Mitigation Program Grant Agreement 5001140 Regarding Southwestern Pond Turtle Restoration at Sycuan Peak Ecological Reserve, March 2012. U.S. Geological Survey data summary prepared for the TransNet Environmental Mitigation Program, San Diego, CA, 20 pp.

Buhlmann, K. A. and T. D. Tuberville. 1998. Use of passive integrated transponder (PIT) tags for marking small freshwater turtles. Chelonian Conservation and Biology 3:102-104.

Bury, R. B. 1972. Habits and home range of the Pacific pond turtle, *Clemmys marmorata*, in a stream community. PhD dissertation, University of California, Berkeley. 205 pp.

Bury, R. B. and D. J. Germano. 2008. *Actinemys marmorata* (Baird and Girard 1852) – western pond turtle, Pacific pond turtle. In: Rhodin, A. G. J., Pritchard, P. C. H., van Dijk, P. P., Saumure, R. A., Buhlmann, K. A. and Iverson, J. B. (Eds.). Conservation Biology of Freshwater Turtles and Tortoises: A Compilation Project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group. Chelonian Research Monographs No. 5, pp. 001.1-001.9, doi:10.3854/crm.5.001.marmorata.v.1.2008, http://.iucn-tftsg.org/cbftt.

California Department of Fish and Game (CDFG) 1989. Buena Vista Lagoon Draft Interim Management Plan. California Department of Fish and Game, Sacrament, CA.

Carlsbad Watershed Network (CWN). 2002. Carlsbad Watershed Management Plan. Prepared for the State Water Resources Control Board by Carlsbad Watershed Network. Carlsbad, CA.

Clark, D. R., C. S. Brehme, and R. N. Fisher. 2010. Arroyo toad monitoring results at Naval Base Coronado, Remote Training Site, Warner Springs, 2010. U.S. Geological Survey technical report prepared for Environmental Department, Naval Base Coronado. 33 pp.

Coastal Environments. 2000. Buena Vista Lagoon Land Management Plan elements Biological Analysis. Prepared for Buena Vista Lagoon Foundation. La Jolla, CA 95pp.

Fisher, R.N., Wood, D.A., Brown, C.W., Spinks, P.Q., and A.G. Vandergast. 2012. Phylogenetic and Population Genetic Analyses of Western Pond Turtle (*Emys marmorata*), in Southern California. Prepared for the Department of Fish and Game in fulfillment of Agreement No. P0850013-01, March 2012. U.S. Geological Survey, San Diego, CA, 20 pp.

Hays, D. W., K. R. McAllister, S. A. Richardson, and D. W. Stinson. 1999. Washington State recovery plan for the western pond turtle. Washington Department of Fish and Wildlife, Olympia. 66 pp.

Holland, D. 1991. A synopsis of the ecology and status of the western pond turtle (*Clemmys marmorata*) in 1991. Report to National Ecological Research Center. United States Fish and Wildlife Service, San Simeon, California. 38 pp.

Holland, D. C. 1994. The western pond turtle: Habitat and history. Final report to U. S. Department of Energy, Bonneville Power Administration, Portland, Oregon. 303 pp.

Iverson, J. B. 1992. A revised checklist with distribution maps of the turtles of the world. Privately printed, Richmond, Indiana.

Jennings, M. R. and M. P. Hayes. 1994. Amphibian and reptile species of special concern in California. Report prepared for California Department of Fish and Game, Rancho Cordova, California. 255 pp.

Lovich, J. and K. Meyer. 2002. The western pond turtle (*Clemmys marmorata*) in the Mojave River, California, USA: highly adapted survivor or tenuous relict? Journal of Zoology London 256:537-545.

Madden-Smith, M. C., E. L. Ervin, K. P. Meyer, S. A. Hathaway, and R. N. Fisher. 2005. Distribution and status of the arroyo toad (*Bufo californicus*) and western pond turtle (*Emys marmorata*) in the San Diego MSCP and surrounding areas. Report to County of San Diego and California Department of Fish and Game, San Diego, California. 190 pp.

Markert, J. A., C. W. Brown, M. J. Bagley, D. E. Nacci, J. S. Grear and R. N. Fisher, 2011. Genetic diversity and population resilience. Ecological Society of America Symposium—"Integrating evolution into policy: improved science-based decision-making for environmental stewardship. Austin, Texas, August 2011.

Moravec, F., D. G. Huffman, and D. J. Swim. 1995. The first record of fish as paratenic hosts of *Falcaustra* spp. (Nematoda: Kathlaniidae). Journal of Parasitology 81:809-812.

Morrison, M. L., T. A. Scott, and T. Tennant. 1994. Wildlife-Habitat Restoration in an Urban Park in Southern California. Restoration Ecology 2:17-30.

Rathbun, G. B., M. R. Jennings, T. G. Murphey, and N. R. Seipel. 1993. Status and ecology of sensitive aquatic vertebrates in Lower San Simeon and Pico Creeks, San Luis Obispo County, California. Unpublished report to National Ecology Research Center, Piedras Blancas Research Station, San Simeon, California, 93452-0070. Cooperative Agreement 14-16-0009-91-1909. 103 pp.

Rathbun, G. B., N. J. Scott Jr., and, T. G. Murphy. 2002. Terrestrial habitat use by pacific pond turtles in a Mediterranean climate. The Southwestern Naturalist 47:225-235.

Reese, D. A. 1996. Comparative demography and habitat use of western pond turtles in northern California: The effects of damming and related habitat alterations. PhD dissertation, University of California Berkeley, Berkeley, CA. 253 pp.

Reese, D. A. and H. H. Welsh, Jr. 1998. Habitat use by western pond turtles in the Trinity River, California. Journal of Wildlife Management 62:842-853.

SanGIS. 2014. SANDAG Conserved Lands Database; Conserved_Lands_061814. San Diego Geographic Information Source. San Diego, CA.

Silbernagel, C., J. Foley, and D. Clifford. 2012. Guajome Regional Park Turtle Disease Project Final Report. Prepared for County of San Diego Department of Parks and Recreation. Davis, CA. 3 pp.

Silbernagel C, D. L. Clifford, J. Bettaso, S. Worth, J. Foley. 2013. Prevalence of selected pathogens in western pond turtles and sympatric introduced red-eared sliders in California, USA. Diseases of Aquatic Organisms. 107:37-47

Spinks, P.Q. and H.B. Shaffer. 2005. Rangewide molecular analysis of the western pond turtle (*Emys marmorata*): cryptic variation, isolation by distance, and their conservation implications. Mol. Ecol. 14:2047-2064

U.S. Geological Survey (USGS). 2006a. USGS Aquatic species and habitat assessment protocol for south coast ecoregion rivers, streams, and creeks. U.S. Geological Survey protocol. San Diego, CA. 48 pp.

U.S. Geological Survey (USGS). 2006b. USGS western pond turtle (*Emys marmorata*) visual survey protocol for the southcoast ecoregion. U.S. Geological Survey protocol. San Diego, CA. 56 pp.

U.S. Geological Survey. San Luis Rey quadrangle, California [map]. Photorevised 1997. 1:24,000. 7.5 Minute Series. Reston, VA: United States Department of the Interior, USGS, 1999

APPENDIX A

Site information, characteristics, habitat suitability and aquatic species observed.

Table 4. Site information, characteristics, habitat suitability and aquatic species observed.

Watershed	Site	Landowner/Manager	Conserved Lands Database?	Level of Human Access	Naturalness of Site	Basking Sites	Aquatic Refugia	Streamside Refugia	Upland Nesting Habitat	Habitat Quality Total	Habitat Quality Rating	Water ≥.5m	Wet/Dry Initial Survey	Aquatic Natives Observed	Aquatic Nonnatives Observed
San Luis Rey River	Wilderness Gardens Preserve	County of San Diego	Yes	Moderate	Modified Natural	1	1	2	2	6	Good	Yes	Wet		*Trachemys scripta* *Lithobates catesbeianus*
	Hanson Ponds	Pala Band of Mission Indians	No	Low	Modified Natural	2	2	2	2	8	High	Yes	Wet		*Trachemys scripta* *Micropterus salmoides* *Lithobates catesbeianus*
	San Luis Rey River Park	Caltrans/County of San Diego	Yes	High	Natural	0	0	1	1	2	Poor	No	Wet		*Procambarus* spp. *Lithobates catesbeianus*
	San Luis Rey River Trail	City of Oceanside	Yes	High	Modified Natural	2	2	1	1	6	Good	Yes	Wet		*Trachemys scripta* *Procambarus* spp.
	Rosemary Mountain Quarry-North River Unit	Granite Construction/Center for Natural Lands Management	Yes	Low	Modified Natural	-	-	-	-	0	Poor	No	Dry		
	Los Jilgueros Preserve	Fallbrook Land Conservancy	No	High	Modified Natural	1	1	2	2	6	Good	Yes	Wet		*Trachemys scripta*
	Wilmont Ranch/ Morro Hills/ Arrowood Golf Course	Center for Natural Lands Management	Yes	Moderate	Artificial	-	-	-	-	-	Poor	No	Dry		
	Foss Lake Preserve, Pilgrim Creek Tributary	Center for Natural Lands Management	Yes	Low	Modified Natural	1	1	1	1	4	Marginal	Yes	Wet	*Emys marmorata*	*Trachemys scripta* *Gambusia affinis*
	Foss Lake Preserve, Lake	Center for Natural Lands Management	Yes	Low	Modified Natural	1	1	1	1	4	Marginal	Yes	Wet		*Procambarus* spp.
	Pilgrim Creek Ecological Reserve	California Department of Fish and Wildlife	Yes	Moderate	Modified Natural	-	-	-	-	-	Poor	No	Dry		
	Anstine-Audubon Preserve	San Diego Audubon Society	Yes	Low	Modified Natural	2	1	1	1	5	Good	Yes	Wet		*Lithobates catesbeianus*
	Guajome County Park, Guajome Lake	County of San Diego	No	High	Artificial	2	1	1	1	5	Good	Yes	Wet		*Trachemys scripta* *Procambarus* spp. *Gambusia affinis*
	Guajome County Park, Ponds	County of San Diego	No	High	Modified Natural	2	2	2	1	7	High	Yes	Wet		*Trachemys scripta* *Procambarus* spp.
	Libby Lake Park	City of Oceanside	No	High	Artificial	2	1	1	1	5	Good	Yes	Wet		*Trachemys scripta*
	Talone Lake	Talone Conservancy Group	Yes	Low	Modified Natural	-	-	-	-	-	-	-	-		
	Santa Fe Pond	Vista Sandalwood Owners Association	No	High	Artificial	-	-	-	-	-	Poor	Yes	Wet		

Table 4 (continued).

Watershed	Site	Landowner/Manager	Conserved Lands Database?	Level of Human Access	Naturalness of Site	Basking Sites	Aquatic Refugia	Streamside Refugia	Upland Nesting Habitat	Habitat Quality Total	Habitat Quality Rating	Water ≥.5m	Wet/Dry Initial Survey	Aquatic Natives Observed	Aquatic Nonnatives Observed
Loma Alta Creek	Rancho del Oro Preserve	North San Diego County Transit Development Board/ Center for Natural Lands Management	Yes	Low	Modified Natural	1	2	1	1	5	Good	Yes	Wet		*Procambarus* spp.
	Loma Alta Slough	City of Oceanside	No	High	Artificial	1	2	1	1	5	Good	Yes	Wet		*Procambarus* spp.
Buena Vista Creek	Buena Vista Creek Channel	City of Vista	Yes	Moderate	Artificial	0	1	1	0	2	Poor	No	Wet		
	Buena Vista Creek Ecological Reserve	California Department of Fish and Wildlife	Yes	Moderate	Modified Natural	2	2	2	2	8	High	Yes	Wet		*Trachemys scripta* *Procambarus* spp. *Lepomis* spp. *Lithobates catesbeianus*
	Buena Vista Lagoon Ecological Reserve	California Department of Fish and Wildlife	Yes	High	Modified Natural	2	2	2	1	7	High	Yes	Wet		*Trachemys scripta* *Procambarus* spp.
Agua Hedionda Creek	North Las Posas Pond	Vista San Marcos Ltd	No	High	Modified Natural	-	-	-	-	-	-	No	Dry		
	Las Posas Pond	Rancho Santalina Homeowners Association	No	High	Modified Natural	2	1	1	1	5	Good	Yes	Wet		*Trachemys scripta* *Micropterus salmoides* *Lithobates catesbeianus*
	Dawson Los Monos Reserve	University of California San Diego Natural Reserve System	Yes	Low	Natural	2	2	2	2	8	High	Yes	Wet	*Pseudacris regilla*	*Procambarus* spp. *Lepomis cyanellus* *Lepomis macrochirus* *Ameiurus* spp. *Gambusia affinis* *Micropterus salmoides*
	Buena Vista Pond	City of Vista	No	High	Artificial	1	1	1	0	3	Marginal	Yes	Wet		*Procambarus* spp. *Lithobates catesbeianus*
	Village Pond	Calavera Hills Homeowners Association/Center for Natural Lands Management	Yes	Low	Modified Natural	-	-	-	-	-	Poor	No	Dry		
	Agua Hedionda Creek Mouth	San Diego Gas and Electric	Yes	Moderate	Modified Natural	-	-	-	-	-	Poor	No	Dry		

Table 4 (continued).

Watershed	Site	Landowner/Manager	Conserved Lands Database?	Level of Human Access	Naturalness of Site	Basking Sites	Aquatic Refugia	Streamside Refugia	Upland Nesting Habitat	Habitat Quality Total	Habitat Quality Rating	Water ≥.5m	Wet/Dry Initial Survey	Aquatic Natives Observed	Aquatic Nonnatives Observed
Agua Hedionda Creek	Agua Hedionda Lagoon	San Diego Gas and Electric/California Department of Fish and Wildlife	Yes	Low	Modified Natural	2	2	2	1	7	High	Yes	Wet		
	Upper Calavera Creek	City of Carlsbad/Center for Natural Lands Management/City of Oceanside	Yes	Low	Modified Natural	2	2	2	1	7	High	Yes	Wet		*Lithobates catesbeianus*
	Lake Calavera Preserve	City of Carlsbad	Yes	High	Artificial	2	2	2	1	7	High	Yes	Wet	*Emys marmorata*	*Procambarus* spp. *Lepomis* spp. *Micropterus salmoides* *Lithobates catesbeianus*
	Carlsbad Oaks Preserve, Faraday Pond	Center for Natural Lands Management	Yes	Low	Modified Natural	2	2	2	2	8	High	Yes	Wet		*Procambarus* spp. *Lithobates catesbeianus*
	Carlsbad Oaks Preserve, Agua Hedionda Creek Tributary	Center for Natural Lands Management	Yes	Low	Natural	-	-	-	-	0	Poor	No	Dry		
	Agua Hedionda Creek Falls	City of Carlsbad/ Center for Natural Lands Management	Yes	Low	Natural	-	-	-	-	-	Poor	No	Dry		
Canyon de las Encinas Creek	Palomar Oaks Pond	Palomar Oaks Business Center Association	Yes	Moderate	Artificial	1	0	1	1	3	Marginal	Yes	Wet		
	Upper Canyon de las Encinas Creek	Mar Brisa Homeowners Association	Yes	Moderate	Modified Natural	1	0	1	1	3	Marginal	No	Wet	*Pseudacris regilla*	*Gambusia affinis* *Procambarus* spp.
	Lower Canyon de las Encinas Creek	Center for Natural Lands Management	Yes	Moderate	Modified Natural	1	0	1	1	3	Marginal	Yes	Wet	*Pseudacris regilla*	*Gambusia affinis* *Procambarus* spp.
	Canyon de las Encinas Palms	Costco Wholesale Corp/Hadley Fruit Orchards	Yes	High	Modified Natural	1	0	0	1	2	Poor	No	Wet		*Gambusia affinis* *Procambarus* spp.
	Canyon de las Encinas Marsh	North San Diego County Transit Development Board	Yes	High	Modified Natural	1	0	0	1	2	Poor	No	Wet		*Gambusia affinis*

Table 4 (continued).

Watershed	Site	Landowner/Manager	Conserved Lands Database?	Level of Human Access	Naturalness of Site	Basking Sites	Aquatic Refugia	Streamside Refugia	Upland Nesting Habitat	Habitat Quality Total	Habitat Quality Rating	Water ≥.5m	Wet/Dry Initial Survey	Aquatic Natives Observed	Aquatic Nonnatives Observed
San Marcos Creek	Jack's Pond	City of San Marcos	Yes	High	Modified Natural	2	1	2	1	6	Good	Yes	Wet		*Trachemys scripta* *Lithobates catesbeianus* *Lepomis* spp.
	San Marcos Creek Ponds I	City of San Marcos	Yes	Moderate	Modified Natural	-	-	-	-	-	Poor	No	Dry		
	San Marcos Creek Ponds II	City of San Marcos	No	Moderate	Modified Natural	-	-	-	-	-	Poor	No	Dry		
	Upper San Marcos Creek	Citizens Development Corporation	No	High	Artificial	1	0	1	1	3	Marginal	Yes	Wet		*Trachemys scripta* *Lepomis* spp.
	Lake San Marcos	Citizens Development Corporation	No	High	Artificial	1	1	1	0	3	Marginal	Yes	Wet		*Trachemys scripta* *Lepomis* spp.
	Rancho La Costa Preserve, San Marcos Creek Quarry	Center for Natural Lands Management	Yes	Moderate	Modified Natural	2	1	1	2	6	Good	Yes	Wet		*Trachemys scripta* *Micropterus salmoides* *Lithobates catesbeianus*
	Rancho La Costa Preserve, Middle San Marcos Creek	Center for Natural Lands Management	Yes	Moderate	Natural	2	1	1	2	6	Good	Yes	Wet		*Trachemys scripta* *Micropterus salmoides*
	Rancho La Costa Preserve, Box Canyon	Center for Natural Lands Management	Yes	Low	Natural	2	2	2	2	8	High	Yes	Wet		*Trachemys scripta* *Micropterus salmoides*
	Rancho La Costa Preserve, Lower San Marcos Creek	Center for Natural Lands Management	Yes	Low	Natural	2	1	1	1	5	Good	Yes	Wet		*Lepomis* spp.
	Batiquitos Lagoon Ecological Reserve	California Department of Fish and Wildlife	Yes	Moderate	Modified Natural	2	2	1	1	6	Good	Yes	Wet		
	Carrillo Ranch	Center for Natural Lands Management	Yes	Moderate	Modified Natural	-	-	-	-	-	Poor	No	Dry		
	Rancho Carrillo	Rancho Carrillo Homeowners Association	Yes	Moderate	Modified Natural	1	1	0	1	3	Marginal	Yes	Wet		
	Cottonwood Creek Park	City of Encinitas	Yes	High	Artificial	1	0	1	0	2	Poor	Yes	Wet		
	Moonlight State Beach	State of California	Yes	High	Artificial	1	1	0	0	2	Poor	Yes	Wet		
	Discovery Lake	City of San Marcos	Yes	High	Artificial	2	2	1	1	6	Good	Yes	Wet		*Trachemys scripta* *Lepomis* spp.
	South Lake	Vallecitos Water District/City of San Marcos	Yes	Low	Modified Natural	2	2	1	1	6	Good	Yes	Wet		*Micropterus salmoides*

Table 4 (continued).

Watershed	Site	Landowner/Manager	Conserved Lands Database?	Level of Human Access	Naturalness of Site	Basking Sites	Aquatic Refugia	Streamside Refugia	Upland Nesting Habitat	Habitat Quality Total	Habitat Quality Rating	Water ≥.5m	Wet/Dry Initial Survey	Aquatic Natives Observed	Aquatic Nonnatives Observed
Escondido Creek	Harmony Grove	Escondido Creek Conservancy	Yes	Low	Natural	2	2	2	2	8	High	Yes	Wet		*Micropterus salmoides*
	Elfin Glen	Escondido Creek Conservancy	Yes	Low	Natural	2	2	2	2	8	High	Yes	Wet		*Trachemys scripta* *Micropterus salmoides* *Ameiurus* spp.
	Wildflower Estates	Escondido Creek Conservancy	Yes	Low	Natural	2	2	2	1	7	High	Yes	Wet		*Trachemys scripta* *Micropterus salmoides* *Ameiurus* spp.
	Little Oaks	City of Encinitas/San Elijo Lagoon Conservancy	Yes	High	Modified Natural	-	-	-	-	-	Poor	No	Dry		
	Lower Escondido Creek	San Elijo Lagoon Conservancy	Yes	Moderate	Modified Natural	-	-	-	-	-	Poor	No	Dry		
	El Mirlo Ponds	Private/County of San Diego	Partial	Low	Modified Natural	1	1	1	1	4	Marginal	Yes	Wet		
	San Elijo Lagoon Ecological Reserve	California Department of Fish and Wildlife	Yes	High	Modified Natural	2	1	1	2	6	Good	Yes	Wet		*Procambarus* spp.
	Copper Creek	Center for Natural Lands Management	Yes	Low	Natural	2	2	2	2	8	High	Yes	Wet		*Procambarus* spp.

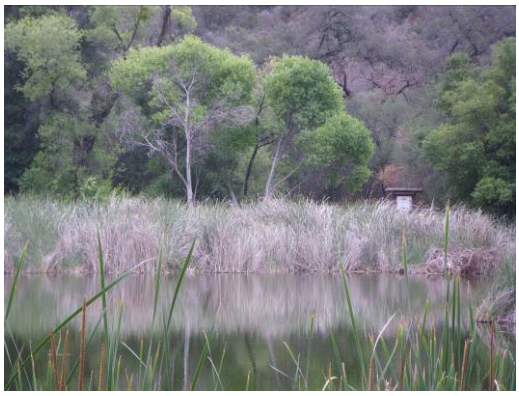
APPENDIX B

Site and captured species photographs, organized by watershed.

Site and Captured Species Photographs

San Luis Rey River Site Watershed

Wilderness Gardens Preserve



Hanson Ponds

San Luis Rey River Park

San Luis Rey River Trail



Rosemary Mountain Quarry-North River Unit


Los Jilgueros Preserve

Wilmont Ranch/ Morro Hills/ Arrowood Golf Course

Foss Lake Preserve, Pilgrim Creek Tributary

Foss Lake Preserve, Lake

Pilgrim Creek Ecological Reserve

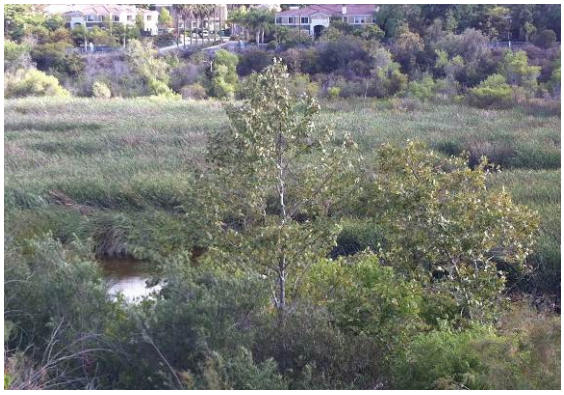
Anstine-Audubon Preserve

Guajome County Park, Guajome Lake

Guajome County Park, Ponds

Libby Lake Park

Talone Lake

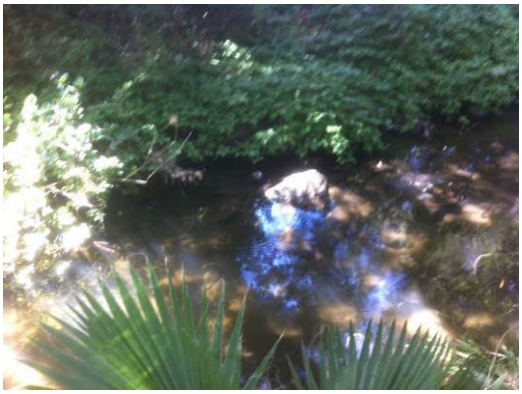


Loma Alta Creek Watershed

Rancho del Oro Preserve

Buena Vista Creek Watershed

Buena Vista Creek



Buena Vista ER

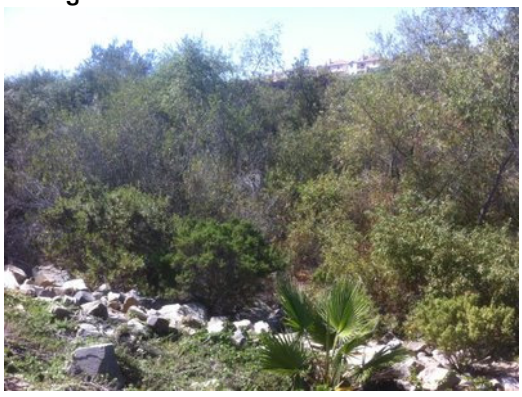
Buena Vista Lagoon

Agua Hedionda Creek Watershed

Las Posas Pond

Dawson Los Monos Reserve

Village Pond



Agua Hedionda Creek Mouth

Upper Calavera Creek

Lake Calavera Preserve

Carlsbad Oaks Preserve, Faraday Pond

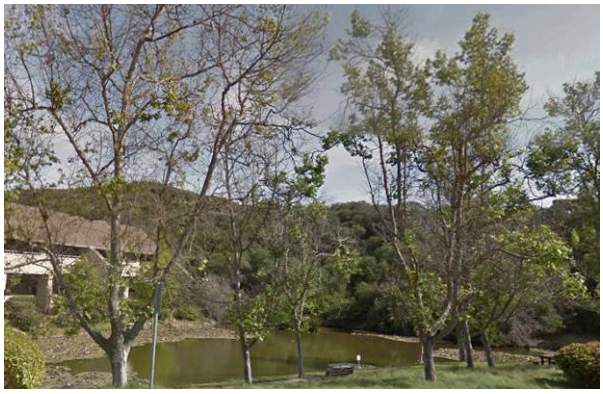
Carlsbad Oaks Preserve, Agua Hedionda Creek Tributary



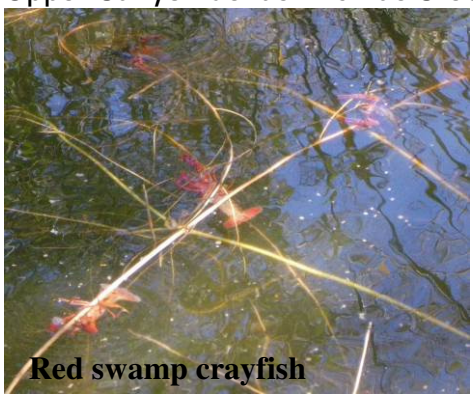
Agua Hedionda Creek Falls

Canyon de las Encinas Creek Watershed

Palomar Oaks Pond



Upper Canyon de las Encinas Creek



Lower Canyon de las Encinas Creek

Canyon de las Encinas Palms

Canyon de las Encinas Marsh



San Marcos Creek Watershed

Jack's Pond

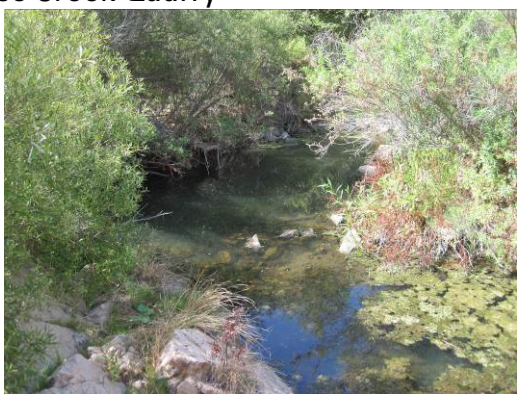
San Marcos Creek Ponds I



San Marcos Creek Ponds II

Upper San Marcos Creek

Rancho La Costa Preserve, San Marcos Creek Quarry



Rancho La Costa Preserve, Middle San Marcos Creek

Rancho La Costa Preserve, Box Canyon

Rancho La Costa Preserve, Lower San Marcos Creek

Basking Red-eared Sliders

Cottonwood Creek Park



Moonlight State Beach



Discovery Lake



Escondido Creek Watershed

Harmony Grove



Elfin Glen



Red-eared slider

Wildflower Estates


Little Oaks

Lower Escondido Creek

El Mirlo Ponds

Copper Creek

APPENDIX C

Dates of western pond turtle visual and trapping surveys, 2012-2014.

Table 5. Western pond turtle visual and trapping survey dates. Sites were typically visually surveyed once and trapped either one time, two times, or not at all based on the presence of suitable habitat or the presence of western pond turtles.

Watershed	Site	Dates of Visual Surveys	Dates of First Trapping	Dates of Second Trapping
San Luis Rey River	Wilderness Gardens Preserve	30 Sept 2014 21 May 2015	--	--
	Hanson Ponds	5 Aug 2013	5-9 Aug 2013	
	San Luis Rey River Park	8 Aug 2013 30 Sept 2014 28 April 2015	--	--
	San Luis Rey River Trail	8 Aug 2013	--	--
	Rosemary's Mountain Quarry-North River Unit	24 Sept 2012 8 Aug 2013	--	--
	Los Jilgueros Preserve	3 Nov 2012 9 Feb 2015	--	--
	Wilmont Ranch/ Morro Hills/ Arrowood Golf Course	24 Sept 2012 11 Sept 2013	--	--
	Foss Lake Preserve, Pilgrim Creek Tributary	24 Sept 2012 10 July 2013 14 Aug 2014	22-26 July 2013	11-13 Sept 2013
	Foss Lake Preserve, Lake	10 July 2013 14 Aug 2014	22-26 July 2013	11-13 Sept 2013
	Pilgrim Creek Ecological Reserve	11-Sep-13	--	--
	Anstine-Audubon Preserve	19 June 2014	--	--
	Guajome County Park, Guajome Lake	8 Aug 2013	--	--
	Guajome County Park, Ponds	8 Aug 2013	--	--
	Libby Lake Park	10 July 2013	--	--
	Talone Lake	--	--	--
	Santa Fe Pond	8 Aug 2013	--	--
Loma Alta Creek	Rancho del Oro Preserve	24 Sept 2012 22 Aug 2013	--	--
	Loma Alta Slough	24 Sept 2012 22 Aug 2013	--	--
Buena Vista Creek	Buena Vista Creek Channel	24 Sept 2012 15 Aug 2013	--	--
	Buena Vista Creek Ecological Reserve	24 Sept 2012 15 Aug 2013	27-31 Aug 2014	--
	Buena Vista Lagoon Ecological Reserve	24 Sept 2012 15 Aug 2013	27-31 Aug 2013	--

Table 5 (continued).

Watershed	Site	Dates of Visual Surveys	Dates of First Trapping	Dates of Second Trapping
Agua Hedionda Creek	North Las Posas Pond	25 Sept 2014	--	--
	Las Posas Pond	25 Sept 2014	--	--
	Dawson Los Monos Reserve	10 Sept 2013	--	--
	Buena Vista Pond	10 Sept 2013	--	--
	Village Pond	24 Sept 2012	--	--
	Agua Hedionda Creek Mouth	24 Sept 2012 10 Sept 2013	--	--
	Agua Hedionda Lagoon	10 Sept 2013	--	--
	Upper Calavera Creek	24 Sept 2012 10 July 2013 15 Aug 2013	8-12 July 2013	20-25 Aug 2013
	Lake Calavera Preserve	24 Sept 2012 10 July 2013 15 Aug 2013	8-12 July 2013	20-25 Aug 2013
	Carlsbad Oaks Preserve, Faraday Pond	24 July 2013	--	--
	Carlsbad Oaks Preserve, Agua Hedionda Creek Tributary	24 July 2013	--	--
	Agua Hedionda Creek Falls	24 July 2013	--	--
Canyon de las Encinas Creek	Palomar Oaks Pond	25 Sept 2014	--	--
	Upper Canyon de las Encinas Creek	25 Sept 2014	--	--
	Lower Canyon de las Encinas Creek	25 Sept 2014	--	--
	Canyon de las Encinas Palms	25 Sept 2014	--	--
	Canyon de las Encinas Marsh	25 Sept 2014	--	--

Table 5 (continued).

Watershed	Site	Dates of Visual Surveys	Dates of First Trapping	Dates of Second Trapping
San Marcos Creek	Jack's Pond	23 April 2012	--	--
	San Marcos Creek Ponds I	22 Aug 2013	--	--
	San Marcos Creek Ponds II	22 Aug 2013	--	--
	Upper San Marcos Creek	9 Aug 2012 22 Aug 2013	--	--
	Lake San Marcos	9 Aug 2012	--	--
	Rancho La Costa Preserve, San Marcos Creek Quarry	24 Sept 2012 22 July 2013	22-23 July 2013	--
	Rancho La Costa Preserve, Middle San Marcos Creek	24 Sept 2012 22 July 2013	--	--
	Rancho La Costa Preserve, Box Canyon	24 Sept 2012 22 July 2013	--	--
	Rancho La Costa Preserve, Lower San Marcos Creek	24 Sept 2012 22 July 2013	22-23 July 2013	--
	Batiquitos Lagoon Ecological Reserve	9 Aug 2012	--	--
	Carrillo Ranch	24 July 2013	--	--
	Rancho Carrillo	24 July 2013	--	--
	Cottonwood Creek Park	25 Sept 2014	--	--
	Moonlight State Beach	25 Sept 2014	--	--
	Discovery Lake	15 Aug 2013	--	--
	South Lake	15 Aug 2013	--	--
Escondido Creek	Harmony Grove	19 Sept 2014	--	--
	Elfin Glen	13 Aug 2014	15-19 Sept 2014	--
	Wildflower Estates	13 Aug 2014	15-19 Sept 2014	--
	Little Oaks	9 Aug 2012	--	--
	Lower Escondido Creek	9 Aug 2012	--	--
	El Mirlo Ponds	9 Aug 2012	--	--
	San Elijo Lagoon Ecological Reserve	9 Aug 2012	--	--
	Copper Creek	24 Sept 2012 10 July 2013	8-12 July 2013	--