Distribution and Status of the Arroyo Toad (*Bufo californicus*) and Western Pond Turtle (*Emys marmorata*) in the San Diego MSCP and Surrounding Areas

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County of San Diego

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

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By Melanie C. Madden-Smith[1], Edward L. Ervin[2], Kathie P. Meyer[3], Stacie A. Hathaway[1], and Robert N. Fisher[1]

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[1]San Diego Field Station
USGS Western Ecological Research Center
5745 Kearny Villa Road, Suite M
San Diego, CA 92123

[2]Current address:
Merkel & Associates, Inc.
5434 Ruffin Rd.
San Diego, CA 92123

[3]Current address:
USFS- San Bernardino National Forest
Front Country Ranger District
1209 Lytle Creek Road
Lytle Creek, CA 92358

Sacramento, California

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U.S. DEPARTMENT OF THE INTERIOR
GALE A. NORTON, SECRETARY

U.S. GEOLOGICAL SURVEY
P. Patrick Leahy, Acting Director

For additional information, contact:

Center Director
Western Ecological Research Center
3020 State University Dr. East
Modoc Hall, Room 3006
Sacramento, CA 95819

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Abstract

Rapid urbanization has led to the loss and degradation of riparian habitats within the Southern California Coastal Sage Scrub Region. In response to the need to protect and manage riparian and other sensitive habitats in southern California, the Natural Communities Conservation Planning (NCCP) Act was enacted in 1992. The San Diego County subregional plan under the NCCP is the San Diego County Multiple Species Conservation Program (MSCP). The MSCP has been designated to protect such sensitive species as the arroyo toad (*Bufo californicus*) and western pond turtle (*Emys marmorata*) within its boundaries by preserving lands with known populations, controlling non-native species, minimizing human impacts, and restoring or enhancing native habitats. Direct habitat loss in conjunction with hydrological alterations and the introduction of non-native species has caused the arroyo toad to disappear from about 75% of previously occupied habitat (Jennings & Hayes 1994) and has resulted in a decrease in the number of viable populations of the western pond turtle in southern California (Brattstrom & Messer 1988; Jennings et al. 1992; Jennings & Hayes 1994). Prior to this study, little was known about the current status and distribution of the arroyo toad and the western pond turtle within the San Diego MSCP lands.

In 2002 and 2003 the U. S. Geological Survey conducted focused surveys for the arroyo toad and western pond turtle within nine watersheds of San Diego County, eight of which fall within the MSCP boundaries. Daytime arroyo toad habitat surveys were conducted at 39 sites. Eighteen of these sites were determined to have potential for supporting arroyo toads because of the presence of suitable habitat and/or the close proximity of historical locality record(s) and were surveyed nocturnally for the presence of arroyo toads. Arroyo toads were located at five sites, all but one were previously known locations and all were within the MSCP boundaries. Visual and/or trapping surveys were conducted for western pond turtles at 68 sites for a total of 67 visual and 45 trapping surveys. Western pond turtles were detected at nine sites, six of which are within the MSCP boundaries, and all locations but one were previously known. Population sizes of both species appear to be small. Although mark-recapture data were not collected for arroyo toads and it is not possible to make population estimates, 18 was the largest number of arroyo toads detected at a site during the course of the study. Mark-recapture data were collected

for western pond turtles and the largest population was estimated to have a minimum of 38 individuals and a maximum of 80 individuals (Poisson 95% confidence limit; true lower limit is 30 individuals). Additionally, non-native aquatic species, many known to be predatory or harmful to arroyo toads and/or western pond turtles, were detected at 23 sites surveyed for arroyo toads and 51 sites surveyed for pond turtles. Most remarkable was the distribution and abundance of non-native turtles, which occurred at 25 sites. It is likely that these wild non-native turtles were sold as pets and subsequently released. Western pond turtles and non-native turtles were found to co-occur at four of these sites, all within the MSCP boundaries, and many of the sites that contained non-native turtles were known or possible historic locations for western pond turtles. Furthermore, results showed that western pond turtles are more likely to occur at more natural sites with limited human access, while non-native turtles are more likely to occur at artificially modified sites that are heavily accessed by humans. Some species of non-native turtles, such as the red-eared slider (*Trachemys scripta elegans*), are known to have established breeding populations outside of their native range. Based on the numbers and size ranges of the non-native turtle species observed during this study, especially the red-eared slider, it appears these species may be breeding successfully at some locations. Currently, the threats posed by non-native turtles are not certain, but may include their serving as vectors for disease and parasites as well as competing for critical resources, including basking sites and food.

1. Introduction

California leads the nation in riparian habitat loss with fewer than ten percent of the historic habitat remaining (Dahl 1990). In 1988 the California Department of Parks and Recreation reported that California had lost approximately 95 percent of riparian wetlands, 90 percent of freshwater marshes and 90 percent of the vernal pools (CDPR 1988). Similar to statewide losses, 90 to 95 percent of southern California riparian ecosystems have been eliminated (Faber et al. 1989). Much of the aquatic and riparian habitat that exists in California today is either degraded or human-made (USFS 2000) & low-elevations streams (<1000 meters) are especially impacted (Hunter 1999). Like many areas in southern California, high levels of urbanization driven by large human population pressures have lead to significant declines in the number, size, connectivity, and quality of riparian habitats in San Diego (Wheeler & Fancher 1984). Riparian ecosystems only occupy between 0.2 percent and 0.5 percent of the total land area in San Diego County (Wheeler & Fancher 1984) and had been reduced by 40 percent of their historic coverage by the late 1980's (CDPR 1988).

Many animal species are to some extent dependant on riparian habitats and have been impacted by the significant decline in these habitats. For example, riparian habitats support 83% of the amphibian and 40% of the reptile species in California (Brode & Bury 1984). Fifty-five percent of the animals and 25% of the plants designated as threatened or endangered by the State of California are dependant on riparian habitats for their survival (Ferren et al. 1996).

In response to the need to protect and manage riparian ecosystems and other sensitive habitat for native species and better balance the loss of wildlife and habitat with human needs for development in the Southern California Coastal Sage Scrub Region, the state of California enacted the Natural Communities Conservation Planning (NCCP) Act in 1992. Under the NCCP the state government establishes agreements with landowners, local governments, and other stakeholders to identify the most important areas to set aside for threatened or endangered species in exchange for state permitted "take" of a covered species (MSCP Web Portal 2005). The federal government has a similar plan under Section 10A of the Endangered Species Act (1973) which involves creating Habitat Conservation Plans (HCP) (MSCP Web Portal 2005). Wildlife agencies in California have combined the NCCP and HCP process to provide permits for listed species (MSCP Web Portal 2005). In addition, local governments can lead in developing these plans and receive state and federal permits (MSCP Web Portal 2005). In San Diego County the sub-region NCCP program is known as the San Diego Multiple Species Conservation Program (MSCP). The San Diego MSCP is a long-term habitat conservation plan which addresses the needs of multiple species and the preservation of natural vegetation communities in San Diego County while taking into account the potential impacts of urban growth, natural habitat loss and species endangerment and creates a management plan to mitigate for the potential loss of a MSCP covered species and their habitat due to these potential impacts (MSCP Subarea Plan 1997). A total of 85 species (46 plant and 39 animal) are covered by the San Diego MSCP and most have some level of state or federal protection. Under the San Diego MSCP, species that are not state or federally protected have regulatory protection for development projects and requirements for management and adaptive monitoring. Further protection is provided by the wetlands section of the Resource Protection Ordinance of the County of San Diego (1991) which has a no-net-loss standard. Information about the status, distribution and basic biology of some of the San Diego MSCP covered species is limited and initial studies are being conducted to determine their current status and distribution throughout the MSCP reserve. The baseline information collected in these studies will be used to develop management plans for the covered species.

Two such species are the arroyo toad (*Bufo californicus*) and the western pond turtle (*Emys marmorata,* formerly referred to as *Clemmys marmorata* and from here on referred to as "pond turtle" in the text). The arroyo toad and pond turtle differ in their use and reliance on wetland habitats, but both species have been significantly affected by riparian degradation and loss (Jennings & Hayes 1994). In addition, both species rely on terrestrial habitats and have been further affected by the degradation and loss of such habitats. USGS was contracted by the County of San Diego through a local assistance grant funded by the California Department of Fish and Game to conduct baseline surveys for the arroyo toad and the pond turtle in the San Diego MSCP. The data collected during these surveys, including the current status and distribution of these species and possible impacts affecting them, will help facilitate land managers in identifying specific areas to protect and manage for these species.

1.1 Arroyo Toad

The arroyo toad, a small (55-82 millimeters snout to urostyle), dark-spotted toad of the family Bufonidae, is a mostly terrestrial species that uses streams primarily during the breeding season in January to September (dates range depending on precipitation and location) (USFWS 1999a) (Figure 1). The arroyo toad is considered to have the most specialized habitat requirements of any amphibian found in California and its distribution is naturally limited because of these requirements (Jennings & Hayes 1994). Arroyo toads breed only in shallow, slow-moving water in riparian habitats that are typically disturbed naturally on a regular basis by flooding (USFWS 1999a). Sweet (1992) describes the major characteristics of arroyo toad breeding pools as: "proximity to sandy terrace habitat; minimal current; majority of pool < 1 inch deep; substrate of sand, gravel, or pebbles; gently sloping shoreline, or central bar; and bordering vegetation low or set back such that most of the pool is open to the sky." Unlike most western species of *Bufo* that will initiate breeding after rain events and often breed in ponds and standing water, the arroyo toad waits to initiate breeding until the above conditions exist (Sweet 1992; USFWS 1999a). Because of the arroyo toad's naturally limited distribution, the small size of most populations, and the fact that the arroyo toad is specialized in such a stochastically fluctuating habitat, the additional stress of habitat degradation and loss from manmade factors and predation by non-native species has lead to its disappearance in 75 percent of the previously occupied habitat in California (Jennings & Hayes 1994).

Due to its drastic decline, the arroyo toad was listed as an endangered species under the Federal Endangered Species Act on December 16, 1994 (USFWS 1994, Federal Register 59(241):64859-64867) and in 2001, 22 riparian land units were designated as critical habitat for the arroyo toad (USFWS 2001, Federal Register 66(26):9414-9474). As a result of litigation against the U. S. Fish and Wildlife Service (USFWS) and the acquisition of new survey data for the arroyo toad, critical habitat designation was re-proposed for the 22 riparian land units in 2004 (USFWS 2004, Federal Register 69(82):23254-23328) and in 2005 a new final rule was published (USFWS 2005, Federal Register 70(70):19562-19633). The new final rule states that all essential lands within San Diego County are excluded from critical habitat designation for economic reasons (USFWS 2005). USFWS states that while habitat protection is necessary for species conservation, in most cased the designation of critical habitat is of little additional value for listed species, yet is costly (USFWS 2005).

The decline of the arroyo toad is considered largely due to the degradation and destruction of breeding and upland habitat as a result of urban development, agriculture, mining, roads, livestock grazing, recreational activities, introduced plants and animals, and natural (e.g., droughts, floods) and unnatural (e.g., fire due to human activities) disturbances and particularly, dam construction and operation (Sweet 1992; USFWS 1994; Campbell et al. 1996; USFWS 1999a). Dam construction and operation has been considered one of the greatest impacts on the arroyo toad. Approximately 40% of the estimated original range of the toad has been lost to dam construction, including at least 25 large reservoirs that have inundated over 190 kilometers (120 miles) of suitable upland and breeding habitat (USFWS 1994; Campbell et al. 1996; USFWS 1999a). In San Diego County, there are 56 dams within the jurisdiction of the State of California's Department of Water Resources (CDWR 1993) and nearly all drainages that contain arroyo toads within San Diego County have been dammed. As a result of the habitat degradation and loss that has occurred in San Diego County, arroyo toad populations within the MSCP have been greatly reduced and are highly fragmented.

1.2 Western Pond Turtle

The pond turtle, a shy drab-colored turtle of the Emydidae family, is the only turtle native to coastal California (Figure 2). Unlike the arroyo toad, the pond turtle is a habitat generalist and inhabits many types of water bodies ranging from permanent to intermittent and from freshwater to brackish environments (Holland 1991, 1994; Buskirk 2002). Pond turtles are known to inhabit creeks, slow moving rivers, marshes, ponds, lakes, reservoirs, vernal pools, canals and even sewage treatment plants (Stebbins 1985; Holland 1991; Ernst et. al 1994; Reese 1996) and prefer habitats with slow flowing water with the presence of woody or rocky debris that provide emergent and underwater refugia sites (Reese 1996; Reese & Welsh 1998b; Buskirk 2002). Historically, it was common in most major coast-facing drainages and had a relatively continuous distribution from Washington to northern Baja California, with a few scattered isolated populations elsewhere (Storer 1930; Stebbins 1985; Ernst et al. 1994; Jennings & Hayes 1994). In southern California, pond turtles were once widespread and common (Brattstrom 1988; Brattstrom & Messer 1988) and were once quite abundant in some portions of coastal San Diego County (Brattstrom & Messer 1988).

The pond turtle is in a general state of decline throughout much of its range (Brattstrom & Messer 1988; Holland 1991; Jennings & Hayes 1994; Gray 1995; Janzen et al. 1997). Bury (in press) estimates the pond turtle has declined in 95% to 99% of its range. In the late 1980's, work by Brattstrom and Messer (1988) suggested that only a few viable populations of pond turtles remained in southern California because they only observed pond turtles in 53 locations (compared to a known 87 known sites described in historical records). They also found that in areas where pond turtles remained, the number of individuals at many of these sites was low (1-5 individuals observed). Despite the apparent decline in the southern portion of the species range, the pond turtle is only considered a Federal Species of Concern by the U. S. Fish and Wildlife Service (USFWS) and protected as a California Species of Concern by the California Department of Fish and Game (CDFG). In San Diego, the pond turtle has been designated regulatory protection for development projects and requirements for management and adaptive monitoring under the San Diego MSCP. Further protection is provided by the wetlands section of the Resource Protection Ordinance of the County of San Diego (1991) which has a no-net-loss standard for habitat that might be occupied by pond turtles.

Similar to the arroyo toad, the principal cause of decline in the pond turtle is riparian and terrestrial habitat loss and degradation, although historically pond turtles were also widely used for food. Pond turtles are mostly aquatic, but will leave water to travel to surrounding upland habitats to nest, over-winter, bask and aestivate (Holland 1991; Reese 1996; Reese & Welsh 1998a; Lovich & Meyer 2002; Rathbun et al. 2002). Although it is clear that pond turtles rely on these terrestrial environments to meet their life history requirements, the amount of time that they spend in these areas and the distance they travel from water is poorly known in the arid southern portion of its range (except see Goodman 1997a). Additionally, many of the streams in San Diego County have been dammed (Brattstrom & Messer 1988; CDWR 1993) and the reaches below these dams are more vulnerable to going dry than systems without dams. During dry years and drought periods, water courses with drinking water reservoirs upstream (most reservoirs in San Diego County are drinking water reservoirs) are more likely to go dry below the dam during the summer months and drought periods below the dam may be extended due to the need to maximize water capture by drinking water reservoirs (Madden-Smith et al. 2004). In addition, due to fluctuating water levels, which can affect shoreline vegetation and invertebrate communities, reservoirs may not provide optimal habitat to pond turtles. It is not known how long pond turtles can survive during extended periods of drought. Turtles in general have delayed sexual maturity and low reproductive output, making them vulnerable to increased mortality, thus human activities (e.g., habitat alteration, dam operations) may cause rapid declines and recovery may be very slow (Brooks et al. 1991). Small populations are particularly sensitive to both human and natural disturbance (Dodd 1990).

1.3 Objectives

The San Diego MSCP Subarea Plan objectives for the arroyo toad and pond turtle involve minimizing impacts to riparian and upland habitats, minimizing human impacts, controlling non-native species and restoring/enhancing habitat. For arroyo toads the MSCP Plan (1996) specifically states that:

> "Area specific management directives must address the maintenance of arroyo toad through control of non-native predators, protection and maintenance of sufficient suitable low gradient habitat (including, appropriate water quality) to meet breeding requirements, and preservation of sheltering and foraging habitat within the reserve within 1 kilometer of occupied breeding habitat within preserved lands. Area specific management directives must include measures to control human impacts to the species within the preserve (e.g., public education, patrols)."

Additionally, the plan requires that indirect effects resulting in habitat degradation outside of the preserve are to be offset through management within the preserve (USFWS 1998). Similarly, for the purpose of protecting pond turtles, the MSCP Plan (1996) states,

> "Maintain and manage areas within 1500 feet around known locations within preserve lands for the species. Within this impact avoidance area, human impacts will be minimized, non-native species detrimental to pond turtles will be controlled, and habitat restoration/enhancement measures will be implemented."

The initial step in fulfilling these MSCP Plan requirements is the collection of baseline data on arroyo toads and pond turtles within the MSCP preserve. In 2002 and 2003 surveys were conducted for both species within the San Diego MSCP and surrounding areas with the following objectives in mind:

1. Identify habitat most likely to support the arroyo toad and pond turtle within the San Diego MSCP and perform daytime habitat surveys to assess habitat suitability;

2. Determine the current status and distribution of the arroyo toad and pond turtle within the San Diego MSCP;

3. Determine the current distribution of non-native predatory species known or expected to be detrimental to the arroyo toad and pond turtle;

4. Identify human disturbances and other negative impacts to habitat at each survey site; and

5. Provide management recommendations based on findings in this study.

2. Study Area

The majority of the sites surveyed fall within the boundaries of the County of San Diego MSCP Subarea Plan and many of the sites are covered by the San Diego MSCP. The MSCP covers a total of 582,243 acres within San Diego County (Figure 3) and approximately 43% (252,132 acres) of the total area is unincorporated land under the jurisdiction of San Diego County (MSCP Plan 1996). The total number of acres given here does not include the City of Chula Vista's recently annexed portion of Otay Ranch. The MSCP Subarea Plan is broken down into three segments: Lake Hodges, Metro-Lakeside-Jamul, and South County. Surveys were conducted within each of the three segments.

A total of nine watersheds were covered during this study, eight of which fall within the boundaries of the San Diego MSCP. A watershed was defined as an area of land that drains into a particular body of water, in this case the Pacific Ocean. Below are brief descriptions of the nine watersheds (listed from north to south) based mainly on information gathered from the California Coastal Conservancy (2001) Southern California Wetlands Recovery Project Information Station online database and field experience.

Escondido Creek watershed: Encompasses approximately 124 square kilometers and includes the major tributaries of Escondido Creek and La Orilla Creek. Escondido Creek discharges into San Elijo Lagoon.

San Dieguito River watershed: Encompasses approximately 563 square kilometers, 486 of which are behind dams. The two major dams are Lake Hodges and Lake Sutherland. There are three tributaries that join the San Dieguito River below the dams. The flow of the river is intermittent and the riverbed upstream from tidal influence is often dry.

Los Peñasquitos Creek watershed: Encompasses approximately 486 square kilometers, extending from Poway (inland) to Torrey Pines State Park in the Soledad Valley. The tributaries, Los Peñasquitos Creek and Carmel Creek, flow year-round due to urban runoff.

Rose Creek watershed: Includes Rose Creek and is joined by the San Clemente Canyon drainage before it discharges into Mission Bay at the Rose Inlet. Rose Creek flows year-round due to urban runoff and flow in the San Clemente Canyon drainage is intermittent. The drainage area was not determined for this watershed.

San Diego River watershed: Encompasses approximately 708 square kilometers. The river runs through rural, suburban and urban lands and discharges just south of Mission Bay. There are four major dams within the San Diego River watershed: El Capitan on the San Diego River and San Vicente, Lake Jennings, and Cuyamaca on tributaries. These reservoirs store water that is both local and imported from the Colorado River.

Chollas Creek watershed: Includes Chollas Creek and some unnamed drainages which flow into the creek. Chollas Creek is an urban drainage which flows from the Chollas Valley through the Pueblo Lands of San Diego and discharges into San Diego Bay. The drainage area was not determined for this watershed.

Sweetwater River watershed: Encompasses approximately 370 square kilometers. The river runs through rural, suburban and urban lands and discharges into San Diego Bay.

There are two major dams on the Sweetwater River, forming Loveland Reservoir and Sweetwater Reservoir. Sweetwater Reservoir is composed of local runoff and imported water from northern California and the Colorado River. Loveland Reservoir is local runoff only at this time.

Otay River watershed: Encompasses approximately 257 square kilometers. The river runs through rural, suburban and urban lands and discharges into San Diego Bay. There is one major dam on the Otay River, the Savage Dam which forms the Lower Otay Reservoir. The Lower Otay Reservoir is the terminus of the second San Diego Aquaduct.

Tijuana River watershed: Encompasses approximately 2735 square kilometers (2003 in Mexico and 732 in the United States). The major drainages include Cottonwood Creek and Campo Creeks in the United States and the Rio Las Palmas in Mexico. The watershed contains three major dams, the Morena Dam and Barrett Dam on Cottonwood Creek in the United States and the Rodriguez Dam in Mexico. The Tijuana River is highly polluted by industrial runoff and waste from Mexico.

3. Methods

Habitat assessment and surveys for the arroyo toads and pond turtle were conducted at as many riparian preserves as possible within the MSCP and surrounding areas. For logistical and recording purposes, areas identified on maps were broken into discrete sampling units by political boundaries and differences in the type of system (i.e., an area such as Mission Trails Regional Park that contained both a lacustrine and a riparian system was defined as two survey sites). Management areas such as Hollenbeck Canyon Wildlife Area were divided into separate drainage units (e.g., Jamul Creek, Hollenbeck Creek, Dulzura Creek, Pringle Creek, and Honey Springs drainage) and were all treated as separate survey sites. Figure 4 shows a map of sites surveyed in 2002 and 2003. Table 1 represents a breakdown of sites surveyed for each species and includes information on ownership and whether or not a site was within the San Diego MSCP boundaries.

3.1 Arroyo Toad

The design of this study was based on an extensive approach at a regional scale, surveying a number of sites across a large area (i.e., San Diego MSCP Subarea), compared to an intensive approach, with a greater survey effort focused at fewer sites. Quantitative measurements of many habitat variables at all sites were beyond the scope of this study. To maximize the usefulness of resources, a multi-step filtering process recently developed by USGS (based on USFWS and U. S. Forest Service (USFS) arroyo toad protocols) to obtain a single habitat rating for each site was used (Ervin & Fisher 1999). This habitat quality rating serves as a measure of predicting the likelihood of the arroyo toad occurring at sites and provides an efficient system for the sites to be ranked in terms of priority for follow-up focused nighttime surveys.

The three characteristics most commonly associated with arroyo toad breeding habitat include: 1) sandy channel substrate, 2) adjacent open sandy terraces, and 3) channel braiding, all of which are associated with low stream gradients (i.e., $\leq$ 3 %) and thus lower flow velocities

(Sweet 1992; Campbell et al. 1996; Barto 1999) (Figure 5). Water flow is a function of gradient and lower stream gradients contain greater amounts of habitat features that are highly correlated with suitable arroyo toad breeding habitat. Consequently, it can be assumed that if these characteristics are present (sandy substrate, sandy terraces, and channel braiding), there will be low channel gradient. In addition, the reverse may also be true (i.e., if the channel gradient is low these characteristics may exist). A low gradient reach (≤ 3%) with a sandy depositional substrate often results in conditions conducive to the formation of required seasonal quiet backwater breeding pools (Sweet 1992; Jennings & Hayes 1994; Campbell et al. 1996). The habitat quality rating used in this study is based on the presence of the three characteristics most commonly associated with arroyo toad habitat.

The multi-step process used in this study includes the following steps:

1. Assess drainages that could potentially contain suitable arroyo toad habitat (i.e., lotic habitat with low gradient) using USGS 7.5 minute series topographic maps.

2. Survey (ground truth) the selected drainages, identify the areas of suitable arroyo toad habitat, and then rate them in terms of habitat quality (*high, good, marginal,* or *poor*) in accordance with the toad's life history requirements.

3. Conduct nocturnal presence surveys (visual and aural) for arroyo toads, only at sites that contained suitable habitat (*high quality* or *good quality*) or had historic records for arroyo toads or arroyo toad habitat, in search of any of the various behaviors/life history stages (i.e., calling males, egg strings, larvae, metamorphic individuals (metamorphs), and foraging juveniles and adults in riparian and upland habitats).

4. Record all non-native species and other possible impacts observed during both daytime habitat assessment and nocturnal encounter surveys.

3.1.1 Initial Site Selection

Criteria used for initial site selection consisted of identifying sites that contained lotic habitat (i.e., stream, creek, and river), with a low gradient. This habitat feature was easily determined from USGS topographic maps. With the use of TOPO!® California seamless USGS topographic maps on CD-ROM (National Geographic 2003), USGS 7.5 minute series topographic maps of potential study sites were examined and all drainage reaches with low gradients were identified as potentially suitable arroyo toad breeding habitat.

3.1.2 Daytime Habitat Assessment Surveys

The objectives of the daytime habitat assessment survey were to confirm the presence and determine the distribution of suitable breeding and foraging/burrowing habitat within a site. To meet these objectives daytime habitat assessment surveys (ground truthing) were conducted along all potentially suitable drainages at least once, regardless of stream gradient. This was necessary to verify which reaches contained habitat features of suitable arroyo toad breeding habitat.

The daytime habitat assessment surveys consisted of hiking up stream courses and the adjacent uplands (i.e., terraces and flood plains) and noting physical features known to be associated with suitable arroyo toad habitat. Habitat assessment was based on physical features and channel morphology, and not on the presence of surface water (seasonal breeding pools). Ultimately the classification system used to rate habitat quality was based on the presence of the aforementioned key physical features shown to be highly correlated with the presence of arroyo toad populations (Sweet 1992; Jennings & Hayes 1994; Campbell et al. 1996; Griffin & Case 2002).

Any given drainage, or portion there of, was assigned one of four habitat quality types (*high, good, marginal,* or *poor)* based on the number of the three key physical features determined to be present within a reach:

High: Any given survey reach with *all three* physical features present.

Good: Any given survey reach with *two* of the three physical features present.

Marginal: Any given survey reach with *one* of the three physical features present.

Poor: Any given survey reach with *none* of the three physical features present and unsuitable for arroyo toads.

Figure 6 provides photographic examples of the four habitat quality types.

Daytime habitat assessment surveys were also conducted along several drainage reaches with high gradients to verify the assumption that the key physical habitat features are not associated with steeper gradient reaches. Copper Canyon, Buttewick Canyon and Cedar Canyon on Otay Mountain and Lawson Creek in Sycuan Peak Ecological Preserve are some of the high gradient sites surveyed.

3.1.3 Nocturnal Presence Surveys

Follow-up nocturnal presence surveys were conducted within sites that contained suitable habitat (*high quality* or *good quality* habitat), had historic records for arroyo toads, or historically contained suitable habitat. Determinations of historical records or historical suitable habitat were made through communications with peers and resource managers (C. Smith, personal communication for San Diego River, Mission Trails Regional Park), historical accounts and aerial imagery (White & Greer 2002 for Los Peñasquitos Creek), and museum records of the San Diego Natural History Museum, Los Angeles County Natural History Museum and the University of California Berkeley Museum of Vertebrate Zoology. It is important to point out that the absence of historical records for a site does not necessarily indicate the absence of a species at a site- a particular site may not have been surveyed, a voucher may not have been taken, or records may have never been submitted or published. The purpose in conducting follow-up nocturnal presence surveys in habitats that presumably contained suitable arroyo toad habitat historically was to either confirm the presence of arroyo toads, or in the case of nondetection, increase the confidence of their absence. Some sites that were rated as high or good quality were not surveyed nocturnally due to safety concerns such as the presence of homeless camps or water quality issues. This includes Fairbanks Ranch (surveyed only in 2003 due to presence of many homeless in 2002) and Tijuana River Valley Park (migrant traffic, presence of homeless and water quality).

Nocturnal presence surveys were conducted during the arroyo toad breeding season on three nights per site (except sites surveyed for Sweetwater Authority, which were surveyed for six nights- see section 3.1.4 below) with at least one week between surveys. Six surveys are required by USFWS protocol to conclude the absence of the arroyo toad at a site; however, due to the scale of this study and the need to take an extensive approach, we were precluded from conducting six surveys at every site. Surveys entailed walking along drainages and adjacent upland terraces in search of any of the various behaviors/life history stages (i.e., calling males, egg strings, larvae, metamorphic individuals, and foraging juveniles and adults in riparian and upland habitats) by using multiple cues (direct observation and/or aural detection of calling males). Biologists experienced and familiar with the life history and ecology of the arroyo toad conducted all nocturnal presence surveys. Such experience included the ability to discern between the eggs and the larvae of the western toad (*Bufo boreas*) and the arroyo toad as well as the identification of the male arroyo toad advertisement call. Headlamps with 45,000-candle power were used to provide the required amount of illumination to maximize detection (USFWS 1999b). Age-class, sex (if possible) and GPS coordinates were recorded for each arroyo toad observation. The arroyo toad is restricted to breeding in lotic habitats, with a range of hydroperiods (e.g., perennial, semi-permanent, seasonal, and ephemeral) (Sweet, 1992; USFWS 1999a), therefore nocturnal presence surveys were conducted along riparian corridors irrespective of the presence of surface water. Sites determined to have arroyo toads in 2002 were resurveyed in 2003 to get a better understanding of population size and status. Sites were also resurveyed in 2003, if no arroyo toads were detected in 2002, but suitable habitat or previous records for arroyo toads or arroyo toad habitat existed. Additionally, in 2003 the USGS initiated an arroyo toad skeletochronology study, which overlapped survey efforts for this study (see section 3.1.5 Skeletochronology below) and usually meant additional visits to sites with known arroyo toad populations. The number of visits to the skeletochronology sites was dependent on the number of toads being captured at a site and was not based on a standardized number of surveys as in this study.

Survey efforts were concentrated within habitat patches containing the best high and good quality arroyo toad habitat. These patches offer the greatest opportunity for detection of arroyo toads, presumably due to concentrated resources. For example, sparsely vegetated terraces or flood plains along the channel are prime areas for adults to forage and burrow; eggs and larvae are found in the still-quiet pools used for breeding; and metamorphs are often found on the sandy banks adjacent to suitable breeding habitat where they like to forage and seek refuge in small divots in the damp sand.

Adult arroyo toads may be observed from January through September, depending on location and precipitation, usually corresponding with the period of greatest rainfall for a location. Most observations are made from February through July. Adult arroyo toads are strongly nocturnal, favoring damp/wet substrate for activities above ground and typically avoiding cold and/or extremely dry conditions, and possibly full moon conditions. Considering the primary method of detecting arroyo toads during the nocturnal presence survey was by visual encounter (aural being secondary), search efforts were concentrated during periods with the greatest probability of detecting toads with the least amount effort and under the most favorable environmental conditions (i.e., temperatures above 15 degrees Celsius and less than 95 percent of full moon illumination). The loglinear modeling program, PRESENCE (MacKenzie et al. 2002), was used to estimate the detection probability of arroyo toads using these survey methods.

3.1.4 Sweetwater Authority Study

In 2002, USGS was contracted by the Sweetwater Authority to conduct a risk assessment examining the effects of Loveland Dam operations on the arroyo toad population found below the dam (see Madden-Smith et al. 2004). In 2003, USGS conducted daytime habitat and nocturnal presence surveys for arroyo toads at sites along the Sweetwater River as part of the second phase of this study (Madden-Smith et al. 2005). The sites within the study area fall within the MSCP boundaries and data from these surveys are included in this report. Daytime habitat assessment of this study area was conducted according to the more refined methods developed by USGS in 2003. Nocturnal surveys were conducted in the same manner as those conducted for the MSCP study except a total of six nocturnal surveys were conducted in comparison to the three conducted for the MSCP study. The sites that fall within this study area include: Sycuan Peak Ecological Reserve, Sweetwater River; San Diego National Wildlife Refuge, Sweetwater River; Cottonwood Golf Course along the San Diego National Wildlife Refuge border and Sweetwater River just east of Sweetwater Reservoir.

3.1.5 Skeletochronology

Due to the need to better understand demographics and longevity in the arroyo toad, which is currently thought to live 4-5 years, USGS began a study in 2003 using skeletochronology to age adults at breeding sites. Populations within the MSCP are included in this study, including Cottonwood Creek- Marron Valley; San Dieguito River Valley Park, San Pasqual Valley; San Vicente Creek (south of Kimball Valley); and Boden Canyon Ecological Reserve. Skeletochronology involves the aging of individuals using a sample of bones (Bastien & Leclair 1992), toes were used in this case. This technique allows more accuracy for aging than with pit-tagging alone, because it is not necessary to rely on sites with previously marked toads and the demographics of the population can be identified in one to a few years as opposed to tracking a single cohort or staggering pit-tagging efforts for many years. Thus, breeding site demographics can be investigated for any population where adequate samples can be taken. The purpose of this skeletochronology study is to provide an understanding of the demographics of breeding arroyo toad populations and to provide an initial estimate of arroyo toad longevity. In addition, it may provide the basis for identifying the minimum and maximum breeding age for the arroyo toad. The results may also show that the El Niño climatic events that drive much of the hydrology of southern California could be a major factor in the age structure of this species.

3.2 Western Pond Turtle

3.2.1 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 2002 and 2003 were below normal rainfall years [According to NOAA (2002), the 2001-2002 seasonal rainfall total for San Diego was the lowest since records began back in 1850-1851], 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), 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 2002 were revisited in 2003 to determine if there was enough precipitation to create more suitable habitat. All resurveyed sites deemed unsuitable in 2002 were also found unsuitable in 2003 due to dry conditions from low rainfall and the failure to detect pond turtles.

3.2.2 Habitat Assessment

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 non-native plant species, possible impacts observed and global positioning system (GPS) locations of water features (e.g., pools, ponds) and possible trap locations.

3.2.2.1 Habitat Quality Rating

Based on literature (Bury 1972; Holland 1991; Jennings & Hayes 1994; Reese 1996; Reese & Welsh 1998b; 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 given a qualitative value 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 (similar to the arroyo toad habitat quality ratings) 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 ($\geq$ 1 m) and 2002 and 2003 were low rainfall years, thus it was assumed that during wetter years, pools that were $\geq$ 0.5 meter during 2002 and 2003 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. In addition, pools $\geq$ 0.5 meter were assumed to be more permanent than those < 0.5 m. 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 presence 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.

3.2.2.2 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. The ratings of human access and naturalness were made to explore the following hypotheses (Figure 7):

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 non-native turtles. As the level of human access increases and the level of naturalness decreases, the likelihood of non-native turtles being present increases.

Pond turtles should 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 non-natives, predation by scavengers (e.g., opossums, skunks, raccoons, and dogs), etc. Non-native turtles should 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*, *medium* 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).

Medium: Sites with restricted or limited access, but with a moderate frequency of trespassing (e.g., private reservoirs), sites with access less restricted (e.g., CDFG 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).

After sites were ranked according to human access and naturalness, the number of pond turtle and the number of non-native turtle detections (both visual and trapping detections) for each type of site rating was tallied. Chi-squared analysis was used to determine the significance of differences in detections per category.

3.2.3 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 (Figure 8) 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 non-native turtles were processed similarly to the pond turtles except they were not implanted with a PIT tag nor were they released. All non-native turtles removed from the wild went to the San Diego Natural History Museum to be assessioned as voucher specimens or to the San Diego Turtle and Tortoise Society to be adopted by members of the society. All non-native turtles given to the San Diego Turtle and Tortoise Society were marked with a notch on the right femoral scute, so that if future trapping yielded captures of marked individuals, we would know that they had been re-released. 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. Sites where pond turtles were caught in 2002 were trapped again in 2003 in order to get a better idea of population size and status.

Petersen mark-recapture (using the unbiased estimator) and Poisson confidence intervals as described in Krebs (1999) were used to estimate the pond turtle population size from the trapping mark-recapture data. The loglinear modeling program, PRESENCE (MacKenzie et al. 2002), was used to estimate the detection probability of pond turtles using the trapping survey methods described above.

4. Results and Discussion

4.1 Arroyo Toad

4.1.1 Daytime Habitat Assessment Survey

Daytime habitat assessment surveys were conducted for arroyo toad habitat at 39 sites (Table 2; Figure 9). In most cases, sites were surveyed because they met the minimum criteria established for the determination of whether a site would likely contain suitable arroyo toad habitat (i.e., the presence of lotic habitat and low stream gradient). Some sites, such as Cedar Canyon, O'Neal Canyon, Copper Canyon, and Buttewick Canyon, did not meet the minimum requirement of low stream gradient, but habitat assessment was conducted in order to validate the assumption that stream gradients > 3 % did not support suitable arroyo toad habitat. This assumption proved to be true for these high gradient sites (Appendix 1). Taking into consideration only the highest habitat quality rating for a site, of the 39 sites surveyed, eight were rated *high quality*, eight were rated *good quality*, nine were rated *marginal quality* and 14 were rated as *poor quality*. A total of 57 different reaches were rated for arroyo toad habitat quality, resulting in nine reaches rated as *high quality*, nine reaches rated as *good quality*, 18 reaches rated as *marginal quality*, and 21 reaches rated as *poor quality* (Appendix 1).

The results of the daytime habitat assessment surveys are discussed below and are presented by watershed from north to south. Some sites had multiple habitat quality ratings (multiple reaches with varying habitat quality), but only the highest habitat quality rating for each site is discussed below. A summary of habitat quality ratings and the arroyo toad habitat characteristics found within each reach at a site can be found in Appendix 1. Maps illustrating the limits of the habitat quality ratings within a site can be found in Appendix 2.

4.1.1.1 San Dieguito River Watershed

Daytime habitat assessment surveys were conducted at seven sites within the San Dieguito watershed (Appendix 1 & Appendix 2, Maps 1 - 5). Of these seven sites, three contained *high quality* arroyo toad habitat: 1) Boden Canyon Ecological Reserve, Santa Ysabel Creek, 2) San Dieguito River Valley Park, San Pasqual Valley, and 3) Fairbanks Ranch; one contained *good quality* arroyo toad habitat: Boden Canyon Ecological Reserve, unnamed tributary; and three contained only *poor quality* habitat: 1) Golem Land Trust, 2) 4S Ranch and 3) Lusardi Creek Preserve Lands. All sites within this watershed that contained high or good quality arroyo toad habitat were surveyed nocturnally.

4.1.1.2 Los Peñasquitos Creek Watershed

Daytime habitat assessment surveys were conducted at one site within the Los Peñasquitos Creek watershed. This site, Los Peñasquitos Creek in the Los Peñasquitos Canyon Preserve, contained only *marginal quality* (Appendix 1 & Appendix 2, Maps 6 - 7). Although the entire site received only a *marginal* rating, nocturnal surveys were conducted in a small patch that may have historically supported arroyo toads. This was based on the existence of historical photographs and supporting evidence (e.g., low gradient reach with channel braiding) documenting what appeared to be, high quality arroyo toad habitat prior to recent effects of urbanization (e.g., permanent water flow from urban run-off, establishment of dense vegetation and stabilization of banks) (White & Greer 2002).

4.1.1.3 San Diego River Watershed

Daytime habitat assessment surveys were conducted at nine sites within the San Diego River watershed (Appendix 1 & Appendix 2, Maps 8 - 12). Of these nine sites, one contained *high quality* arroyo toad habitat: 1) San Vicente Creek, south of Kimball Valley; one contained *good quality* arroyo toad habitat: Mission Trails Regional Park, Kumeyaay Lake (riparian habitat in the vicinity of the lake); two contained *marginal quality* habitat: 1) Carlton Oaks and 2) Mission Trails Regional Park, San Diego River; and five contained only *poor quality* habitat: 1) San Vicente Open Space Preserve, Foster Valley, 2) Sycamore Canyon/Goodan Ranch Open Space Preserves, 3) Louis Stelzer Open Space Preserve, 4) San Diego River, Mission Valley (south of Qualcomm Stadium), and 5) San Diego River, Mission Valley (First San Diego River Improvement Project (FSDRIP)). All sites with high or good quality arroyo toad habitat within this watershed were surveyed nocturnally.

The San Vicente Creek, Kimball Valley; San Vicente Open Space Preserve, Foster Valley; Louis Stelzer Open Space Preserve; Sycamore Canyon/Goodan Ranch Open Space Preserves and Mission Trails Regional Park, San Diego River sites burned in the 2003 Cedar Fire and it is possible that the habitat quality ratings have changed for these sites. The fire may have improved arroyo toad breeding habitat by the addition of coarse sediments (including sand and fine gravel) from the erosion of the exposed uplands and the removal of dense riparian vegetation. These factors combined may have increased channel braiding. In contrast, the fire may have made the habitat less suitable for arroyo toad breeding, at least in the years immediately following the fire, due to debris flows, the addition of fine sediments and silts which can suffocate eggs and larvae, the run-off of chemical pollutants (e.g., byproducts of the fire) into the watershed, or changes in stream morphology (USFWS 1999a).

4.1.1.4 Sweetwater River Watershed

Daytime habitat assessment surveys were conducted at six sites within the Sweetwater River watershed (Appendix 1 & Appendix 2, Maps 13 - 15). Of these six sites, three contained *high quality* arroyo toad habitat: 1) Sycuan Peak Ecological Reserve, Sweetwater River, 2) San Diego National Wildlife Refuge, Sweetwater River, 3) Upper Sweetwater Reservoir; one contained *good quality* arroyo toad habitat: 1) Cottonwood Golf Course and two contained *marginal quality* habitat: 1) Sweetwater Regional Park, Sweetwater River and 2) Sycuan Peak Ecological Reserve, Lawson Creek. All sites with high or good quality arroyo toad habitat within this watershed were surveyed nocturnally. The habitat surveys conducted at all of these sites, except for the Sweetwater Regional Park site and the Sycuan Peak Ecological Reserve, Lawson Creek site, were part of the baseline arroyo toad surveys associated with the USGS risk assessment examining the effects of Loveland Dam to arroyo toads in the Sweetwater River (Madden-Smith et al. 2004) (see section 3.1.4).

4.1.1.5 Otay River Watershed

Daytime habitat assessment surveys were conducted at 10 sites within the Otay River watershed (Appendix 1 & Appendix 2, Maps 16 - 21). Of these 10 sites, two contained *good quality* arroyo toad habitat: 1) Sycamore Canyon and 2) Otay Valley Regional Park, upper; four contained *marginal quality* habitat: 1) Jamul Creek, Rancho Jamul Ecological Reserve, 2) Hollenbeck Creek, Hollenbeck Canyon Wildlife Area, 3) Honey Springs Road Drainage, Hollenbeck Canyon Wildlife Area, 4) Dulzura Creek, Hollenbeck Canyon Wildlife Area and Rancho Jamul Ecological Reserve; and four contained only *poor quality* habitat: 1) Pringle Canyon, Hollenbeck Canyon Wildlife Area, 2) Cedar Canyon, 3) O'Neal Canyon and 4) Otay Valley Regional Park, lower. All sites with high or good quality arroyo toad habitat within this watershed were surveyed nocturnally.

The majority of these sites in the Otay River watershed burned in the Otay fire in October, 2003. These sites are: 1) Jamul Creek, Rancho Jamul Ecological Reserve, 2) Dulzura Creek (in Rancho Jamul Ecological Reserve only), 3) Cedar Canyon, 4) Sycamore Canyon, 5) O'Neal Canyon and 6) Otay Valley Regional Park. It is possible that the arroyo toad habitat quality ratings recorded at the time of these surveys have improved for the lower gradient sites that burned (i.e., all sites except for O'Neal Canyon), mainly as a result of the addition of coarse sediments into the riparian areas from erosion of the unvegetated slopes, which may have been compounded by the recent rains, and the removal of dense riparian habitat.

Although there are historic records of arroyo toads in Dulzura (most likely in Dulzura Creek- see Appendix 4), only *marginal quality* arroyo toad habitat exists in the portion of this drainage that was surveyed during this study. The hydrology of Dulzura Creek underwent a dramatic change after the completion of the Dulzura conduit in 1909, which was engineered to transport water from Cottonwood Creek (now Barrett Lake) within the Tijuana River watershed over the Dulzura Summit to the Otay River watershed (Fowler 1952). Water is diverted, into Dulzura Creek, via the conduit, on a "as need basis" and is not regulated to mimic natural flow regimes in terms of discharge level, duration, or the timing of the release. It is likely that the changes in Dulzura Creek hydrology have resulted in the reduction of arroyo toad habitat quality over the years.

Similarly, hydrologic changes due to the operation of Savage Dam (Lower Otay Reservoir) have resulted in habitat changes downstream. The existence of a small patch of *high quality* arroyo toad habitat below the dam in upper Otay Valley Regional Park suggests that an arroyo toad population could have occupied this site, but the presence of high quality habitat does not confirm that arroyo toads ever existed there and due to the effects of the dam, especially the reduction in water flow and the increase in vegetation due to the lack of scouring flows, it is unlikely an arroyo toad population could persist at this location. Additionally, inundation of the river by the creation of the dam may also have resulted in the loss of arroyo toad habitat upstream of the dam (USFWS 1994 & 1999).

4.1.1.6 Tijuana River Watershed

Daytime habitat assessment surveys were conducted at six sites within the Tijuana River watershed (Appendix 1 & Appendix 2, Maps 22 - 24). Of these six sites, one contained *high quality* arroyo toad habitat: 1) Cottonwood Creek- Marron Valley; three contained *good quality* arroyo toad habitat: 1) Tecate Creek / Tijuana River- Marron Valley, 2) Tijuana River Valley Park, Tijuana River and 3) Tijuana River Valley Park, Dairymart Pond (riparian habitat in the vicinity of the pond); and two contained only *poor quality* habitat: 1) Buttewick Canyon and 2) Copper Canyon. All sites with high or good quality arroyo toad habitat within this watershed were surveyed nocturnally, except for the Tijuana River Valley Park sites due to safety concerns related to illegal immigrant traffic and water quality. Previous water quality studies conducted by USGS-Water Resources Discipline have shown that the Tijuana River is a highly polluted waterway containing biological (i.e., fecal coliform, *E. coli*) and chemical pollutants (e.g., cadmium, chromium) (C. Church, 2004 written communication).

4.1.2 Nocturnal Presence Surveys

Nocturnal surveys were conducted at 18 of the 39 sites surveyed for arroyo toad habitat (Table 2; Figure 9). Arroyo toads were detected at five sites and were only detected at sites rated as *high* or *good quality*. Arroyo toads were detected at four sites that were characterized as *high quality* and one site that was characterized as *good quality*. Breeding evidence was only detected at two locations; however, it is likely that breeding would have been detected at more locations if 2002 and 2003 had not been below normal rainfall years. Arroyo toads were not detected at some known historic locations (Table 3).

Sites where nocturnal presence surveys were conducted are discussed below and are organized by watershed from north to south. Arroyo toads were detected at five locations within the boundaries of the MSCP: 1) Boden Canyon Ecological Reserve, unnamed tributary, 2) Boden Canyon Ecological Reserve, Santa Ysabel Creek, 3) San Dieguito River Park, San Pasqual Valley, 4) San Vicente Creek, south of Kimball Valley, and 5) Cottonwood Creek, Marron Valley. All arroyo toad populations were at previously known locations except for the population south of Kimball Valley along San Vicente Creek, but arroyo toads had been previously recorded upstream from this location. Maps illustrating the limits of the nocturnal surveys within a site can be found in Appendix 2.

Of the 18 sites surveyed nocturnally, the proportion of sites occupied was 0.2853 (SE = 0.1087) and the estimated detection probability for the nocturnal survey methods used in this study was 0.4544. Using this detection probability, if arroyo toads are present at a site there is an 84% chance of detecting an arroyo within three survey nights and a 97% chance after six survey nights (Figure 10). The chance of detecting an arroyo toad does not reach 100% until the ninth survey.

4.1.2.1 San Dieguito River Watershed

Of the four sites nocturnally surveyed in this watershed, arroyo toads were detected at three: 1) Boden Canyon Ecological Reserve, unnamed tributary, 2) Boden Canyon Ecological Reserve, Santa Ysabel Creek, and 3) San Dieguito River Valley Park, San Pasqual Valley. The arroyo toad was not detected at the Fairbanks Ranch, San Dieguito River site (Appendix 2, Maps 1, 2 & 5).

Prior to the commencement of the surveys the arroyo toad was known to occur at both sites within the Boden Canyon Ecological Reserve (BCER) and at San Pasqual Valley, San Dieguito River Park site. The populations within BCER were recently reported in 1999 (Zimmitti & Mahrdt 1999; USGS, unpublished data). At the site within the unnamed tributary of BCER, no arroyo toads were detected in 2002 and one was detected in 2003. At the site within Santa Ysabel Creek in BCER, arroyo toads were observed on two nights in 2002, resulting in a total of 13 observations and arroyo toads were observed on two of the nights in 2003 resulting in a total of 13 unique observations (toads were being marked for the skeletochronology study). During the surveys in BCER, Santa Ysabel Creek adult arroyo toads were occasionally observed sitting on the dirt road that parallels the unnamed Boden Canyon stream as had been previously reported (Zimmitti & Mahrdt 1999). The 2003 surveys at these two sites within BCER overlapped with the USGS skeletochronology study (see section 3.1.6). Surveys at the San Pasqual Valley site only occurred during 2003 as part of the USGS skeletochronology study. Arroyo toads were detected on all three surveys at the San Pasqual Valley site for a total of 18 unique observations (toads were being marked for the skeletochronology study).

Although the habitat at the Fairbanks Ranch site was ranked as *high quality*, no arroyo toads were detected during the nocturnal presence surveys, and no previous records of arroyo toads exist for this site (Jennings & Hayes 1994; Campbell et al. 1996; USFWS 1999a; CDFG 2003; SDNHM records); however, the lack of historical records does not necessarily indicate that the arroyo toad does not or did not occur here. Surveys could not be conducted in 2002 due to safety issues related to homeless camps, but in 2003, although the homeless camps were still active, it was determined that the conditions were safer than in 2002 due to the reduction in occupants. In addition, six surveys were conducted independently from this study in April through June of 2003 by EDAW, Inc., an environmental consulting firm (EDAW 2003). Arroyo toads were not detected during these surveys either.

4.1.2.2 Los Peñasquitos Creek Watershed

One site was nocturnally surveyed in the Los Peñasquitos Creek watershed, a small patch of Los Peñasquitos Canyon Preserve (Appendix 2; Map 7). Although, according to historical photos there appeared to be high quality arroyo toad habitat present at this site, no historical arroyo toad records exist for this site (Jennings & Hayes 1994; Campbell et al. 1996; USFWS 1999a; CDFG 2003; SDNHM records) and no arroyo toads were detected during the nocturnal presence surveys. Surveys were conducted despite the habitat quality rating of *marginal*, because a lack of arroyo toad detections would increase the confidence in the species absence from this site, while a detection of the species would have been a significant find.

4.1.2.3 San Diego River Watershed

Of the two nocturnally surveyed sites in the San Diego River watershed, arroyo toads were detected at the San Vicente Creek site, but were not detected at Mission Trails Regional Park, Kumeyaay Lake (Appendix 2; Maps 8 & 11). The arroyo toad has been previously reported along San Vicente Creek in Kimball Valley; however, no records have been reported from the area south of Kimball Valley Road, the location of these nocturnal surveys (Jennings & Hayes 1994; Campbell et al. 1996; USFWS 1999a; CDFG 2003; SDNHM records). Due to difficulty in accessing San Vicente Creek (access was not granted to private road at the top of the site until the end of the project, so site had to be accessed at the bottom by boat on San Vicente Reservoir) only two surveys were conducted in 2002, resulting in no arroyo toad observations; and only one survey was conducted in 2003, resulting in a total of two adult arroyo toad and two arroyo toad larvae observations. No previous arroyo toad records exist for the Mission Trails Regional Park, Kumeyaay Lake site (Jennings & Hayes 1994; Campbell et al. 1996; USFWS 1999a; CDFG 2003). In 2003, only one survey was conducted at the Kumeyaay Lake site.

4.1.2.4 Sweetwater River Watershed

Arroyo toads were not detected at any of the four sites nocturnally surveyed in the Sweetwater River Watershed: 1) Sycuan Peak Ecological Reserve, Sweetwater River, 2) San Diego National Wildlife Refuge, Sweetwater River, 3) Cottonwood Golf Course and 4) Sweetwater River, east of Sweetwater Reservoir (Appendix 2; Maps 13 - 15). All of these sites were surveyed six times as part of the baseline monitoring phase of the USGS study examining the effects of Loveland Dam on the arroyo toad in the Sweetwater River (Madden-Smith et al. 2004, 2005). All surveys were conducted by USGS, except the surveys at the site located just east of Sweetwater Reservoir on Sweetwater Authority property. This site was surveyed according to USGS protocol by Sweetwater Authority biologist, Peter Famolaro, who was assisted by various Sweetwater Authority personnel (Appendix 2; Map 15). In addition, the Sweetwater Authority site is the only one of the four nocturnally surveyed sites in this watershed with previous confirmed records of arroyo toads (Jennings & Hayes 1994; Campbell et al. 1996; Haas & Famolaro 1998; Famolaro 1999; USFWS 1999a; Famolaro 2000; Famolaro & Tikkanen Reising 2001; Famolaro 2002; CDFG 2003;). Arroyo toads were last detected at this site in 1998 (Haas & Famolaro 1998; Famolaro 1999, 2000; Famolaro & Tikkanen Reising 2001; Famolaro 2002). Recent changes upstream may have caused degradation of the arroyo toad habitat in this location (e.g., the vegetation cover has increased and the substrate is becoming increasingly muddy) (Madden-Smith et al. 2004).

In early 2003, as part of the Sweetwater Authority study, letters requesting permission to access all public and private properties along the Sweetwater River between Loveland and Sweetwater Reservoirs were sent to property owners. Access was only obtained for public lands and Sweetwater Authority property, and was not obtained for the only known extant population within the stretch of Sweetwater River between Loveland and Sweetwater Reservoirs (Haas & Famolaro 1998; W. Haas, personal communication; Madden-Smith et al. 2005). This population occurs in Sloan Canyon on private property previously owned by the Vulcan Minerals, Inc. Sloan Canyon Mining Company who denied access to their land (Sloan Canyon is now owned by the Sycuan Band of Indians). Some data on the Sloan Canyon arroyo toad population was obtained from limited survey information that had been submitted to USFWS (Haas, unpublished data) and a survey report completed for the Sweetwater Authority (Haas & Famolaro 1998). According to Haas and Famolaro (1998), as many as 26 adult males and 16 adult females were present during surveys in 1997 and successful recruitment was documented in 1995-1998. According to the summary Haas (unpublished data) provided to the USFWS, a minimum of 25 calling males were detected on April 15, 1999, approximately 50 arroyo toads were detected on February 5, 2000 and 32 calling males were detected on March 14, 2001, including two pairs in amplexus (Haas, unpublished data). Successful recruitment was also documented in 1999 (Haas, unpublished data).

Despite the occurrence of the Sloan Canyon population, the arroyo toad is not known to have colonized the *high* or *good quality* habitat upstream or downstream from this location. The intervening conditions between the occupied habitat in Sloan Canyon and the *high quality* habitat downstream (San Diego National Wildlife Refuge and private property) and upstream (Sycuan Peak Ecological Reserve) is highly disturbed and geomorphologically and hydrologically altered. Lack of arroyo toad movement from Sloan Canyon upstream to Sycuan Peak Ecological Reserve (SPER) may be due to habitat degradation that has occurred over time due to the operation of Loveland Dam (Madden-Smith et al. 2004). There is an unconfirmed historical record for an arroyo toad near the SPER border (USFWS 2000). Downstream from the Sloan Canyon population habitat degradation has occurred as a result of the sand and gravel mining operations of Vulcan Minerals Inc. and the subsequent formation of the sand/gravel pond known as Lake Emma, in addition to the construction of Singing Hills Golf Course and a housing development along the drainage channel. These disturbances, especially the reduction in water flow due to the presence of the dam at Lake Emma, appear to function as a barrier to the successful establishment of arroyo toads downstream from Sloan Canyon to the San Diego National Wildlife Refuge (SDNWR) site (e.g., migrating adults by own volition, disbursing larvae by water current) and are likely worsened due to the effects of Loveland Dam upstream (Madden-Smith et al. 2004). In addition, according to aerial photos there appears to be arroyo toad habitat remaining (although the uplands have been developed) along the stretch of Sweetwater River that runs through Singing Hills golf course between Lake Emma and SDNWR (access was also denied for these properties). This stretch could possibly serve as a dispersal corridor if habitat restoration occurs. There was one unconfirmed record of arroyo toad breeding (one breeding pool with young larvae on or near the SDNWR property and one downstream from this location) within the stretch of Sweetwater River between Singing Hills Golf Course and Cottonwood Golf course in 1997 (Haas & Famolaro 1998; P. Famolaro, personal communication)

The downstream effects of Loveland Dam on the arroyo toad in the Sweetwater River have been a concern and were the basis of the risk assessment USGS conducted for Sweetwater Authority in 2003-2004. The operation of Loveland Dam has resulted in effects typical of dams and includes the following: changes in the timing, amount, and duration of channel flows (Baxter 1977; Williams & Wolman 1984; Ligon et al. 1995; Collier et al. 2000; Nilsson & Berggren 2000), loss of coarse sediments below the dam- coarse sediments are trapped behind the dam and replaced below the dam through channel and bank erosion (Baxter 1977; Nilsson et al. 1991; Ligon et al. 1995; Richter et al. 1996; Trimble 1997; Collier et al. 2000; Nilsson & Berggren 2000), and an increase in vegetation density due to the decrease or elimination of scouring flows (Williams & Wolman 1984; Ligon et al. 1995; Lind et al. 1996; Collier et al. 2000). In regards to the arroyo toad, the initial downstream effects of a dam will modify and degrade breeding habitat, but in the long-term will eventually eliminate it.

4.1.2.5 Otay River Watershed

Arroyo toads were not detected at any of the five sites nocturnally surveyed in the Otay River Watershed: 1) Jamul Creek, Rancho Jamul Ecological Reserve, 2) Hollenbeck Canyon, Hollenbeck Canyon Wildlife Area and Rancho Jamul Ecological Reserve (portion of drainage immediately before confluence with Dulzura Creek), 3) Dulzura Creek, Hollenbeck Canyon Wildlife Area and Rancho Jamul Ecological Reserve, 4) Sycamore Canyon and 5) Otay Valley Regional Park – Upper (Appendix 2; Maps 16 - 20). No known arroyo toad records exist for these sites (Jennings & Hayes 1994; Campbell et al. 1996; USFWS 1999a; CDFG 2003), except possibly the Dulzura Creek site. A series of five preserved adults specimens (SDNHM 13358-13362) collected by F.E. Walker in 1930 were verified by USGS (Appendix 3), but because of the vague locality information provided, "Dulzura," it is unclear exactly what location or drainage the specimens were collected from. However, it is most likely that these specimens came from somewhere in Dulzura Creek. At this time only *marginal* quality arroyo toad habitat exists in the portion of this drainage that was surveyed. In addition, the presence of arroyo toad breeding habitat below the lower Otay Reservoir in the upper portion of Otay Valley Regional Park suggests that the arroyo toads may have historically occurred this location. The effects of Savage Dam (Lower Otay Reservoir) appear to be similar to those of Loveland Dam (see section 4.1.2.4). It is also possible that arroyo toads still occur in parts of the watershed we could not survey due to lack of access.

4.1.2.6 Tijuana River Watershed

Of the two nocturnally surveyed sites in the Tijuana River watershed, arroyo toads were detected at the Cottonwood Creek- Marron Valley site, but none were detected at the Tecate Creek/Tijuana River- Marron Valley site (Appendix 2; Map 22). Cottonwood Creek is well known for its high quality arroyo toad habitat and its breeding population of arroyo toads, so the survey effort for this site was only two surveys in 2002 and in 2003, but four additional surveys for the skeletochronology study were conducted in 2003. This enabled resources to be focused on conducting arroyo toad surveys at other MSCP sites that, to our knowledge, have not been thoroughly surveyed for the arroyo toad. In 2002, 13 adult arroyo toads were observed on the first visit and one individual was observed on the second visit, for a total of fourteen adult arroyo toad observations in 2002. In 2003, the two MSCP surveys resulted with the detection of two tadpoles, two metamorphs and one adult and the three skeletochronology surveys resulted with the detection of five unique adults (toads are being marked for the skeletochronology study), two metamorphs and one observation of tadpoles. The Tecate Creek/Tijuana River- Marron Valley site was only surveyed in 2003 for a total of three surveys. Due to safety concerns related to illegal immigrant traffic and contaminated water, survey teams avoided direct contact with the water and stayed clear of any dense riparian vegetation after sundown. The upland habitat on the north side of the Tecate Creek/Tijuana River was surveyed by searching for migrating or foraging adult arroyo toads while listening for male toads calling from the water. This was the only site surveyed in this manner. Previous focused surveys have been conducted at this site and similarly no arroyo toad observations were made (USGS, unpublished data). Again, the Tijuana River Valley Park sites were not nocturnally surveyed due to safety concerns related to illegal immigrant traffic and water quality, which were thought to be more of a concern at this location.

4.1.3 Non-native Species Detected

During the daytime reconnaissance and nocturnal focused arroyo toad surveys a total of 14 non-native species were observed, including aquatic predatory species, at 23 of the 39 sites surveyed (Appendix 4). During the arroyo toad surveys, the highest number of non-native species, 14, was detected in the San Diego River watershed (Appendix 5). Previous studies have demonstrated that non-native aquatic predatory species can have negative effects on native amphibians, including the arroyo toad (Sih et al. 1992; Sweet 1992, 1993; Jennings & Hayes 1994; Gamradt & Kats 1996; Axelsson et al. 1997; Gamradt et al. 1997; Griffin et al. 1999; Lawler et al. 1999; Knapp & Matthews 2000; Griffin & Case 2002; Vredenburg 2004). Potential negative impacts of these non-native species on native species include, introduction of exotic pathogens and parasites, competition, predation, as well as trophic alterations (Hurlbert et al. 1972; Taylor et al. 1984; Sweet 1993; Alford & Richards 1999; Warburton et al. 2002; Maezono & Miyashita 2003). The following non-native species are of particular concern to the arroyo toad and are discussed in detail below: crayfish (*Procambarus clarkii*), bullhead species (*Ameiurus* spp.), largemouth bass (*Micropterus salmoides*), green sunfish (*Lepomis cyanellus*), mosquitofish (*Gambusia affinis*), goldfish (*Carassius auratus*), African clawed frog (*Xenopus laevis*), and bullfrog (*Rana catesbeiana*).

Crayfish are widespread throughout coastal San Diego County and because they are used as fishing bait, they are most often associated with the presence of non-native fish fauna (USGS, unpublished data). Recent studies have demonstrated that crayfish have the ability to consume native amphibian eggs and larva and are not deterred by the protective chemicals often used for defense (Gamradt & Kats 1996; Gamradt et al. 1997; Punzo & Lindstrom 2001). In addition, preliminary results of a USGS study of arroyo toads on Marine Corps Base Camp Pendleton found that arroyo toad larvae were 20 times more likely to be detected when crayfish were absent; however, it is unclear at this time whether this is due to a direct or indirect effect (Brehme et al. 2004).

Arroyo toad larvae do not possess effective anti-predatory mechanisms (Sweet 1992) and thus are vulnerable to predatory fish (Sexton & Phillips 1986; Bradford 1989; Fisher & Shaffer 1996; Hecnar & Closkey 1997). Game fish (e.g., black bullhead, largemouth bass, green sunfish), mosquitofish, and goldfish have all been shown to prey on amphibian eggs, larvae and/or transformed individuals despite the chemical compounds used for defense (e.g., noxiousness, unpalatability, and/or toxicity) (Lewis & Helms 1964; Grubb 1972; Gamradt & Kats 1996; Hecnar & Closkey 1997; Ervin et al. 2000; Monello & Wright 2001; Hovey & Ervin 2005). Warm-water game fish have been intentionally introduced throughout coastal San Diego County beginning in the late 1800's to create/enhance recreational angler opportunities. In addition, mosquitofish are widely introduced into streams, rivers, ponds, and reservoirs throughout coastal San Diego County regularly by the County of San Diego Department of Environmental Health Vector Control Program with the intent of controlling mosquito larvae and to reduce the risk of mosquito borne diseases to humans. Mosquitofish are known to prey on arroyo toad larvae and other amphibian larvae under laboratory conditions (Grubb 1972; Sweet 1993) and have been shown to prey on other amphibian larvae in the field (Gamradt & Kats 1996). Green sunfish are also considered major predators of arroyo toad larvae (Sweet 1992) and have been shown to lower densities of amphibian larvae (Sih et al. 1992). Goldfish are not as ubiquitously distributed in the wetlands of San Diego as are the game fish and mosquitofish. However, goldfish are one of the most popular fish in the pet industry and are often released into natural habitats. As a result, populations of goldfish have become established in many parts of southern California including San Diego County (e.g., San Diego River) (Moyle 2002).

In addition, the fish species discussed above have the potential to serve as vectors for the transmission of parasites and diseases to other fish, and under some circumstances, to amphibian larvae, creating a larger pool of non-native parasites and diseases (Kuperman et al. 2001; Warburton et al. 2002). Infections may include iridoviruses and the protozoan commonly referred to as white spot disease, or 'Ich' (*Ichthyophthirius multiliis*). A study of wild fish communities in San Diego County determined that native and introduced fish species were infected with the exotic parasite *I. multiliis* (Kuperman et al. 2001). Recent studies have demonstrated that iridoviruses and the protozoan *I. multiliis* can be transmitted between different taxonomic classes (e.g., fish ↔ amphibians) (Moody & Owens, 1994; Gleeson 1999; Mao et al. 1999). Although outbreaks of *I. multiliis* infections have been reported in wild fish and amphibian larva in the past, it is currently not known what effect this infection has at the population level (Gleeson 1999; Scholz 1999).

Bullfrogs are also widespread throughout San Diego County and can often be found at sites with perennial water sources. Studies of bullfrog diets demonstrate that bullfrogs are opportunistic generalist predators of invertebrates (e.g., earthworms, insects, crayfish, and snails) and vertebrates (e.g., tadpoles, salamanders, frogs, fish, turtles, lizards, snakes, birds, rodents, and bats) (Bury & Whelan 1984). Bullfrogs are known to prey on arroyo toad adults and juveniles (Sweet 1993; Griffin & Case 2002) and are suspected of being partly responsible for the decline of several other sensitive species (Jennings & Hayes 1994; Lawler et al. 1999). Bullfrogs were found to co-occur with arroyo toads at both Boden Canyon Ecological Reserve sites and the San Vicente Creek site. It is possible that predation by bullfrogs may be impacting arroyo toad populations at these sites by limiting recruitment and reducing population numbers.

Much has been published on the indiscriminant feeding of both the African clawed frog and bullfrog (Bury & Whelan 1984; Wager 1986; Tinsley & McCoid 1996; Measey & Tinsley 1998). The African clawed frog is principally an aquatic frog, essentially occupying a fish-like niche. Its diet consists of aquatic organisms such as zoobenthos, zooplankton, insects, tadpoles, and small fish. Consequently, where the African clawed frog occurs, native amphibian larvae are at great risk of predation. However, the relative impact of predation would depend on the abundance and density of the predator, prey, and available refugia. The African clawed frog was found to co-occur with the arroyo toad at only one location, Cottonwood Creek, Marron Valley and because African clawed frogs were detected in the Sweetwater River in Sycuan Peak Ecological Reserve, they likely co-occur with the arroyo toad population downstream in Sloan Canyon. At this time it is unclear whether African clawed frogs are impacting either of these populations.

4.1.4 Native Non-target Species Detected

During the daytime habitat assessment and nocturnal presence surveys a total of 15 native species, including arroyo toad, were observed (Appendix 4). Several of these species are covered by the San Diego MSCP and/or are Federal and/or California Department of Fish and Game Species of Special Concern. No species, other than the arroyo toad, are listed as federally endangered or threatened. Species protected under the San Diego MSCP and/or considered species of special concern include the pond turtle (*Emys marmorata*), two-striped garter snake (*Thamnophis hammondii*), western patch-nosed snake (*Salvadora hexalepis*), red diamond rattlesnake (*Crotalus ruber ruber*) and western spadefoot toad (*Spea hammondii*). Common species that do not have special status by either jurisdiction include California treefrog (*Hyla cadaverina*), Baja California coachwhip (*Masticophis flagellum*), Pacific treefrog (*Hyla regilla*), ringneck snake (*Diadophis punctatus*), southern alligator lizard (*Elgaria multicarinata*), striped racer (California whipsnake) (*Masticophis lateralis*), western blind snake (*Leptotyphlops humilis*), western rattlesnake (*Crotalus viridis*), and western toad (*Bufo boreas*).

4.2 Pond Turtle

4.2.1 Visual Surveys

A total of 69 visual surveys (39 visual encounter surveys and 30 reconnaissance surveys) were conducted at 61 of the 68 sites surveyed for pond turtles (Table 2; Figure 11). Visual encounter surveys were conducted at 34 sites and reconnaissance surveys were conducted at 30 sites. Some sites were visually surveyed more than once, in most cases to determine if sites deemed unsuitable or unsafe to trap in 2002 had improved in 2003 or to survey again for pond turtles. Some sites were not visually surveyed and were only surveyed by trapping. Visual surveys resulted in pond turtle detections at three locations, Pine Valley Creek and Sycuan Peak Ecological Reserve, sites with healthy populations; and Los Peñasquitos Canyon Preserve. Pine Valley Creek was the only site with turtles that was not trapped. This population was known prior to the survey and was used to test the visual survey techniques of this study (i.e., if pond turtles exist at a site, can they be visually detected with the methods used in this study). Incidental observations of pond turtles did occur during trapping surveys at Sycuan Peak Ecological Reserve, Barrett Lake, and Escondido Creek. Pond turtles were also incidentally observed in Cedar Creek above El Capitan during another USGS study conducted in 2002, but are not included in the analysis of this report. Although pond turtles can be detected with the visual survey methods used in this study, trapping surveys resulted in the detection of pond turtles at more locations. In addition, visual surveys may only be productive where moderate to large sized populations exist (and basking sites are available), which is not the case for most of the populations that fall within the MSCP. Trapping is the most accurate method to verify the presence of pond turtles for the following reasons: 1) the shy nature of the pond turtle makes them difficult to visually detect and 2) the large number of non-native turtles that now occur within the MSCP, which can easily be misidentified as pond turtles from a distance when small and/or melanistic (common in red-eared sliders) or may prevent visual detection of pond turtles by out-competing for basking resources (pond turtles are most often visually detected while they are basking). Maps of pond turtle visual survey locations are located in Appendix 6.

4.2.2 Habitat Assessment

Habitat Assessments were conducted at 67 sites during visual encounter, reconnaissance or trapping surveys (Table 2). Sites were ranked based on the presence of habitat characteristics associated with pond turtle presence and the presence of slow moving, pooled water. Thirty-two sites were ranked as *high quality*, 16 sites were ranked as *good quality*, seven sites were ranked as *marginal quality* and 12 sites were ranked as *poor quality* (Table 2; Appendix 7). Of the nine locations where pond turtles were found, seven locations were ranked as *high quality*, one location was ranked as *good quality* and one location was ranked as *marginal quality*. Although little is known about the suitability of reservoirs for pond turtles in southern California, all reservoirs surveyed in this study were ranked as *high* or *good quality*. Reservoirs may possess many of the characteristics of suitable pond turtle habitat, but may be less suitable overall due to fluctuating water levels (affecting plant and invertebrate communities), less complex underwater structure (aquatic refugia), cooler water temperatures due to deeper waters, and because most reservoirs are recreated frequently (e.g., boating and fishing) and are host to many introduced aquatic species (including known predatory species). Reese (1996) found that a pond turtle population in a northern California reservoir was small and adult biased and the presence of pond turtles could be predicted by higher water temperatures within the shallower portions of the reservoir (Reese 1996).

4.2.3 Trapping Surveys

Of the 68 sites surveyed, 39 sites were trapped for pond turtles for a total of 45 trapping surveys (Table 2; Figure 11). 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 (e.g., difficulty of terrain, homeless camps) during visual surveys, or access was never attained during the study period. Five of the sites were trapped multiple times and in most cases this was because pond turtles had been detected in 2002 and the site was resurveyed in 2003 to get more data on population size and status. Trapping effort included a total of 1,895 trap days or 45,477 trap hours and resulted in the detection of pond turtles at eight sites (Table 4). Pond turtles were detected at 1) Escondido Creek (four pond turtles; outside of MSCP boundary), 2) 4S Ranch (nine pond turtles), 3) Los Peñasquitos Canyon Preserve, pond (two pond turtles), 4) Los Peñasquitos Canyon Preserve, creek (one pond turtle), 5) Santee Lakes (one pond turtle), 6) Lake Murray (one pond turtle), 7) Barrett Lake (one pond turtle), and 8) Sycuan Peak Ecological Reserve, Sweetwater River (30 pond turtles). Pond turtles were not detected at several historic locations, including the San Diego River in Mission Valley, Lake Hodges, Otay River below

Savage Dam, and Cottonwood Creek (Brattstrom & Messer 1988; Wells & Turnball 1998; CDFG 2003; Merklel & Associates, Inc. 2003; B. Ortega, personal communication; SDNHM records) (Table 3).

Using the trapping methods used in this study, the proportion of sites occupied by pond turtles was 0.2390 (SE = .0821) and the estimated detection probability was 0.4828. Using the detection probability estimate, after four days of trapping, the typical trapping period in this study, the probability of detecting a pond turtle at a site if pond turtles are present is 93% (Figure 12). The probability of detecting a pond turtle at a site does not reach 100% until the ninth day of trapping. This suggests that the probability of detecting pond turtles according to these methods is high for four days of trapping, but to more accurately rule out the presence of pond turtles at a site, a site should be trapped for at least nine days. Maps of pond turtle trapping survey locations are located in Appendix 6.

Forty-nine individual pond turtles were captured and marked during the trapping surveys (Table 4). The largest population was at Sycuan Ecological Reserve, Sweetwater River, with an estimated minimum population size of 38 and an estimated maximum population size of 80 individuals (Poisson 95 % confidence limit; true lower limit = 30). The next largest population occurs at 4S Ranch with an estimated minimum population size of 15 and an estimated maximum population size of 29 (Poisson 95 % confidence limit; true lower limit = 9). All other populations lacked the mark-recapture data necessary to estimate population size and very few individuals were detected (only 1 - 4 individuals captured) (Table 4). This indicates that even the largest populations within the MSCP may not be viable (large enough to sustain itself over time). Recent estimates by Dan Holland suggest that close to 200 individuals are necessary for a pond turtle population to be viable (see Hays et al. 1999).

Most populations were male dominated and the overall ratio of males to females captured within the study area was approximately 2:1 (Table 4). Pond turtle sex ratios reported by Holland (1991) range from 4:1 to 2:1 for males to females and Bury (1972) and Lovich and Meyer (2002) reported sex ratios closer to 1:1. Higher proportions of males in turtle populations is not uncommon and is likely due to the increased chance of predation or injury females face as they spend more time in the uplands to nest. Females are especially vulnerable in highly urbanized areas where chances of road mortality are increased (Marchand & Litvaitis 2004; Steen & Gibbs 2004; Gibbs & Steen 2005). The two larger populations, Sycuan Ecological Reserve, Sweetwater River and 4S Ranch, had sex ratios of 4:1 and 9:0 males to females, respectively. The possible absence of females is especially a concern for the 4S Ranch population, which is already small, has been facing pressures from permitted housing and road construction and will continue to be impacted from the effects of the urbanization that completely surrounds the population. If there are no or very few females and recruitment is either not occurring or is very limited, this population may not be able to survive the possible impacts of urbanization, unless steps are taken to mitigate these impacts.

Like other declining populations of pond turtles throughout the range of the species, the populations within the MSCP appear to be adult dominated or seemingly void of juveniles (Holland 1991, 1994; Jennings & Hayes 1994; Reese & Welsh 1998a; Spinks et al. 2003; Holland et al., unpublished report). No juvenile turtles were captured at any of the sites, nor were they visually observed. Adults in southern California range from about 105-170 mm in carapace length (Holland 1992) and the smallest captured turtle was 108.5 mm in carapace length at Lake Murray (Figure 13). In comparison to the adult dominated populations in the MSCP, a healthy population (approximately 200 or more individuals per Holland et al., unpublished report) within Cockleburr Creek on Marine Corps Base Camp Pendleton was trapped for less than 24 hours and 45% of the 29 captures were juveniles (USGS, unpublished data) (Figure 14). The percentage of adults in pond turtle populations has been reported to be anywhere from 55-70% (Bury 1972; Holland 1992 & 1994) and as high as 90-95% in areas negatively affected by anthropogenic factors (Holland et al., unpublished report). Adult biased populations are not uncommon in turtles, as they tend to have high juvenile mortality and high adult survival rates (Congdon et al. 1993). Survivorship in pond turtles is thought to increase once they reach 120 mm in carapace length (Holland 1994).

The lack of juvenile detections within the MSCP suggests that little or no recruitment is occurring, which is typical of pond turtle populations in heavily impacted or altered drainages (Holland et al., unpublished report). Congdon et al. (1993) suggest three hypotheses for low numbers of juvenile detections; 1) juveniles occupy habitats not searched by researcher, 2) juveniles are more secretive, or 3) poor recruitment resulting in juveniles being more difficult to detect. Others also believe that low proportions of juveniles signify low recruitment, attributable to the ease of detecting juveniles in other turtle populations (Rubin et al. 2004; Daigle & Jutras 2005; USGS, unpublished data). According to Holland et al. (unpublished report) the lack of juvenile pond turtle detections is not likely due to differential habitat use or inadequate sampling, but most likely due to a true deficiency in recruitment as a result of loss or alteration of nesting habitat, differential predation on eggs and/or small turtles, and food limitation. For example, in healthy populations where successful recruitment is occurring, juveniles have been detected by trapping and/or observation (Holland et al., unpublished report; USGS, unpublished data). At most sites sampled in this study, traps with the ability to capture very small turtles were set in or near habitat thought to support juvenile pond turtles (shallow water with emergent vegetation). Juveniles greater than one year old are thought to show very little variation in microhabitat use compared to adults (Holland 1994; Holland et al., unpublished report) and thus may have been just as susceptible as adults to being caught by our trapping methods.

Only one gravid female (at Sycuan Ecological Reserve, Sweetwater River) was detected during the course of the study, reinforcing the possibility of little or no recruitment occurring. In a population of pond turtles studied by Pires (2001), pond turtles tended to defer reproduction following a period of low resource availability, which according to Pires is consistent with a few studies conducted on other turtle species. This study occurred during a period of drought, therefore reproduction may have been deferred (or at least limited) due to limited water and food resource availability. Detecting only one gravid female does not necessarily indicate that females are not producing or laying eggs. It is sometimes difficult to detect gravidity through palpation (method used in this study); only x-ray radiographs can detect gravidity for certain. It is also possible that the female captures in this study occurred post oviposition or between clutches, because trapping was done late into the pond turtle breeding season.

In southern populations of pond turtles, females typically produce eggs yearly and sometimes double clutch (Goodman 1997a, 1997b; Lovich & Meyer 2002; Bury, in press, Scott et al., manuscript). Clutch sizes range from about 1 to 13 eggs and is positively correlated with body size (Holland 1991, 1994; Hays et al. 1999; Pires 2001; Lovich & Meyer 2002). Hatchling survivorship is low; under undisturbed conditions only 10-15% survive the first year (Hays et al. 1999).

4.2.4 Non-native Turtles

One of the most significant findings in this study is the number, distribution, and diversity of non-native turtles within the study area. In contrast to the nine sites where pond turtles were detected, non-native turtles were detected at 25 sites (17 sites by trapping survey only, four sites by visual survey only, and four sites by visual and trapping survey) with a total of 256 detections (213 detected by trapping, 41 detected by visual survey, and two by hand capture). A total of seven species, including at least 12 subspecies, were detected, with the red-eared slider (*Trachemys scripta elegans*) being detected at the most sites and being the most abundant non-native turtle detected by trapping and visual survey (Table 5; Appendix 4 & 5). Other species detected include: painted turtle (*Chrysemys picta*), river cooter (*Pseudemys concinna*), map turtle (*Graptemys psuedogeographica*), common snapping turtle (*Chelydra serpentina*), spiny softshell (*Apalone spinifera*), and Mexican mud turtle (*Kinosternon integrum*). In addition to the non-native turtle species detected during this study, an incidental observation of a Reeves' turtle (*Chinemys reevesii*), a species from southern Asia, was made at Lake Jennings in June 2002 by C. Rochester (USGS, unpublished data).

Also in contrast to pond turtles, non-native turtle populations do not appear to be as male biased and it appears that recruitment is occurring in some populations, at least within the sliders. The overall ratio of males to females for all the non-natives captured in this study is 1.35:1 (112:83) and the overall ratio of males to females in the sliders is 1.38:1 (102:74), compared to 3.9:1 (39:10) in pond turtles. The difference in sex ratios between pond turtles and sliders is significant ($\chi^2 = 7.67$; $p \leq 0.01$). Similar to the pond turtle only one gravid red-eared slider was detected during trapping (at Mission Trails Regional Park, Kumeyaay Lake) and likewise it may have been due to the method used to detect gravidity (palpation) or that females were caught post-oviposition or in between clutches. Additionally, juvenile red-eared sliders and a juvenile spiny softshell were detected at several sites. Juvenile red-eared sliders were captured at the following five locations and resulted in 8% of the total captures for this species: 1) Los Peñasquitos Canyon Preserve, pond, 2) Santee Lakes, 3) Carlton Oaks, 4) Lake Murray and 5) FSDRIP, Mission Valley. Red-eared sliders within the juvenile size range were visually observed at Chollas Lake. Due to the number of red-eared sliders detected at these locations, it is likely that recruitment is occurring and that the juveniles detected were not simply young released pets (Figure 15). The one juvenile spiny softshell was detected at Sweetwater Reservoir and is also most likely a sign of recruitment occurring within this population. Pete Famolaro of the Sweetwater Authority has been removing spiny softshells (nearly 30 to date) and other non-native turtles, including red-eared sliders (nearly 160 to date) from this reservoir since 1999 (P. Famolaro, unpublished data).

Although the threats of non-native turtles to pond turtles are not certain at this time, potential threats include serving as vectors for disease and parasites (Holland 1991, 1994; Hays et al. 1999; Jacobson et al. 1999; Cadi & Joli 2004) and competition for resources, including food and basking sites (Spinks et al. 2003; Cadi & Joli 2003, 2004). Pond turtles in California have evolved without the presence of other turtles and may be more susceptible to diseases and competition, whereas most non-native species (native to other areas within the United States), such as the red-eared slider, have evolved in assemblages of multiple turtles and are more accustomed to inter-specific competition (Cadi & Joly 2003, 2004). Furthermore, pond turtles, which typically are smaller than most of the introduced species and other species of Emydid turtles, are known to display avoidance behavior with larger turtles (Bury & Wolfheim 1973; Lindeman 1999), so it is likely that the larger non-native turtles can easily out-compete for resources. It is possible that non-native turtles are an important factor in the decline of the pond turtle within the MSCP, because they appear to be thriving in locations where pond turtles historically occurred or now only occur in small numbers.

The red-eared slider is the non-native turtle of most concern due to its abundance and widespread distribution. 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). In San Diego, red-eared sliders have established large populations within the MSCP and by the numbers of adult and young turtles captured or seen during this study, it is likely that these populations are reproducing. Compared to pond turtles, red-eared sliders can grow to be much larger and are considered aggressive (Arvy & Servan 1998; Cadi & Joli 2004). Red-eared sliders also have higher fecundity than pond turtles- they nest more often (up to five times per year compared to 1-2 times per year in pond turtles), lay more eggs (up to 23 per clutch compared to 13 in pond turtles), and their eggs are more tolerant to higher moisture levels (pond turtles eggs are hard-shelled and are incapable of expanding when substrate moisture levels rise enough to increase internal pressure) (Storer 1930; Ernst et al. 1994; Goodman 1997a, 1997b; Arvy & Servan 1998; Hays et al. 1999; Pires 2001; Spinks et al. 2003; Cadi & Joli 2004; Bury, in press; Scott et al., manuscript). It is also possible that the red-eared sliders are vectors for disease and parasites (including non-native parasites from their home range). Hays et al. (1999) suggested that the red-eared slider was the vector of a respiratory disease that killed many pond turtles in Washington in 1990.

A sample of red-eared sliders (containing both visibly sick and normal control specimens) from large populations of non-native turtles in the San Diego River in Mission Valley (FSDRIP) and Lake Murray in Mission Trails Regional Park and from a smaller population in Lake Miramar were sent to the USGS National Wildlife Health Center in 2003 for examination. Examinations revealed that both the visibly sick (2) and normal control (1) turtles from the San Diego River were moderately to highly parasitized by leeches and intestinal parasites, anemic, emaciated, and one of the turtles had a fish-hook embedded in its esophagus (Figure 16) (USGS NWHC, unpublished data). Both the sick (1) and normal control (1) turtle from Lake Murray contained a mild to moderate number of parasites, had minimal fat reserves and one had mild edema. The visibly sick turtle had a chronic bacterial infection of the right inner ear (USGS NWHC, unpublished data). Both the sick (1) and normal control (1) turtle from Lake Miramar were highly parasitized. In addition, the normal control had a perforation in its esophagus from a fish-hook, had multiple abscesses and was emaciated with moderate edema and anemic. The visibly sick turtle also had a prominent cavitating ulcer on its plastron (USGS NWHC, unpublished data). The anemia and emaciation is possibly a result of parasitism, starvation (due to overpopulation or overexploitation of food resources), or undetected infection or chronic intoxication (USGS NWHC, unpublished data). At this time it is not known if the leeches and internal parasites are native to California or if they are native to the red-eared slider's (or other non-native turtle's) home-range. Need to add info from paper on leeches from these turtles. Reference red-eared sliders from their native habitats were not available for comparison, thus it is not possible to conclude the cause or significance of the parasites and abnormalities in these turtles (USGS NWHC, unpublished data). It is also unclear how or if the parasites found in these red-eared sliders affect pond turtles.

In Europe, the red-eared slider has become widespread and is considered a factor in the decline of the endangered European pond turtle (*Emys orbicularis galloitalica*), a species similar to the western pond turtle in that it is still relatively widespread, but populations are declining and usually occur without the presence of other turtle species (Luiselli et al. 1997; Gianaroli et al. 1999; Cadi & Joly 2003, 2004). The red-eared slider has demonstrated competitive dominance over the European pond turtle (e.g., out-competes for preferred basking sites) and removal of red-eared sliders has become part of European pond turtle conservation (Gianaroli et al. 1999; Cadi & Joly 2003, 2004).

4.2.5 Pond Turtle and Non-native Turtle Presence in Relation to Human Access and Naturalness of Site

As discussed in section 3.2.2.2, sites were ranked according to the level of human access they received and according to their level of naturalness. As hypothesized, pond turtle presence was negatively correlated with the amount of human access and non-native turtle presence was positively correlated with the amount of human access ($\chi^2 = 252.838$; $p \leq 0.001$) (Figure 17). The differences between the sites considered low and high access ($\chi^2 = 246.207$; $p \leq 0.001$), low and medium ($\chi^2 = 10.678$; $p \leq 0.01$), and medium and high access ($\chi^2 = 122.991$; $p \leq 0.001$) were significant.

Also according to hypothesis, pond turtle presence was positively correlated with the naturalness of a site and non-native turtles were more likely to occur at modified or artificial wetland locations ($\chi^2 = 193.322$; $p \leq 0.001$) (Figure 18). The differences between natural and artificial sites ($\chi^2 = 61.650$; $p \leq 0.001$) and natural and modified-natural sites ($\chi^2 = 177.727$; $p \leq 0.001$) were significant. The difference between modified-natural sites and artificial sites was not significant ($\chi^2 = 0.544$; $p \leq 1$).

One pond turtle was detected at a site characterized as high access and artificial, Santee Lakes. Although pond turtles are historic to the San Diego River watershed and Santee Lakes are located along the Sycamore Canyon drainage within this watershed, this individual was most likely introduced into this artificial environment (water treatment ponds). An employee of Santee Lakes reported that a wildlife rescue organization had released an unknown species of turtle into Santee Lakes; however, we were unable to determine the name of the organization to get details regarding the release.

4.2.6 Other Non-native Animals

In addition to the seven species of non-native turtles detected during the surveys, 20 other non-native species were detected, including predatory species such as the bullfrog, large-mouth bass and African clawed frog (Appendix 4). In contrast, only five native species, including the pond turtle, were detected (Appendix 4) during the pond turtle surveys. Non-native species were detected at a total of 51 sites compared to the 21 sites where natives were detected. San Vicente Reservoir, a heavily fished reservoir, had the highest number of non-native species detected, 12, most of which are non-native fish. Kumeyaay Lake in Mission Trails Regional Park and the lower portion of Otay Valley Regional Park both had the second highest number of non-native species detected (10). Other than red-eared sliders, bluegill (*Lepomis macrochirus*) were the most abundant non-native species detected followed by crayfish and bullfrog. Mosquitofish were detected at the most locations (25), bullfrogs were detected at 24 locations and bluegill were detected at 23 locations. The highest number of non-native species detected in a watershed during the pond turtle surveys was 19 in the San Diego River watershed (Appendix 5).

Introduced predators, especially bullfrogs and largemouth bass, pose potential threats to pond turtles, especially young (Holland 1991, 1994; Lovich & Meyer 2002). Bullfrogs and/or largemouth bass were detected at most of the locations that were surveyed within the MSCP, including locations where pond turtles occur. In general, pond turtles are most vulnerable to predation during the juvenile life history stages. When pond turtles enter aquatic systems, they are about the size of a silver dollar. Bass and bullfrogs are "gape limited" predators that have been reported to eat young pond turtles (Moyle 1973; Brattstrom & Messer 1988; Holland 1991, 1994). Additionally, a study by Britson (1998) found that largemouth bass handled (i.e., categorically eaten or rejected) cryptic hatchling turtles (common snapping turtle) more than conspicuously colored hatchlings (painted turtle). Semlitsch and Gibbons (1989) and Britson and Gutzke (1993) also found a lack of largemouth bass predation on the conspicuously colored red-eared slider. This suggests that cryptically colored turtles, such as the pond turtle, are more susceptible to depredation by largemouth bass. Due to the threats non-native predators pose to population recruitment and because recruitment rates appear low or absent within the MSCP pond turtle populations, non-native 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.

Sunfish (*Lepomis* spp.), carp (*Cyprinus carpio*), and mosquitofish, although not predatory on turtles, are also threats to pond turtles and should be controlled where pond turtle populations exist. Sunfish, which were detected at almost every site surveyed in this study, are suspected of competing with pond turtles for food (Holland 1991; Jennings & Hayes 1994; McAllister et al. 1996; Hays et al. 1999). The diet of young pond turtles is poorly understood, but they are thought to eat nekton (Jennings & Hayes 1994; McAllister et al. 1996). Sunfish are known to keep nekton levels so low that they stunt their own growth (McGinnis 1984; Jennings & Hayes 1994). Sunfish may also impact adult pond turtles through the depletion or alteration of the invertebrate prey base (Holland 1991). In addition, sunfish and mosquitofish are known paratenic hosts (an intermediate host in which no development of the parasite occurs, although its presence may be required as an essential link in the completion of the parasite's life cycle) of turtle parasites in the genus *Falcaustra* (Moravec et al. 1995). Carp, which can negatively impact water quality, were also detected at several locations. The feeding activities of carp can muddy water, which can also influence the densities of the zooplankton young turtles may rely on as a food source (Hays et al. 1999).

Although pond turtles can persist and even thrive in areas heavily populated by non-native predators (e.g., bullfrogs at Sycuan Peak Ecological Reserve) or non-native fishes (e.g., San Mateo Creek), pond turtles in human altered aquatic systems and landscapes (most sites in the MSCP are significantly altered) are more susceptible non-native invasions. Native species have been found to resist invasions by non-natives as long as the habitats are relatively undisturbed by human activity (Baltz & Moyle 1993; Marchetti et al. 2004). In other words, species invasions are influenced by anthropogenic disturbances (Byers 2002). Additionally, if human disturbance extremely alters habitats, invading non-native species may be better adapted to the altered habitat than the competing native species (Byers 2002).

5. Monitoring and Management Recommendations

5.1 Arroyo Toad

Historical records indicate that the arroyo toad was more widespread in coastal San Diego County as well as within the San Diego MSCP (Table 3). The following monitoring and management suggestions are proposed as a means to sustain and improve arroyo toad populations within the San Diego MSCP. Increasing these populations and expanding them into other suitable areas should be a part of the MSCP management goals and may be achieved by increasing habitat quality and restoring a more natural hydrologic regime within the drainages that contain arroyo toads. The following suggestions should benefit the arroyo toad and improve the understanding of this declining species within the study area. Very few populations of arroyo toads remain within the MSCP, thus aggressive actions will be necessary to effectively manage for this species.

5.1.1 Minimize Disturbance and Take

Due to the low number of arroyo toads detected, the populations within the MSCP are at increased risk due to human activities that may lead to disturbance and take (e.g., recreation, collection, roads). MSCP reserve lands should be managed to prevent or minimize disturbance to arroyo toads and/or their habitat resulting from on-site activities (e.g., agriculture or livestock grazing, incompatible recreation). This includes restricting access to arroyo toad upland and breeding habitats to help prevent disturbance to all arroyo toad life history stages (egg strings, larvae, metamorphs and adults). If possible, activities should be restricted in upland arroyo toad habitat year-round and in arroyo toad breeding habitat during the core of the breeding season (March to July), where the greatest threat to arroyo toad eggs, larvae and metamorphs will occur (see Madden-Smith et al. 2004).

5.1.1.1 Human Recreation

Moderate amounts of non-consumptive recreation (recreation that does not involve direct consumption of resources) can have an affect on arroyo toad populations (USFWS 1999a), thus recreation near or in arroyo toad breeding or upland habitat should be restricted. Disturbance from non-consumptive recreation may result in altered behaviors, displacement and avoidance which can then lead to distribution and habitat changes that may ultimately alter reproductive success and lead to unstable populations (Boyle & Samson 1985; Cole & Landres 1995; Knight & Cole 1995; Joslin & Youmans 1999; Gains et al. 2003; Ervin et al., in press).

Backpacking, hiking, horseback riding, and mountain biking may stress or displace any life stage of the arroyo toad even if direct contact does not occur (Joslin & Youmans 1999; USFWS 1999a). If these activities occur near arroyo toad breeding habitat, erosion of trails can lead to siltation of breeding pools which can be detrimental to eggs and larvae (USFWS 1999a). If these activities occur within arroyo toad breeding habitat, breeding pool structure may become altered and pools can become filled with sediment, preventing breeding from occurring or preventing the development of eggs or larvae. In addition, arroyo toad populations in or near recreation areas may be at risk of increased direct mortality as a result of handling, trampling or killing (intentional and unintentional) by humans or their pets (e.g., dogs and horses) (Sweet 1993; Joslin & Youmans 1999; USFWS 1999a; Ervin et al., in press). Arroyo toads often use roads, especially dirt roads, to forage at night and may bury themselves in sandy roadbeds during the daytime when they can be crushed by vehicle, bicycle or foot traffic (USFWS 1999a). Sweet (1993) noted significant direct mortality of arroyo toad juveniles and destruction of arroyo toad breeding habitat as a result of trampling related to recreational activities (e.g., fishing, hiking). In addition, wild predators, such as coyote, ravens, striped skunks and raccoons, may also be supported in higher numbers in recreational areas or in areas surrounded by urbanization (Joslin & Youmans 1999). Disturbance from recreational activities may also result in invasions by non-native plant species (Cole & Landres 1995) which can negatively affect arroyo toad breeding habitat and result in a reduction in overall recruitment (USFWS 1999a).

Limiting recreational activities near the arroyo toad population in San Pasqual Valley, San Dieguito River Park and Boden Canyon Ecological Reserve will be especially important. As the San Dieguito River Park and the “Coast to Crest” trail is further developed and use increases, human, dog and horse encounters with arroyo toads and arroyo toad habitat will likely increase. At Boden Canyon Ecological Reserve, both populations occur either close to a road or a road crossing, making the arroyo toad habitat easily accessible. In addition, the arroyo toads here often use the roads to forage and may even burrow in them, making them susceptible to impacts from recreation. If Cottonwood Creek in Marron Valley is ever opened to recreation, the arroyo toad population here will face similar threats, because a road also bisects that population and toads are often seen on the road. Purchasing habitat occupied by arroyo toads (including upstream, downstream and upland habitat) could be used as mitigation for recreation where appropriate.

5.1.1.2 Agriculture and Grazing

Agriculture and livestock grazing activities should be monitored and restricted near arroyo toad populations within the MSCP. This will be especially important for the population in the San Dieguito River Park in San Pasqual Valley, where there is intensive agricultural activity throughout the valley; for the populations in Boden Canyon where non-authorized grazing was witnessed on several occasions (including the location of the upper arroyo toad population); and for the population in Marron Valley in Cottonwood Creek, which is in an area that was formerly grazed, but grazing does continue upstream. Because land managers have little authority over agricultural practices within the MSCP, it may be beneficial to establish relationships with the County of San Diego Land Use and Environment Group Farm and Home Advisor and the San Diego County Farm Bureau to coordinate on issues related to the effects of agriculture on the arroyo toad.

Agricultural activities can affect arroyo toad populations through the destruction of habitat (planting of crops), the reduction of stream flow due to groundwater pumping, the permanency of water due to runoff (possibly leading to the establishment of non-native plants or non-native predatory species such as bullfrogs), the runoff of contaminants such as herbicides, insecticides and fertilizers, increased sedimentation of pools by fine sediments from runoff, and direct mortality from the operation of machinery (USFWS 1999a). A study by Bishop et al. (1999) found anuran density lowest and species the fewest in agricultural zones and suggested that nutrient runoff was the causal or contributing factor. Similarly, Knutson et al. (1999) found a negative association with frog and toad abundance and the presence of agriculture in Iowa and Beja and Alcazar (2003) found intensification of agricultural land uses to be one of the strongest negative correlates to amphibian abundance. Boone et al. (2004) found that even a short-lived insecticide such as carbaryl, a commonly used pesticide, can significantly alter the community dynamics of amphibians.

Grazing by livestock may affect arroyo toads directly or indirectly though habitat destruction (Sweet 1992, 1993). Livestock may cause direct mortality through the trampling of adults in the uplands or the trampling of eggs, larvae or metamorphs in the breeding pools (USFWS 1999a). Livestock may also destroy breeding habitat and affect arroyo toad breeding by changing the structure of the pools, changing the duration or extent of the presence of water, changing stream morphology by altering erosion and stream flow, and degrading water quality downstream from grazing due to increased siltation (Friend & Cellier 1990; Sweet 1992, 1993; Campbell et al. 1996). Limited and closely monitored grazing may be beneficial for arroyo toads in areas where dense herbaceous vegetation is reducing the friability of the upland soils used for burrowing. However, monitored grazing would best be done by small ungulates such as goats.

5.1.1.3 Roads

Both paved and unpaved roads have the potential to negatively affect arroyo toads, especially when the roads are close to or bisect arroyo toad habitat (USFWS 1999a), thus steps should be taken to minimize the impacts to arroyo toad populations near roads. Amphibians in general may be especially vulnerable to roadkill because they are inconspicuous, relatively slow-moving and their life histories often involve upland movement (Trombulak & Frissell 2000). Arroyo toads often use roads, especially dirt roads, to forage at night and may bury themselves in sandy roadbeds during the daytime when they can be crushed by vehicle, bicycle or foot traffic (USFWS 1999a). In addition to causing animal mortality, roads also change soil density, temperature, soil water content, light levels, dust levels, surface waters, patterns of runoff, sedimentation, and they add heavy metals (especially lead), salts, organic molecules, ozone, and nutrients to roadside environments (Trombulak & Frissell 2000).

The populations at Boden Canyon Ecological Reserve and Cottonwood Creek in Marron Valley are at most risk to the effects of roads. The main access road that runs through Boden Canyon bisects the breeding habitat of the lower population and bisects and runs along the upper population. Cottonwood Creek in Marron Valley is also bisected by a dirt road and receives a high volume of U. S. Border Patrol activity due to its proximity to the border. During the surveys associated with this study, arroyo toads were found using the road in the lower location of Boden Canyon Ecological Reserve, one road-killed arroyo toad was found on the road in the upper location of Boden Canyon Ecological Reserve and several arroyo toads were seen on the road crossing of Cottonwood Creek in Marron Valley. In surveys done for arroyo toads in Boden Canyon Ecological Reserve by Zimmitti and Mahrdt (1999) most of the arroyo toads they observed were on this main access road and they recommended that only vehicles moving slowly (<5 mph) with an occupant experienced in identifying arroyo toads should be allowed to use this main road after sunset. Another consideration may be the installation of ecopassages (Barichivich & Dodd 2002) with diversion walls tall enough to prevent arroyo toads from using the roads. The arroyo toads may depend on the open dirt road for foraging, thus diverting them from using the roads should only be considered after enhancement or restoration of upland foraging habitat has been completed. The arroyo toad population in Santa Ysabel Creek in the San Dieguito River Park in San Pasqual Valley also occurs near roads and should be investigated for the effects of roads.

5.1.1.4 Collection

As mentioned above, with increased human access there is a greater possibility of humans encountering arroyo toads and collecting them. Arroyo toads are most susceptible to collection during their immature life stages, as egg masses or tadpoles. At the egg mass and tadpole stages, a larger number of individuals can be removed from the system than if a visitor finds and collects a single adult animal. Signage within the MSCP reserve should encourage people to enjoy the wildlife experience, but to leave what they encounter in place. In addition, it should be clear that taking of this endangered species is a state and federal offense and should include an understandable definition of take (California Fish and Game Code Section 2080, Article 3; Endangered Species Act of 1973). However, signs should not call attention to arroyo toads, as this may increase collection.

5.1.2 Education and Outreach

Educational kiosks or signs should be installed at trailheads to educate and inform the public of any restrictions. This is especially important at all locations where arroyo toads occur, especially those sites frequently recreated or easily accessed by humans such as the San Dieguito River Park in San Pasqual Valley, Boden Canyon Ecological Reserve and Cottonwood Creek in Marron Valley (mostly Border Patrol and illegal traffic). At a minimum, these informative displays should provide information such as the following: 1) any restrictions for the site (e.g., no hiking or biking in or near riparian areas), 2) the importance of not disturbing or molesting any wildlife they may encounter, 3) the potential danger(s) of handling and collecting wild animals, 4) the ramifications of disturbing, collecting, or killing protected species. Outreach should also involve working with Border Patrol and other law enforcement agencies that patrol areas with known arroyo toad populations to further minimize impacts.

In addition, educational pamphlets could provide information similar to what is provided at the kiosks, signs or display cases. These pamphlets could be made available at suitable locations in the vicinity of MSCP reserves to educate people about wildlife species that they may encounter on or near the reserve lands. USGS could provide advice on information that could be provided in these pamphlets or at the kiosks, signs or display cases.

Another form of education could be through outreach and educational programs that promote the value of arroyo toads and native ecosystems as well as the negative effects of non-native species. In general, the public is largely unaware of the high biological diversity in San Diego County. If the public is informed of this, they may have a better appreciation and willingness to protect and conserve the natural resources within the preserve and beyond. Educational programs may also be initiated or incorporated with currently existing school programs (e.g., elementary school, high school) throughout San Diego County.

Education and outreach may be provided by the already established MSCP Outreach Committee in conjunction with landowners. The MSCP Outreach Committee includes members of the County Departments of Planning and Land Use, Parks and Recreation, Public Works and Environmental Health, the City of San Diego, USFWS, CDFG, and Bureau of Land Management. The committee's objectives include informing the public about the MSCP and educating children about the importance and benefits of the environment (MSCP 2003).

5.1.3 Enforcement of Rules and Restrictions

Although MSCP lands may be patrolled by the various landowner's staff or law enforcement officers, to some degree the level of patrol activity may be inadequate. Even with the patrols, some areas may have problems relating to illegal encroachment, off-road vehicle use, trash dumping and other destructive activities. Without an increase in patrols and other forms of oversight (e.g., fencing), management plans may not be as effective. Patrol routes should consider sensitive habitats, particularly within the breeding and upland habitat of the arroyo toad and other sensitive species.

5.1.4 Additional Surveys

In order to get a better understanding of population size and status and habitat requirements of arroyo toad populations occurring within the San Diego MSCP, surveys using the methods carried out in this study should be repeated and expanded to examine upland habitat use, breeding habitat characteristics, recruitment, survivorship and population viability. More site-specific surveys are necessary to better illuminate the demographic structure and life history requirements of the remaining arroyo toad populations in the MSCP. Additionally, historic locations or possible historic locations with suitable habitat should be resurveyed during a period of normal rainfall to further confirm the absence of arroyo toads in these locations.

5.1.4.1 Population Dynamics and Population Viability

To effectively manage for the arroyo toad in the MSCP, it will be necessary to gain better knowledge of arroyo toad population dynamics and population viability. According to Campbell et al. 1996, this will require the establishment of a long-term monitoring program which investigates the fluctuations in population size, survivorship, age structure and recruitment (see section 5.1.4.2) in both natural and disturbed habitat.

5.1.4.2 Surveys for Egg Masses and/or Larvae

Future arroyo toad surveys should include conducting surveys and monitoring for egg masses and/or larvae annually for all known arroyo toad populations within the MSCP. Egg masses and larvae are hypothesized to be an easier life stage to monitor than adults and provide a direct measure of reproduction (USFS 2002; Atkinson et al. 2003). It is unclear how successful arroyo toad recruitment is (eggs or larvae were only detected at four of five sites San Vicente Creek, Boden Canyon, Santa Ysabel Creek, and Cottonwood Creek- Marron Valley) or whether successful recruitment is even occurring within the MSCP arroyo toad populations, thus it is important that the egg and larval stages be monitored to provide more insight on recruitment and population viability.

5.1.4.3 Breeding Habitat Assessment

Arroyo toad breeding habitat, both current and historic (Table 3, Appendix 1), should be periodically surveyed to assess the extent and quality of arroyo toad breeding habitat within the MSCP and to determine if it is increasing or decreasing (every five or more years). If the extent and quality of arroyo toad habitat decreases, a management program (e.g., habitat restoration or enhancement, removal of invasive non-native plants, maintenance of sandy substrate and open sandy terraces) should be implemented to maintain or improve the habitat.

Habitat changes over many decades have degraded the quality of wetland habitats within the San Diego MSCP. Many human-related activities have resulted in the loss or degradation of seasonal breeding and upland arroyo toad habitat within the MSCP and range wide. These activities include urbanization, agriculture within and adjacent to riparian habitats, dam construction and the resulting reservoirs, water diversions, sand and gravel mining, road placement across and within stream terraces, livestock grazing, introduction of non-native species, off-highway vehicle use, and the use of stream channels and terraces for recreational activities (USFWS 1999a; Ervin et al., in press). Many of these factors, such as dams and livestock grazing, had already degraded arroyo toad habitat within the MSCP reserves before the MSCP was established.

5.1.4.4 Upland Habitat Requirements

The arroyo toad is a primarily terrestrial species, thus determining upland requirements should be another management goal for this species within the MSCP. Arroyo toads have been reportedly found upland over 1000 meters from riparian habitat (Holland & Sisk 2001). To accurately track the upland movements and habitat use of the arroyo toad, radio-telemetry will be necessary (Griffin et al. 1999; Griffin & Case 2001; Ramirez 2002). Habitat analysis should be conducted at both burrow sites and at locations of active arroyo toads and should include the analysis of characteristics such as substrate type, compaction, moisture, pH, temperature, and vegetation type and cover (Griffin et al. 1999; Ramirez 2002). Burrowing sites are especially important to arroyo toad survival, as they provide refugia from predators and desiccation, thus maintaining suitable burrowing sites may be necessary to minimize the risk of mortality (Griffin et al. 1999; Griffin & Case 2001). In addition to gaining information on upland habitat preferences, radio-telemetry can also provide information on arroyo toad home-ranges. Such a study should identify specific areas in need of protection, may identify possible problems with sites meeting the arroyo toad life history requirements and might enable managers to further minimize impacts to arroyo toads. Although upland use of arroyo toads has been studied elsewhere within southern California (see Griffin et al 1999; Griffin & Case 2001; Holland & Sisk 2001; Ramirez 2002), site specific data would be more beneficial for the management of the arroyo toad within the MSCP.

5.1.4.5 Water Quality Assessment

Another measure of habitat quality that should be taken into account is water quality. Water quality should be monitored and if necessary, improved in areas where arroyo toads occur. Water data from either Boden Canyon Ecological Reserve or San Vicente Creek, the most natural of the known arroyo toad locations, could serve as the controls. Water quality measurements should include at a minimum: dissolved oxygen, pH, turbidity, nitrogen (e.g., nitrate and ammonia) and phosphorous (e.g., phosphates) levels. Bishop et al. (1999) found significant correlations between ammonia, phosphorous, particulates, biological oxygen demand (BOD) and total Kjeldahl nitrogen (TKN) levels and anuran development, resulting in lower anuran diversity, density and reproductive success. Furthermore, organophosphorus pesticides and agricultural fertilizers (nitrate and ammonia) have been linked to deformities or mortality of larval amphibians (Bishop et al. 1999).

5.1.4.6 Post Fire Surveys

The effects of the 2003 Cedar and Otay Fires on the arroyo toad populations within the San Diego MSCP are not known and should be investigated. Post fire surveys should assess the current distribution of arroyo toads affected by the fires and the probable changes in the extent and quality of arroyo toad habitat. Fire can negatively affect arroyo toad populations by direct mortality, destruction of upland habitat, erosion of fine sediments and silt, debris flows, and destruction of breeding habitat through changes in stream morphology and composition (USFWS 1999a). Fire can also be beneficial to arroyo toads through the improvement of breeding habitat due to the addition of coarse sediments from the erosion of unvegetated slopes and the removal of dense riparian vegetation. Such an improvement in arroyo toad breeding habitat occurred in Cuyamaca Rancho State Park after the Cedar Fire and resulted in what appeared to be the range expansion of adult arroyo toads and an increase in the number of arroyo toad larvae detections (Mendelsohn et al. 2005). The arroyo toad population in San Vicente Creek may have been affected the most due to the entire reach and surrounding areas being burned in the Cedar Fire. Other populations that may have experienced some effects of the Cedar Fire because they occur downstream from areas that burned are the two populations in Santa Ysabel Creek (San Pasqual Valley and Boden Canyon Ecological Reserve). The arroyo toad population in Cottonwood Creek occurs upstream from the area burned in the Otay fire and was not likely impacted. Some sites that burned and are not currently known to support arroyo toads, but have suitable habitat (*good* or *high quality*) or may have historically supported arroyo toads, may warrant post burn surveys to determine whether habitat has improved. These sites include Sycamore Canyon- Otay Mountain and Dulzura Creek.

5.1.4.7 Effects of Drought

2002 and 2003 were below normal rainfall years, thus future nocturnal arroyo toad presence surveys should be conducted during a period of normal rainfall in order to help confirm the absence of arroyo toads at sites with high and good quality habitat or sites that historically supported arroyo toads or arroyo toad habitat. According to the National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center (NCDC), the 2001-2002 seasonal rainfall total for San Diego was the lowest since records began back in 1850-1851 (NOAA 2002). Although the arroyo toad has evolved with regular periods of drought, manmade stressors (e.g., habitat loss, dam construction, introduction of non-native predatory species, and pollution) may be compounding the effects of drought. Additionally, it has been documented at some sites that arroyo toad breeding is absent or greatly reduced during years of below average precipitation (Sweet 1992; Jennings & Hayes 1994; Haas 2001; Holland et al. 2001; USFS 2002; J. Copp, personal communication). Sweet (1992) attributes this to the time it takes females to eat sufficient prey for vitellogenesis (egg formation) to complete. Due to the scarcity of prey during years of drought, vitellogenesis may not complete until males have ceased calling and have left the breeding pools (Sweet 1992). Specific sites to be resurveyed due to the possibility of improved breeding conditions include SDNWR, SPER, Upper Sweetwater Reservoir, Dulzura Creek, Fairbanks Ranch, Los Peñasquitos Creek, and Sycamore Canyon- Otay Mountain. All known arroyo toad populations within the MSCP should also be resurveyed during normal rainfall to get a better understanding of population status. In addition, research investigating the effects of drought on the arroyo toad should be initiated or continued (e.g., USGS skeletochronology study including the populations at Boden Canyon Ecological Reserve, San Pasqual Valley, and Marron Valley) within the San Diego MSCP.

5.1.5 Non-native Predatory Species

Non-native predatory species known to be detrimental to arroyo toad populations were found at many locations throughout the MSCP, and it is important that these non-native predatory species be controlled within all drainages that support arroyo toads. Eradication of non-native predators should done outside of the arroyo toad breeding season and should be easier during drier years when they are concentrated in the limited number of pools. It will also be important to monitor the effectiveness of eradication techniques and measure benefits to arroyo toads. Early removal of known problem species can be more cost effective than delaying removal until impacts on the arroyo toad are clearly detectable. Bullfrog eradication should be the priority at sites where they occur with arroyo toads (e.g., Boden Canyon and San Vicente Creek). Refer to section 4.1.3 for discussion on the possible impacts of the non-native predatory species found within the MSCP.

5.1.6 Non-native Plant Species

Non-native plant species may degrade upland and breeding habitat, thus their extent and effects on arroyo toad breeding habitat should be monitored. Highly invasive species such as tamarisk (*Tamarix* spp.) and giant reed (*Arundo donax*) can quickly colonize and stabilize flood terraces and decrease the longevity of pools through evapotranspiration (USFWS 1999a). Non-native grasses, such as *Bromus* spp. and *Avena* spp., and weeds such as white sweet clover

(*Melilotus alba*) can make both upland and breeding habitats unsuitable by covering the breeding pools and the friable soils of the upland terraces. Invasive non-native plant species should be removed or controlled, removal effectiveness should be monitored and benefits to arroyo toads should be measured. Non-native grasses are difficult to eradicate, but should be controlled where arroyo toad populations are known to occur. Again, early detection and removal of known problem species can be more cost effective than delaying removal until an impact on the toads is clearly documented.

5.1.7 Habitat Restoration and Creation

Another management goal should be to expand the abundance and range of known populations of arroyo toads through restoration or creation of breeding habitat, including restoration of the natural hydrologic regime of the system. Because arroyo toads require shallow, slow-moving, open, sandy pools to breed and nearby open sandy terraces to forage and burrow, in most cases restoration would involve the removal of dense vegetation (both native and non-native) from breeding habitat and sandy terraces, replacement of sand and other coarse sediments and restoration of a more natural hydrologic regime. The need for restoration may be most apparent below dams, where vegetation cover tends to increase and coarse sediments tend to get flushed away. All five currently known arroyo toad populations within the MSCP would likely benefit from some level of habitat restoration.

5.1.8 Dams

Four of the five (five of six when including the unsurveyed documented population in Sloan Canyon) known arroyo toad populations within the MSCP occur below dams, so it will be necessary to monitor the effects of the dams on the arroyo toads and arroyo toad habitat and may be necessary to mitigate for these effects. Lake Sutherland may be impacting the two arroyo toad populations within Santa Ysabel Creek- San Dieguito River Park in San Pasqual Valley and in Boden Canyon Ecological Reserve (lower) and the population within San Vicente Creek (water diversions and transfers from Lake Sutherland to San Vicente Reservoir via San Vicente Creek); and releases from Barrett Lake are known to have resulted in displacement of eggs and larvae in Cottonwood Creek (USFWS 1999a). Although the arroyo toad population in Sloan Canyon was not a part of this study due to access restrictions, it is potentially impacted by Loveland Dam operations (see Madden-Smith et al. 2004).

Mitigation for the effects of dams may include replacing and maintaining the coarse sediments required for arroyo toad breeding habitat, removing dense vegetation from arroyo toad breeding habitats and upland terraces, and restoring a more natural hydrologic regime. A possible solution to decreased coarse sediments would be to supplement the sediment supply below dams using methods similar to gravel supplementation methods used for restoration of salmon spawning habitat (USDOI 2000; BC Hydro 2003). A suggestion may be to remove sand and fine gravel from the upstream end of reservoirs (where coarser sediments are deposited) and then transfer the sand and fine gravel to the stream channels below the dams. This possible management action needs to be examined further, because the possible consequences of translocating coarse sediments are not known.

5.1.9 Genetics

Although necessary to properly manage for this species, information on arroyo toad genetic diversity is virtually non-existent. Arroyo toad genetic analysis can be used to evaluate the degree of genetic variation within and between populations and to possibly identify genetic bottlenecks or barriers (Campbell et al. 1996). This will be especially important if populations are to be expanded or reestablished through translocation of larvae or juveniles (Section 5.1.10). USGS collected arroyo toad tissue within the MSCP populations as part of the skeletochronology study in 2003 and 2004 with the intention of participating in future genetic analysis of this species.

5.1.10 Population Expansion or Reestablishment

After threats (e.g., habitat loss, non-native predators, non-native vegetation and pollution) to arroyo toads have been removed and suitable habitat has been restored or created, the possibility of reestablishing arroyo toad populations at sites where arroyo toads no longer exist or occur in very low numbers by translocating larvae or juveniles from more robust populations (e.g., Sloan Canyon, San Pasqual Valley) should be explored. Detailed studies investigating the cause of decline or extirpation of the arroyo toad populations must first be conducted at sites considered for population reestablishment. Additionally, it is critical that any causes for decline (e.g., loss of breeding habitat, presence of invasive predatory species) must be remedied before arroyo toad populations can be reestablished. The recovery program for the natterjack toad (*Bufo calamita*), an endangered species in Britain that has faced threats similar to those of the arroyo toad and is also a habitat specialist, has successfully used the reintroduction of egg strings to help restore the historical range of this species (Denton et al. 1997). Methods similar to the natterjack toad reintroduction should be considered for the arroyo toad (see Denton et al. 1997). Possible enhancement/reintroduction sites include San Vicente Creek, and Sweetwater River in Sycuan Peak Ecological Reserve and the San Diego National Wildlife Refuge.

5.2 Pond Turtle

Like the arroyo toad, the pond turtle was historically more widespread and abundant in San Diego County as well as within the San Diego MSCP (Table 3). The below monitoring and management suggestions are proposed as a means to sustain and improve pond turtle populations within the San Diego MSCP. Increasing these populations and expanding them into other suitable areas should be a part of the MSCP management goals and may be achieved by increasing habitat quality, removing non-native turtles and non-native predatory species 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 study area. Very few populations of pond turtles remain within the MSCP, thus aggressive actions will be necessary to effectively manage for this species.

5.2.1 Minimize Disturbance and Take

Due to the low number of females detected, the lack of juvenile detections and the low population sizes, the pond turtle populations within the MSCP are at increased risk due to human activities that may lead to disturbance and take of pond turtles (e.g., recreation, collection, and roads). MSCP reserve lands should be managed to prevent or minimize disturbance to pond turtles and/or their habitat resulting from on-site activities (e.g., fishing, non-native turtles). This includes restricting access to pond turtle upland and breeding habitats to help prevent disturbance to all pond turtle life history stages (egg, juveniles and adults). This will be especially important at sites such as 4S Ranch, where the pond turtle population is surrounded by development and the remaining corridor of habitat is designated for human recreation and Los Peñasquitos Canyon Preserve, which is heavily recreated and possibly impacted by the network of dirt and paved roads that parallel and bisect Los Peñasquitos Creek.

5.2.1.1 Human Recreation

Human access, especially recreation, should be limited in wetland and upland habitats used by pond turtles in order to minimize disturbance and take. Non-consumptive recreation, such as hiking, dog walking, and fishing, can potentially trigger problems for native turtles if the recreational activities interfere with any aspect of the turtle's life history requirements. For instance, Garber & Burger (1995) found a 100% decrease in two wood turtle (*Glyptemys insculpta*) populations within 10 years of a wildlife reserve being opened up to recreation (fishing, hiking and dog walking). Recreation can lead to removal of turtles, road kills, handling by recreationists, increased predation as a function of increased food waste resulting in an increase in predators (raccoons, coyotes) (see also Joslin & Youmans 1999), and disturbance by dogs (Garber & Burger 1995). The effects of human recreation on the pond turtle are of concern because all pond turtle locations within the study area, except for Sycuan Peak Ecological Reserve, Sweetwater River, are heavily recreated.

Fishing is of concern for pond turtles because they can be attracted to bait and subsequently hooked and released, possibly with the hook still embedded in the mouth or esophagus, or the turtles may be taken for consumption or as a pet. In this study, non-native turtles removed from a heavily fished area of the San Diego River (FSDRIP) excreted fish hooks after capture and an x-ray radiograph of a red-eared slider specimen from this site revealed a fish-hook was deeply embedded in its esophagus (Figure 16) and a red-eared slider from Lake Miramar had a perforated esophagus most likely due to a fish-hook (USGS NWHC, unpublished data). In a similar USGS pond turtle study in Orange County, an x-ray of a red-eared slider found dead at a heavily fished site also revealed that a fish-hook was embedded in its esophagus and another red-eared slider at the same site was found dead with fishing line entangling its front legs (USGS NWHC, unpublished data). It is uncertain if the embedded fish-hooks caused impaired feeding, starvation or metal poisoning and it was also uncertain if the fishing line entangled turtle had drowned because of the fishing line or if the fishing line had become entangled postmortem. Pond turtles occurring in heavily fished areas are likely to be similarly affected by fishing and it is also possible that fishing may be one of the many factors in the overall decline of this species (Holland 1991). Holland (1991) noted that pond turtles captured from a fishing site in the Sierra Nevada had either obvious trauma due to hook removal, had hooks in place or were found dead with hooks embedded in their esophagus and that similar records of injury or death from fish-hooks suggest that this situation was widespread and frequent. Pond turtles have also been fished and taken for consumption from San Dieguito River near Lake Hodges (K. Thomas, personal communication). Jennings and Hayes (1994) suggested that fishing with barbed hooks be regulated in areas containing pond turtles.

Other forms of recreation, such as hiking and dog walking, also need to be considered as potential causes of pond turtle population decline due to the possible disturbance and take that may result from these activities. Hikers or joggers may disrupt pond turtle behavior such as basking, foraging or mating and may encounter nesting females and disrupt nesting or collect them as pets. With the slightest disturbance, females may abandon a nesting attempt and head back to the water (Holland 1994; Goodman 1997a). Turtles may also be encountered while they are heading to or returning from upland aestivation or overwintering sites, and young may be encountered as they disperse from nests to wetland habitats. Dogs, especially those that are off leash and allowed to go off-trail, can also disturb or harm nesting females, turtles heading to or returning from upland aestivation or overwintering sites, and dispersing young. Dogs may also dig up nests with eggs or overwintering young or may dig up overwintering or aestivating adult turtles.

As public usage of the MSCP reserve areas increases, there will likely be an increase in the number of people recreating (hiking, biking, dog walking and fishing), both legally and illegally, in areas where pond turtle populations exist. In the Garber and Burger (1995) study on wood turtles (*Clemmys insculpta*), they found a negative correlation between wood turtle population size and human population size in the surrounding area- as human populations increased wood turtle populations declined. Pond turtles may be similarly impacted by the growing population of San Diego. Possible solutions to help prevent future pond turtle decline due to human population growth and increased recreation include gaining a better understanding of pond turtle population dynamics and habitat requirements, better fencing of reserves, limiting off-trail travel, requiring dogs to be leashed, improved signage, improved outreach and public education, and increased patrols. Protecting females and juveniles will be especially important, because few or no females and no juveniles were detected in the pond turtle populations during this study.

5.2.1.2 Collection

As mentioned above, with increased human access there is a greater possibility of humans encountering pond turtles and collecting them. Pond turtles are small and relatively easy to collect, yet much work to maintain in captivity (as are all water turtles). There are several reported cases of collection of pond turtles in southern California and certainly many unreported cases. Bury (1982) noted collection of over 500 pond turtles from a lake in southern California in the 1960's and Holland (1991) noted known collection of approximately 10 turtles (all recovered by reserve personnel) in a period of three years at the Santa Rosa Plateau Ecological Reserve. Incidental collection could be very detrimental to the small populations within the MSCP reserve. Due to the low number of females and absence of juveniles detected during this study, the collection of females and juveniles could have a significant impact on the viability of the MSCP pond turtle populations. Signage within the MSCP reserve should encourage people to enjoy the wildlife experience, but to leave what they encounter in place. However, signs should not call attention to the turtles, as this may increase collection.

5.2.1.3 Roads

Higher road densities near pond turtle populations are a concern due to increased likelihood of turtles being injured or killed due to encounters with vehicles and due to other effects of roads such as runoff, pollution and changes in temperature. Greater road densities are associated with turtle populations that are predominantly male, because females are more susceptible to road mortality due to their higher frequency of upland movements associated with nesting (Marchand & Litvaitis 2004; Steen & Gibbs 2004; Gibbs & Steen 2005). Greater road densities are also associated with turtle populations containing a higher proportion of adults (Marchand & Litvaitis 2004; Steen & Gibbs 2004), indicating reduced recruitment which is possibly a result of the reduction of females in the population. Gibbs and Shriver (2002) used computer simulation to predict that road density >2 kilometers of roads/km^2 with traffic volumes of >200 vehicles/lane/day would increases adult mortality in turtles. In addition to causing animal mortality, roads also change soil density, temperature, soil water content, light levels, dust levels, surface waters, patterns of runoff, sedimentation, and they add heavy metals (especially lead), salts, organic molecules, ozone, and nutrients to roadside environments (Trombulak & Frissell 2000).

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) that will divert turtles from roads. Barichivich and Dodd (2002) recorded a 41% decrease in traffic related wildlife mortality, including a dramatic decline in the number of road-killed turtles, after a wildlife ecopassage and wildlife barriers were created under a busy highway. Similarly, results in Boarman et al. (1997) suggest that barrier fences can reduce wildlife mortality, but the barriers must include a means for animals to safely cross the roads, such as culverts, in order to prevent an increase in population fragmentation. Creating an ecopassage with wildlife barriers will be especially important for the pond turtle population at 4S Ranch, because there is now a road (or roads) bisecting Lusardi Creek between the two large cattle ponds. Turtles may cross the road to migrate between the ponds or females may cross the road while in search of a nest site. The pond turtles at Los Peñasquitos Canyon preserve might also benefit from ecopassages with wildlife barriers, especially at the Black Mountain Road crossing and the Poway Road Crossing which prevents the pond turtles from safely moving between the Los Peñasquitos Creek Pond and the Chicarita Creek Pond. Protecting females and juveniles will be especially important, because few or no females and no juveniles were detected in the pond turtle populations during this study.

5.2.2 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 such as Los Peñasquitos Canyon Preserve and 4S Ranch. People frequent Los Peñasquitos Canyon Preserve for use as a recreational outlet and 4S ranch is currently undergoing development for housing. Hence, the likelihood of unwanted pet turtles being released into these sites is higher than at a more remote site, such as Sycuan Peak

Ecological Reserve. At a minimum, these informative displays should provide information such as the following: 1) any restrictions for the site (e.g., no fishing), 2) the importance of not disturbing or molesting any wildlife they may encounter, 3) the potential danger(s) of handling and collecting wild animals, 4) the ramifications of releasing pet turtles and other non-native pets and emphasizing that it is also illegal (California Fish and Game Code Section 2121 and California Penal Code 597s), and 5) contact information for organizations that will accept unwanted pet turtles, such as the San Diego Turtle and Tortoise Society.

Similar to that discussed for the arroyo toad in section 5.1.2, educational pamphlets, outreach, and educational programs can be used to promote the value of pond turtles and native ecosystems as well as the negative effects of non-native species. Partnerships should be established with organizations such as the San Diego Turtle and Tortoise Society and the San Diego Herpetological Society to educate the public on the negative impacts of releasing pets and offer alternative ways of getting rid of unwanted pets. The San Diego Turtle and Tortoise Society has expressed interest in helping this cause (K. Thomas, personal communication). In addition, an outreach program should be initiated with local pet stores to educate consumers and possibly establish and unwanted turtle return policy. Educational programs may also be initiated or incorporated with currently existing school programs (elementary through high school) throughout San Diego County. Again, education and outreach may be coordinated by the already established MSCP Outreach Committee in conjunction with landowners.

5.2.3 Enforcement of Rules and Restrictions

Similar to that discussed for the arroyo toad in section 5.1.3, patrols of MSCP lands will need to be increased or management plans may not be as effective.

5.2.4 Additional Surveys

In order to get a better understanding of the size, status, and habitat requirements of pond turtle populations occurring within the San Diego MSCP, 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 the MSCP. 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.

5.2.4.1 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 San Diego MSCP 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). In addition to the general habitat characteristics that were collected during the habitat assessment conducted in this study, more detailed data should be collected and should include: more precise measurements of percent of canopy cover and pool size (possibly using digital orthophotographs), pool depth, substrate types (both wetland and upland), and percent of basking site coverage. Results of the habitat assessment may be used to establish criteria for habitat restoration or creation or to establish which criteria are essential when choosing a site for population reestablishment, all of which may be necessary to sustain pond turtle populations within the MSCP.

5.2.4.2 Water Quality Assessment

Another 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.

One site that requires immediate attention is 4S Ranch, where the smell and appearance of the water at the westernmost pond suggest that it is polluted. The source of contamination at this pond should be identified and resolved immediately. It is possible that pond turtles were not detected in the westernmost pond due to the poor water quality, because otherwise the habitat appears suitable. It will be important to monitor the water quality of this site as the development at 4S Ranch progresses and increased run-off (including pesticides and fertilizers) and erosion occurs.

5.2.4.3 Recruitment and Population Viability

It appears that successful recruitment is low or possibly not occurring within the MSCP 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 (see section 5.2.10). A reduction in recruitment will reduce and may eventually eliminate pond turtle populations, so this issue should be addressed immediately. However, effective management must address and protect all life stages in order to maintain viable populations of pond turtles. High adult survival in combination with increased juvenile recruitment can boost turtle population numbers and increase the chances of population persistence into the future (Rubin et al. 2004). Long lived species, such as turtles, usually possess life history traits that limit their ability to maintain stable populations: relatively low fecundity, low nest survival, high adult survival, and as a result they require extremely high juvenile survival to maintain population stability (Congdon et al. 1993).

Radio-telemetry studies should be initiated to gather more information on the reproductive status of the pond turtle populations within the MSCP. Studies should involve tracking female pond turtles, locating and protecting nests and monitoring juvenile survival. In addition to locating nests, nest site characteristics, including soil type, cover, aspect, and distance from water should be recorded. Data collected on nest locations will benefit the management of upland habitats, by helping better understand nesting habitat requirements and also by helping determine the size of upland buffer zone required to help sustain populations. In addition to monitoring reproductive success, it is also important to assess resource availability because pond turtle reproduction appears related to resource availability (Pires 2001). The populations in most need for the type of data that can be gathered from a radio-telemetry study are at 4S Ranch, Los Peñasquitos Canyon Preserve and Sycuan Peak Ecological Reserve (possible control site).

5.2.4.4 Upland Habitat Requirements

There has been very little study of the upland movements of pond turtles in southern California and as a result little is known about the size of the upland buffer zone required to protect pond turtle populations. In a Mediterranean climate, pond turtles are known to move upland to overwinter (take refuge from winter floods), to nest and to rest for short periods (1-5 days) at terrestrial basking sites (Goodman 1997a; Rathbun et al. 2002). Studies (mostly radio-telemetry studies) of pond turtles have found pond turtles moving a maximum of 100 meters to just over 400 meters perpendicular to wetland habitats to nest (Storer 1930; Rathbun et al. 1992; Holland 1994; Goodman 1997a; Reese & Welsh 1997; Lovich & Meyer 2002; Rathbun et al. 2002). Pond turtles are known to travel as far as 500 meters into the uplands (Reese & Welsh 1998; Hays et al. 1999) and linear home ranges as long as 4263.2 meters have been reported (Goodman 1997a; Goodman & Stewart 2000). Rathbun et al. (1992) suggest that pond turtles may require a long and wide upland habitat corridor, extending at least up to 0.5 kilometer on each side of the wetland habitat and that it is important to protect these habitats year-round in order to protect eggs and overwintering hatchlings in nests. Since most of the available upland habitat use data is for northern populations of pond turtles and upland requirements of northern populations may differ from southern populations, more study is needed for upland requirements of the southern pond turtle populations. It is possible that upland habitat is more important in the more arid southern portion of the pond turtle's range, where rivers and streams regularly dry as a result of drought and/or diversion or damming to support human water needs (e.g., drinking water, agriculture).

Radio-telemetry should be used to quantify the extent and determine the timing of pond turtle upland habitat use and to determine how large of a buffer zone will be required to protect nesting and overwintering sites. Data on nesting habitat characteristics should be collected to determine what vegetation, soil and other habitat features are important for successful nesting. These data would also provide helpful information regarding the management and possible creation of nesting sites.

In a study of three aquatic turtles, mud turtle (*Kinosternon subrubrum*), Florida cooter (*Pseudemys floridana*) and slider (*Trachemys scripta*), Burke and Gibbons (1995) found that nesting and overwintering sites occurred exclusively beyond wetland boundaries designated under federal guidelines. Based on radio-telemetry data collected on upland habitat use, they developed two biologically-based buffer zone models to determine a buffer zone large enough to protect nesting and overwintering. A study similar to this could easily be done for the pond turtle and would provide valuable information for protecting these important life-cycle stages.

The sites with highest priority for this type of study are 4S Ranch, Los Peñasquitos Canyon Preserve and Sycuan Peak Ecological Reserve.

Radio telemetry would also be useful in monitoring the upland movements of the pond turtles at 4-S Ranch until construction activities are complete. This would help prevent direct mortality associated with construction activities. Furthermore, if possible, it might be beneficial to limit large equipment operation/earth moving operations when turtles are likely to be using the upland habitats the most (during winter for overwintering and spring to early summer- for nesting) and to make sure that turtle nests and overwintering juveniles are protected.

5.2.4.5 Effects of Drought

2002 and 2003 were below normal rainfall years, thus future pond turtle presence surveys should be conducted during a period of normal rainfall in order to help confirm the 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. Specific sites to be resurveyed include Wilson Creek, Golem Land Trust, Lake Hodges, Mission Trails Regional Park, San Diego National Wildlife Refuge, and Lusardi Creek Preserve. In addition, research investigating the effects of drought on the pond turtle (especially populations most at risk such as those below storage reservoirs) should be considered within the San Diego MSCP. Although southern populations of the pond turtle have evolved with regular periods of drought, manmade stressors (e.g., habitat loss, dam construction, introduction of non-native predatory species, pollution) may be compounding the effects of drought. In addition, drought may have played a factor in the low detection rate of gravid females and the lack of juvenile detections, as females may defer reproduction following a period of low resource availability (Pires 2001).

5.2.5 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. Habitat degradation or loss can lead to abnormal population structure in pond turtles (Dodd 1990; Reese & Welsh 1998a) and eventually result in population decline or extirpation. All known populations of pond turtles within the MSCP would benefit from habitat restoration. Hollenbeck Canyon Wildlife Area and Rancho Jamul Ecological Reserve are locations that should be considered for restoration of historic pond turtle habitat or creation of new habitat with the purpose of reestablishing pond turtle populations.

The Washington Department of Fish and Wildlife and the Oregon Department of Fish and Wildlife have set guidelines, either through pond turtle recovery plans or public outreach, for restoring or creating pond turtle habitat (Hays et al. 1999; ODFW 1999, 2000). Below are detailed descriptions of the required habitat characteristics to consider for restoration or creation of pond turtle habitats based on Bash (1999), Hays et al. (1999), ODFW (1999, 2000), Holzhauser and Work (1999), and others. Although these requirements are based on northern populations of pond turtles, they can still act as guidelines for southern populations.

Water Bodies: Water bodies should contain still or slow-moving water with some areas at least one meter, but preferably up two meters deep for adults. In addition, at least 25% of the water's edge should be less than 30.5 centimeters deep with a gentle gradient for young juveniles. Water body should also be permanent.

Vegetation: There should be emergent and submergent aquatic vegetation present, but the water body should get good sun exposure. Reese and Welsh (1998b) suggest that some cover, especially along the waters edge, may help pond turtles avoid predation and that pools receiving patchy sunshine may allow for better thermo-regulation. If the water bodies become too choked with vegetation, some vegetation should be removed.

The reduction in scouring flows due to water diversion or damming of a watercourse can lead to an increase in downstream vegetation (i.e., the vegetation does not get scoured away on a regular basis as with the historic natural hydrologic regime) (Williams & Wolman 1984; Ligon et al. 1995; Collier et al. 2000), thus allowing vegetation to encroach on pond turtle habitat and eventually completely shade or fill in the deep open pools adults require. This was observed in Sweetwater River below Loveland Dam and in the Otay River below Savage Dam (Lower Otay Reservoir). As a result, monitoring the presence of native or non-native plant species and their effects on pond turtle habitat (e.g., *Typha* spp. or *Arundo donax* encroaching on deep pools), should be a part of the pond turtle management plan. It may be necessary to remove native and non-native species in areas that are too shaded or have become choked with vegetation. These sites should then be monitored to determine the effectiveness of removal and to measure benefits to pond turtles. Early removal of known problem species, especially non-natives, can be more cost effective than delaying removal until an impact on the turtles is clearly detectable.

Aquatic Refugia: If not present, aquatic refugia such as plants, rock, pieces of wood, or roots wads should be added for turtles to retreat or hide.

Basking Sites: If not present or too few in number, aquatic basking sites, such as logs, rocks or root wads should be added to water bodies to provide safe basking areas for pond turtles. In addition, floating basking rafts can be anchored away from land to provide basking sites that are safe from land predators (this would be especially helpful for the population at 4S Ranch, because basking sites are currently restricted to the shoreline).

Hatchling Habitat: Native plants and small root wads or tree branches should be available in shallow areas for juveniles to take refuge.

Upland Nesting Sites: Protect upland habitats at least 500 meters from water bodies (see section 5.2.4.4), especially important are sunny areas. Nesting habitat can be improved or created by creating clear visual and travel paths between the water and large sunny areas, mowing grasses to create patches of short, sparse vegetation with bare soils, and by creating buffer zones around known nest sites and protecting these areas from grazing, human recreation and predation. It is recommended that the created nest sites be at least two by three meters in area. If the soil is too rocky or sandy, silty clay soils can be used to create three by three meter mounds that should be shaped to maximize southern exposure.

Travel Corridors: In addition to nesting corridors, travel corridors such as streams, rivers and riparian areas should allow movement between pools, ponds and populations (important for maintaining genetic diversity). In areas with roads, ecopassages with walls that divert turtles to using these wildlife corridors should be created to prevent road mortality (Barichivich & Dodd 2002).

Water Quality: Water quality must also be considered when restoring or creating habitat for pond turtles. Chemical removal of vegetation or predators should be avoided as they might affect or contaminate the pond turtle's food source. Rotenone, a commonly used pesticide for fishery management, has been documented to kill turtles and should not be used in areas where pond turtles occur (Fontenot et al. 1994; McCoid & Bettoli 1996). Pesticides in general should be avoided within the vicinity of pond turtle populations. This topic is also discussed in section 5.2.4.2.

Predators: Eliminate or control aquatic non-native predators such as bass and bullfrogs. Reduce predation of nests by providing large nesting areas, placing cages over known nest sites to exclude predators (but still allowing sun exposure and hatchling emergence), and trapping and relocating nest predators prior to or during the nesting season. This topic is discussed in more detail in section 5.2.7.

Non-native Turtles: Eliminate or control non-native turtles. Non-native turtles may compete with pond turtles for resources or spread disease. This topic is discussed in more detail in section 4.2.4 and 5.2.6.

5.2.6 Non-native Turtles

Non-native turtles were detected at many more locations in the MSCP than pond turtles, thus the management strategy for the pond turtle needs to include studies on the interspecific relationships between pond turtles and non-native turtles and the benefits of non-native turtle removal to the pond turtle. In order to better understand the probable negative relationship between non-native turtles and the pond turtle, these potential threats should be investigated. For example, pond turtles from isolated populations and populations that coexist with non-native turtles should be compared for disease and parasites to study whether non-native turtles are transmitting disease and parasites to pond turtles. See section 4.2.4 for more information regarding non-native turtles.

Non-native turtle removal should be priority over other non-native species removal and would be most beneficial at or near locations that support pond turtles. At this time, Los Peñasquitos Canyon Preserve (creek and pond), Mission Trails Regional Park- Lake Murray, and Santee Lakes are the only known locations where pond turtles and non-native turtles co-occur. In addition, non-native turtles need to be removed from sites where habitat will be restored or created with the purpose of restoring or expanding pond turtle populations.

5.2.7 Native and Non-Native Predatory Species

Introduced predators, especially bullfrogs and largemouth bass, pose potential threats to pond turtles (Holland 1991, 1994). Bullfrogs and/or largemouth bass were detected at most of the locations that were surveyed within the MSCP, including locations where pond turtles occur. In general, pond turtles are most vulnerable to predation during the younger life history stages (when they are neonates and small juveniles). When pond turtles enter aquatic systems, they are about the size of a silver dollar. Bass and bullfrogs are "gape limited" predators that have been reported to eat young pond turtles (neonates to yearlings) (Moyle 1973; Brattstrom & Messer 1988; Holland 1991, 1994). Due the threats non-native predators pose to population recruitment and because recruitment rates appear low or absent within the MSCP pond turtle populations, non-native 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 to non-native aquatic species, native and non-native terrestrial predators must also be monitored and controlled, if necessary. Native predators, such as raccoons (*Procyon lotor*) and coyotes (*Canis latrans*), and introduced predators, such as opossums (*Didelphis virginiana*) are more likely to injure or take females, eggs and young. Terrestrial predator removal has been shown to reduce the number of destroyed turtle nests and enhance hatchling yield (Christiansen & Gallaway 1984). The reproductive success of pond turtles is low and recruitment rates are very low or absent within the known MSCP populations, thus it is important to monitor predator populations in areas that contain pond turtles.

5.2.8 Other Non-native Threats

Other non-native species that may be detrimental to pond turtle populations, such as sunfish, carp, mosquitofish, and crayfish, were found at many locations throughout the MSCP (see Section 4.2.7). These species may indirectly affect pond turtles by changing the aquatic community, competing for prey, or spreading disease. The presence of these species may also be beneficial, as they may serve as a prey source for pond turtles. However, controlling these species and restoring the aquatic community, especially in or near locations that support pond turtles, will likely benefit pond turtles. It will also be important to monitor the effectiveness of eradication techniques and measure benefits to pond turtles.

Non-native plant species were also detected at many locations throughout the MSCP. Non-native plants should be controlled and monitored in areas that support pond turtles.

5.2.9 Genetics

Several studies have determined that southern California populations of pond turtles are more genetically diverse than northern populations and as a result should receive increased protection (Gray 1995; Janzen et al. 1997; Spinks & Shaffer 2005). Genetic differentiation may signify deep historical splits among populations and thus indicate their individual importance (Janzen et al. 1997). San Diego pond turtle genetics has not been specifically studied, therefore it will be necessary to determine the genetic diversity within these populations to properly manage and protect this species. This will be especially important if populations are to be enhanced, restored or introduced through translocation of adults or through head starting and/or captive breeding (see section 5.2.10). USGS has been collecting pond turtle tissue within the MSCP populations with the intention of future genetic analysis.

5.2.10 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 head starting, captive rearing or translocation) should be considered to maintain or enhance extant populations or to reintroduce turtles where they have been extirpated within the MSCP or to introduce new populations. The head starting, captive breeding and reintroduction programs of the Washington Department of Fish and Wildlife and the Oregon Department of Fish and Wildlife have proved that this type of program can be successful at increasing pond turtle populations (Heltzel 2000; Allen & Slavens 2002). Additionally, a population was successfully established in Orange County, California by translocating adult and juvenile pond turtles to an artificial pond that had been created for pond turtles (Harmsworth Associates & Goodman 2002, 2003).

When the number of pond turtles in the state of Washington was down to approximately 150-200 pond turtles in 1990, the Washington Department of Fish and Wildlife initiated a head starting, captive breeding and reintroduction program in association with the Woodland Park Zoo (Seattle, Washington) and later the program was expanded with the help of the Oregon Zoo (Portland, Oregon) (Bowdoin 1994; Allen 1996; McAllister et al. 1996; Dean 1999; Hays et al. 1999). This program captively rears pond turtles and releases them after they have grown large enough to prevent predation by aquatic predators such as bullfrogs. By 2001, the total number of pond turtles in Washington was estimated to be approximately 500 individuals and many of them were head started turtles that had been released through this program (Allen & Slavens 2002).

In Orange County a pond turtle population was successfully created through habitat creation and restoration and the translocation of adult and juvenile pond turtles from nearby locations (Harmsworth Associates & Goodman 2002, 2003). Pond turtles quickly adapted to the pond, increased in size and weight, and successful recruitment occurred within the first two years (Harmsworth Associates & Goodman 2002, 2003). The success of this project was likely due to the location of the created pond (relatively isolated from human access), suitable aquatic habitat (both deep and shallow areas with appropriate pond turtle refugia), suitable upland habitat (south facing slope with native vegetation), and the absence of non-native species.

The success of a head starting and captive breeding programs or other species recovery programs cannot be determined without research on the behavior and survival of both captive reared and wild turtles (Heppell et al. 1996). A successful strategy for increasing turtle populations through head starting and captive rearing must ensure that the entire population is self-perpetuating (Haskell 1998). In other words, the program will only be effective if causes of older juvenile and adult mortality are reduced and the head started turtles eventually reproduce successfully (Congdon et al. 1993; Heltzel 2000).

A possible source population for similar programs within the MSCP is the Sycuan Peak Ecological Reserve, Sweetwater River population. Other possible source populations to consider outside of the MSCP include those on U. S. Forest Service Land in Pine Valley Creek and Cedar Creek. Possible reintroduction/introduction sites include Jamul Creek (also suggested by Brattstrom and Messer 1988) and several of cattle ponds found within Rancho Jamul Ecological Reserve; Hollenbeck Creek in Hollenbeck Canyon Wildlife Area; and San Diego River and Alvarado Creek in Mission Trails Regional Park. Los Peñasquitos Canyon Preserve, 4S Ranch, Lake Murray/Alvarado Creek in Mission Trails Regional Park, and Sycuan Peak Ecological Reserve should all be considered for population enhancement, as all populations are below what is considered viable (Holland et al., unpublished report).

Summary

The arroyo toad and pond turtle were historically more widespread and abundant within the San Diego MSCP and throughout San Diego County. Only a few small populations of arroyo toads and pond turtles remain within the MSCP, thus increasing and expanding populations should be the main management goals for these species. This will require aggressive actions such as gaining a better understanding of the species needs, increasing habitat quality, removing non-native species, restoring a more natural hydrologic regime and augmenting or creating new populations through translocation or captive rearing. The recommendations in this report were given as guidelines for improving the understanding of these declining species and as a framework for developing adaptive management plans. Successful management of these species will require coordination among agencies, landowners, and the public.

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