MCB Camp Pendleton Arroyo Toad *(Bufo californicus)* Monitoring Results, 2003

Annual Report

Prepared for:

Wildlife Management Branch
AC/S Environmental Security
Marine Corps Base Camp Pendleton

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

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Arroyo Toad Monitoring Results, 2003

By Cheryl S. Brehme, Andrea J. Atkinson, and Robert N. Fisher

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ABSTRACT

In 2003, we implemented a new monitoring program for the endangered arroyo toad (*Bufo californicus*) on Marine Corps Base Camp Pendleton (MCBCP). To address the problems associated with large variations in adult toad activity, we employed a spatial and temporal monitoring approach that tracks the presence of arroyo toad breeding populations by documenting the presence of eggs and larvae. Unlike adult toads, eggs and/or larvae remain visible in the water for months before metamorphosis and have a much higher probability of detection. This year, we began monitoring 89 km of potential toad breeding habitat within MCBCP. We divided the habitat into approximately 60 blocks, each divided into 6 survey site lengths. One site length within each block is surveyed yearly, while the other site lengths are surveyed on a 5 year rotation. We implemented the first year of this rotating panel design by comprehensively surveying 120 randomly stratified survey site lengths (30 km). We then used a loglinear modeling program to model the data and correct for varying detection probabilities. The program provides the framework for powerful statistical analysis of trends in metapopulation dynamics and breeding, as well as the effects of habitat, aquatic variables, and management actions on arroyo toad populations.

In 2003, 78% of potential toad breeding habitat contained water during our survey efforts. Of these areas, 87.4% (se = 9.5) of the habitat was occupied by breeding arroyo toads. The greatest occupancy was recorded on the San Mateo watershed (97.9%), followed by the San Onofre (90.9%) and Santa Margarita (83.8%) watersheds. We evaluated over 14 habitat and survey specific variables in the models. These included landscape variables, environmental variables, and the presence of nonnative plant and aquatic vertebrate species. Results showed that the absence of crayfish was the single most significant predictor of the presence of arroyo toad larvae. Larvae were 20 times (95% CI: 2-249) more likely to be detected when crayfish were absent. Although data on the relationship between crayfish and arroyo toads are sparse, crayfish are known to prey upon amphibian eggs, larvae, and adults, and have been linked with declines in some amphibian populations. It is unknown whether this is a direct link or if crayfish are an indirect indicator of less than favorable habitat conditions.

In order to provide continuity with previous monitoring efforts, monitor numbers of different age classes throughout the breeding season, and determine if counts of arroyo toad larvae correlate with counts of adult toads, we also conducted intensive day and night coupled surveys in eight 1.5 km blocks covering three watersheds (San Mateo, San Onofre, and Santa Margarita). We counted larvae and metamorphs during the day and then counted

adults along the same block at night. Adult toads were also scanned with a PIT (Passive Integrated Transponder) tag reader in order to gain information on toads that were tagged during the 1998-2000 monitoring effort. Adult counts were compared to previous years and correlation analyses of the age classes were performed.

For 2003, we documented all age classes (larvae, metamorphs/juveniles, and adults) in each of the eight blocks. Adult numbers were generally low, but comparable to lower numbers recorded in previous years. The presence of metamorphs and juveniles in each block indicated that recruitment of toads took place throughout MCBCP, although survivorship of juveniles is unknown. There was evidence that breeding was delayed in the Santa Margarita River in comparison to the lower order creeks, presumably due to high water volume in the early spring. The water volume also remained high throughout the breeding season, which may have contributed to lower total numbers of larvae observed along this river. Over the surveys, the probability of detecting arroyo toad larvae (85.2%) was almost double the probability of detecting adults (46.4%). There were no significant correlations in the numbers of larvae to adults, however, there was a significant association between the presence of arroyo toad larvae and adults when the survey data was combined over the season. We found five adults containing PIT-tags from Dan Holland's arroyo toad projects in 2000. Although we could not determine exact ages, four toads were at least 4 years of age and one toad was at least 5 years of age.

By characterizing occupied and unoccupied potential arroyo toad breeding pools, we found that pools containing arroyo toad larvae averaged 8% more vegetative cover than those that did not ($\chi^2 = 4.886$, $p = 0.027$). We also documented the presence and spatial distribution of both native and non-native aquatic species and several non-native plants. Non-native species were most prevalent in the Santa Margarita watershed, where availability of perennial water may enhance their ability to survive and compete with native flora and fauna.

Management recommendations are similar to those made in previous years. Although we found a significant negative association between the presence of arroyo toad larvae and the presence of crayfish, continued monitoring should help to more accurately assess the strength and causal mechanism of this relationship. Several refinements to the survey are recommended in order to increase the value and power of the data collected, as well as increase model fit parameters. These, along with additional years of data, will enable us to provide sound, accurate, science based recommendations for continued arroyo toad management and monitoring efforts on MCBCP.

INTRODUCTION

The primary mission for Marine Corps Base Camp Pendleton (MCBCP) is "to operate an amphibious training Base that promotes the combat readiness of operating forces by providing facilities, services, and support responsive to the needs of Marines, Sailors, and their families" (MCB Camp Pendleton Strategic Plan 2002). In addition, the base has committed to fulfill stewardship and regulatory requirements for the natural resources on base. This includes monitoring and management for the endangered arroyo toad as described in the MCBCP Integrated Natural Resources Management Plan (October 2001). The U.S. Geological Survey was contracted to develop a science based monitoring program for the arroyo toad on MCBCP in 2002 (Atkinson et al. 2003) and implement this monitoring program in 2003.

The Arroyo Toad

The arroyo southwestern toad (*Bufo californicus*) is a specialized amphibian that is endemic to the coastal plain and mountains of central and southern California and northwestern Baja (Jennings and Hayes 1994). It primarily inhabits low gradient streams and rivers that are composed of sandy soils and contain sandy streamside terraces (Sweet 1992, 1993, Barto 1999). Its reproduction is dependant upon the availability of shallow still or low flow pools from which breeding, egg laying, and larval development occur. These habitat requirements are largely dependant upon natural hydrological cycles and scouring events (USFWS 1999, Madden-Smith et al. 2003).

Breeding and larval development within MCB Camp Pendleton typically occur between March and July (Holland et al. 2001), depending upon weather conditions. Females produce a single egg clutch each year. Upon fertilization, arroyo toad larvae (tadpoles) emerge in 12 to 20 days and persist in breeding pools 65 to 85 more days. Newly metamorphosed toads may remain by the breeding pools for a few weeks to several months before dispersing to upland habitat to over-winter. As with most amphibians, the survivorship of developmental stages has been reported to be very low (Sweet 1992). The lifespan of the toads is not known, but thought to be approximately five years (Sweet 1992, 1993).

Currently, the arroyo toad is known to occupy an estimated 25% of its previous occupied habitat within the United States (Jennings and Hayes 1994). The arroyo toads decline has largely been attributed to extensive habitat loss, human modifications to water flow regimes, and the introduction of non-native predators. It was listed by the U. S. Fish and Wildlife Service (USFWS) as endangered in December of 1994. A Recovery Plan for the arroyo toad was then published in 1999 (USFWS).

Study Site

Marine Corps Base Camp Pendleton (MCBCP) is located on approximately 125,000 acres within the Peninsular Ranges physiographic province of California. This province is characterized by a narrow, sandy shoreline, seaside cliffs, coastal plains, low hills, canyons, and mountains which rise to elevations of approximately 2,700 feet (NEESA, 1984). Habitats within the MCBCP include oak woodlands, coastal sage scrub, native and non-native grasslands, coastal dunes, riparian forest/woodland/scrub, as well as wetlands. MCBCP is bordered by the cities of San Clemente and Oceanside to the northwest and southeast, while the Cleveland National Forest and the Pacific Ocean border the northern and western portions, respectively. To date, the base is largely undeveloped and encompasses the largest remaining expanse of undeveloped coastline and coastal habitat in southern California. Because of this, many species that were once common throughout the Peninsular Range now find their refuge within the borders of MCBCP. This is true for the arroyo toad, which populates three of MCBCP's major watersheds: 1) Santa Margarita River, 2) San Onofre Creek, and 3) San Mateo Creek. These represent 3 out of 22 currently occupied drainages among Monterey, Santa Barbara, Ventura, Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Imperial Counties in the United States and support the only known remaining coastal populations of the arroyo toad (USFWS 1999).

Within MCBCP, specific threats to arroyo toad populations may include:

1. Alteration of natural hydrology, increased siltation, and decreased water quality due to increased upstream development in urban areas (e.g., Fallbrook, San Clemente, Temecula). These threats are particularly imminent for the San Mateo watershed (Cristianitos Creek) and the Santa Margarita River (Steinitz et al. 1996).
2. Potential alteration of hydrology and lack of surface water from excessive groundwater pumping for agriculture and human needs, particularly in the lower San Mateo watershed (per Holland et al. 2001).

3. Loss of habitat due to excessive exotic vegetation (giant reed, tamarisk, non-native grasses) which can hinder movement and/or stabilize stream banks.
4. Excessive predation by exotic predators (e.g., bullfrogs, crayfish).
5. Loss of foraging or breeding habitat due to on base development or intense training activities.
6. Direct (crushing) and indirect (siltation, soil compaction) mortality due to training activities that occur during the breeding season.

Population Monitoring

In order to census populations of the arroyo toad, a monitoring program was first implemented on MCBCP from 1996 to 2000 (Holland et al. 2001). Eight 1 km long transects were established on the three occupied watersheds. Transects were surveyed at night for an average of four times per year for juvenile, sub-adult, and adult toads. Mean and median survey counts were used to look for trends in arroyo toad population numbers, however, the large night to night variation made it difficult to assess temporal trends in population size. To better assess population sizes, a capture-recapture program was implemented using PIT tags to mark the animals (Holland et al. 2001). Unfortunately, after three years of effort, the overall recapture rate (including multiple recaptures of the same individual) was too low (20.8%) to perform any meaningful abundance analysis, as the population estimate variances were too large. In order to collect enough data to narrow these large variances, a much more intense monitoring program would need to be performed. This would be costly in terms of the increased time and effort needed to fulfill these requirements. Also, data generated from non-randomly selected permanent transects are limited for use in understanding the spatial and temporal distribution of arroyo toads on base.

In order to better track trends in arroyo toad populations on MCBCP, a spatial and temporal monitoring approach was designed (Atkinson et al. 2003) using a presence/absence model (MacKenzie et al. 2002) that calculates site occupancy. Because the probability of detecting a species on any single survey is typically not perfect, site occupancy can be underestimated. In this model, site occupancy is determined after correcting for a detection probability calculated from data obtained on multiple visits. Percent site occupancy can then be used as a metric to monitor long term trends in populations (MacKenzie et al. 2003). This model also allows for analysis of site and survey specific covariates. These covariates can be any environmental and/or habitat variables that vary (survey specific) or do not vary (site specific) with each survey visit. These include variables that may affect detection probabilities, such as weather and water variables, and/or others that are directly related to land use and management activities, such as presence of non-native plant and/or aquatic species, military activities on site, water quality, and human impacts to the hydrological regime. Thus, impacts of these activities can be assessed over time to make more informed management decisions on base. This approach is currently being implemented for the U.S. Geological Survey's Amphibian Research and Monitoring Initiative (http://armi.usgs.gov). Because only presence/absence data are collected, trends in population abundance are not monitored with this methodology.

A workshop to devise the arroyo toad monitoring protocol reported here was conducted on August 27, 2002 with arroyo toad experts from the USGS, U.S. Fish and Wildlife Service, MCBCP, U.S. Forest Service, California Department of Fish and Game, and the Universities of California, at San Diego and Davis. The discussion points, consensus, and complete theoretical protocol are detailed in Atkinson et al. (2003). In summary, suitable habitat within the three major watersheds on MCBCP (Santa Margarita, San Mateo, and San Onofre) were first to be divided into at least 50 linear blocks which are then subdivided into six equal survey site lengths. The length of blocks and survey sites would be chosen after mapping of the suitable habitat. One site length within each block is surveyed yearly (permanent), while the other site lengths are surveyed on a five year rotating basis. This way, the entire watershed is surveyed every five years, while at least 50 randomly stratified site lengths are surveyed yearly. An important protocol decision was to survey for egg clutches and tadpoles during the breeding season rather than to survey for adult toads. This increases probabilities of detection, because barring flooding, drying, or considerable predation events, eggs and tadpoles are easily observable during the day for up to three months in time. Also, the presence of eggs and/or tadpoles directly indicates the nearby presence of reproductive adults.

This protocol does require the presence of water. Thus, in drought years, some areas may not be surveyed. Even with sufficient rains, breeding may not occur if the rains are unseasonably late. Sweet (1992) attributed the lack of arroyo toad breeding in the Los Padres National Forest in 1990 to cool and dry winter and spring seasons that year. It was hypothesized that the dry period delayed foraging and vitallogenesis. Thus, most female toads apparently did not have mature clutches until after most males had ceased calling.

Thus, the percent site occupied model is limited to breeding activity only. Also, it should be noted that successful recruitment cannot be confirmed with this survey method.

In order to compare this new approach and provide continuity with the 1996-2000 monitoring efforts, eight blocks were designed to overlay the Holland transects (Holland et al. 2001) where count data would also be collected. These “intensive” blocks are surveyed both day and night four times throughout the breeding season. In addition to presence/absence, egg clutches, tadpoles, and adults are counted along each block. The intensive surveys were designed with five main objectives: 1) compare adult numbers to the 1996-2000 data, 2) perform correlations between numbers and presence of animals at different life stages, 3) document different life stages, including metamorphs and juveniles, 4) calculate more accurate detection probabilities for the model, and 5) gather information on individual toads that were originally PIT-tagged from 1998-2000 (Holland et al. 2001).

METHODS AND MATERIALS

Block and Site Selection

On March 26 and April 1, 2003, potential arroyo toad habitat was mapped on the ground by representatives of USGS and MCBCP. Very little habitat was excluded on MCBCP due to past records of species occurrence throughout the three major watersheds. Upper endpoints were chosen on the border of MCBCP property and lower endpoints were located at the approximate ending of fresh water habitat at the mouth of each watershed. The potential habitat mapped for the study was approved by the representative wildlife biologist for AC/S Environmental Security, MCBCP, Robert Lovich, on April 7, 2003. This resulted in the identification of 89 km of potential arroyo toad breeding habitat. This habitat is comprised of 39 km of the Santa Margarita watershed (lower and upper Santa Margarita River, De Luz Creek, Roblar Creek), 18 km of the San Onofre watershed (lower and upper San Onofre Creek, a small portion of the South Fork of San Onofre, and Jardine Canyon Creek), and 32 km of the San Mateo watershed (Lower and Upper San Mateo Creek, Cristianitos Creek, and Talega Canyon Creek). This allowed for the designation of 59.5 survey blocks comprising a total of 357 survey site lengths (Table 1, Figures 1A-1D). Each 1.5 km block was divided into 6 site lengths of 250 m. The eight intensive blocks were co-located as closely as possible with the 1996-2000 transects. Three of the intensive blocks were located in the San Mateo watershed (lower San Mateo, upper San Mateo Creek, Cristianitos Creek), two in the San Onofre watershed (lower and upper San Onofre Creek), and three in the Santa Margarita watershed (lower and upper Santa Margarita River, De Luz Creek, see Figure 2). For the rotating panel sampling design, we chose the survey years for each site (permanent, year 1, year 2, year 3, year 4, year 5) within each block using a random number generator. See Appendix 1 for GPS locations and survey years for all sites.

Survey Methods

Four different survey methods conducted for arroyo toad monitoring in 2003 are described in this section. They are: 1) Initiation of breeding surveys, 2) Presence surveys, 3) Intensive surveys, and 4) Observer variability surveys. Subsequent data analyses, results and discussion sections will also be presented individually for these four survey types. All field survey protocols described in this section were adapted from the MCB Camp Pendleton Arroyo Toad Monitoring Protocol (Atkinson et al. 2003).

INITIATION OF BREEDING

The purpose of these surveys is to determine when arroyo toad breeding has begun. Once breeding is established, we can then schedule subsequent surveys (presence and intensive) for egg clutches and larvae at the appropriate time.

The advertisement call of the arroyo toad is a unique clear, whistling trill lasting between 4 and 9 seconds (Sweet 1992). Arroyo toad females lay eggs at the males calling site in linear envelopes ranging from 10 to 35 feet in length containing around 5000 eggs (Sweet 1992). The egg clutches are very similar to those of the western toad, *Bufo boreas*. However, the western toad primarily lays its eggs in deeper water (12-28 cm) on submerged vegetation, whereas those of the arroyo toad are almost always laid in shallow water away from any vegetation. Because of this microhabitat association, Sweet (1992) suggests that they can be safely identified to species by microhabitat alone. However, the identification cannot be absolute until confirmed by subsequent identification of larvae. For the purposes of this survey, breeding is confirmed after confirmation of calling males followed by observation of egg clutches in pools characteristic of the arroyo toad.

To detect the onset of breeding, we scheduled the eight intensive sites to be surveyed weekly at night for calling males. The call surveys start at approximately 30 minutes after sunset and are ideally started in early February. Once calling arroyo toad(s) are documented, we would then schedule weekly daytime surveys for eggs (Atkinson et al. 2003) until breeding is confirmed.

In 2003, these surveys were delayed until after approval of the monitoring protocol, scope of work, and site selection, which were completed in mid April. Breeding was documented during the weeks of block and site selection, so no formal surveys were conducted.

PRESENCE SURVEYS

Once initiation of breeding was confirmed, we scheduled presence surveys at all permanent and year 1 sites within each block in a spatially stratified order. These surveys were conducted to document the presence or “absence/not detected” of breeding arroyo toads throughout the defined potential habitat on MCBCP. All surveys were conducted with two field biologists trained in identification of arroyo toad eggs and larvae (tadpoles). Training was conducted by an experienced USGS arroyo toad and amphibian biologist, Edward Ervin. In summary, for each survey site the biologists walked slowly upstream and carefully scanned the waters for arroyo toad eggs and larvae. Upon finding the first egg clutch and/or larvae, presence was recorded. The pool containing the egg clutch and/or larvae was then characterized for substrate type, percent plant cover, percent algae cover, water velocity, water depth, and water temperature. Subsequent arroyo toad eggs and larvae encountered along the site length were not recorded, as presence was already established. While walking the site length, all other aquatic species observed were also recorded. Upon completing the length, if no arroyo toad eggs or tadpoles were found, the biologists went back to what represented the most likely potential arroyo toad breeding pool along that survey length and searched for an additional 10 to 15 minutes. If no arroyo toad eggs or larvae were found, they characterized the unoccupied pool. At the end of each site length, biologists also recorded the width of the channel, plant community, number of pools greater and less than two feet in depth, and the site quality. Site quality was assessed by presence of three stream-related habitat characteristics (sandy substrate, sandy terraces, and channel braiding) that are known to be associated with most arroyo toad populations (USFWS 1999). The presence of all 3 characteristics resulted in an excellent rating, while the presence of 2, 1, and 0 resulted in ratings of good, marginal, and poor, respectively. A sub-sample of arroyo toad larvae and adults were digitally photographed as vouchers. A sub-sample of other nonsensitive aquatic species that were incidentally encountered were also photographed and/or preserved in 95% ethanol as voucher specimens in accordance with CDFG Permit SC-4186 and accompanying USGS/USFS Memorandum of Understanding. All vouchers are stored at the USGS/WERC/BRD specimen repository in the San Diego Field Station. The field protocol is provided in Appendix 2. Sites where arroyo toad larvae were not detected upon the first visit were all re-surveyed after a time period of approximately 3 to 4 weeks.

We conducted 172 surveys of 115 sites from April 15 to July 3. Also, a few high water volume sites along the Santa Margarita were revisited on August 12 and 14 to survey for tadpoles and/or metamorphs. We were not able to survey a small stretch of the lower Santa Margarita River (1F, 2A, 2C, 3B, 3C) because the water was too deep even with chest waders up to August 12. We also attempted to access the waters' edge on several occasions and were not able due to closed vegetation. On rare occasions, our ability to conduct surveys during the time period selected was limited by priority military training activities, for instance upper San Onofre Creek could not be surveyed until June 9, 2003.

INTENSIVE SURVEYS

We conducted surveys on the intensive blocks from April 21 to July 3, 2003. These surveys were conducted in order to collect count data for arroyo toad egg clutches, larvae, and adults. All surveys were conducted with two field biologists trained in identification of arroyo toad eggs, larvae, and adults. This protocol consisted of both a day and an evening survey of an entire 1.5 km block (6- 250 m site lengths). The day survey was very similar to that described for the presence surveys, but instead of merely recording presence, all arroyo toad egg clutches, larvae, and metamorphs/juveniles were counted and summed over each site length. For the purposes of these surveys, larvae were defined as tadpoles with or without 2 hind legs. Metamorphs/juveniles were defined as metamorphosing or recently metamorphosed toads with 4 legs (with or without tail) and a snout to urostyle length of ≤ 40 mm and adults were defined as >40 mm. After conducting an intensive day survey, we waited until at least 30 minutes after sunset to conduct the evening survey. For this, we slowly walked back down the stream and streamside terraces using Kohler© wheat lamps and/or flashlights to search for and count adult arroyo toads. We did not pick up or handle any toads for this study. We scanned all toads that were not in the water for PIT tags using an Avid Mini Tracker©. We scanned the toads by slowly moving the scanner above the toad, being careful not to touch the animal. For toads that appeared close to the cut-off of 40mm, an estimation of length was obtained by laying a ruler next to the toad. The field protocol is provided in Appendix 3.

All intensive blocks were wet and surveyed four times each during the year with the following exceptions. Due to the lack of any surface water, upper San Onofre Creek (sites C, D, and E only) was surveyed 3 times, Cristianitos Creek (sites A, B, E, and F only) and lower San Mateo Creek were surveyed one time, and lower San Onofre Creek was not surveyed as it was dry upon first inspection on April 7. Roblar Creek (sites A, B, and C) was initially surveyed on April 21. However, this intensive block was changed to adjacent De Luz Creek due to safety concerns for our biologists, as it entailed a steep climb and descent of a high cliff to access the second half of the Roblar block (D, E, and F). De Luz Creek (block 23) was then surveyed 3 times. Due to high water volume in the upper Santa Margarita River intensive block, we surveyed this block three times with the last survey conducted on August 6. We surveyed the lower Santa Margarita River block (6) for a fifth time on August 14 to detect metamorphs and/or juveniles only.

OBSERVER VARIABILITY SURVEYS

We conducted six observer variability surveys from May 8 to July 3, 2003. These surveys were conducted to estimate the detection probability of arroyo toad tadpoles using two observers and to separate out the effects of observer variability from other factors affecting detection probability, such as timing of breeding in different watersheds. For the first two surveys, one biologist slowly walked 250 m upstream. Upon every egg clutch or larvae sighting, he/she recorded the observation along with a corresponding GPS coordinate. The same procedure was then followed by the second biologist. For the last four surveys, larvae counts were also recorded at each location. Observer walking speed ranged from 24-52 minutes per 250 m stretch. Individual speed depended upon several factors. First, the speed each observer felt was appropriate to not miss sighting egg clutches and larvae. Second, the time it took each observer to enter in the GPS coordinates and data, and third, the number of egg clutches and larvae encountered. The field protocol is provided in Appendix 4. Surveys were conducted on San Onofre Creek, De Luz Creek, and the lower Santa Margarita River. Although, four of the six surveys were conducted in the Lower Santa Margarita River, they were conducted at different sampling sites.

Data Analysis

PRESENCE SURVEYS

We analyzed the data from presence surveys using the loglinear modeling program PRESENCE (MacKenzie et al. 2002). We calculated percent site occupancy and detection probabilities for all watersheds together and separately. For the entire data set, we also separately analyzed a number of site covariates (presence or absence of channel braiding, sandy terraces, sandy substrate, habitat quality, channel width, percent slope, watershed, stream order, and presence of non-native vegetation- tamarisk and giant reed) and survey covariates (presence of non-native aquatic species- i.e. large predatory fish, mosquitofish, crayfish, and bullfrogs) to see if they improved the fit of the model. Covariates were analyzed singly due to the inability of the program to properly fit higher order models to the dataset. Because the models showed evidence of less than perfect fit with the Pearson chi-square goodness of fit statistic, a conservative approach was taken for analyses of the model data. First, standard errors for site occupancy and covariate coefficients were adjusted for higher than expected variance using the dispersion parameter (c-hat) as recommended by MacKenzie and Bailey (unpublished manuscript):

$$\text{se (adj)} = \text{se} * \sqrt{\text{c-hat}}$$

where , se = standard error
c-hat = model dispersion parameter

Second, Quasi-likelihood Aikike's Information Criterion (QAIC) were calculated to compare the models (Burnham and Anderson 1998). Model selection using QAIC reduces the weight of the model likelihood value and increases the weight of the number of parameters, thereby favoring the most parsimonious model.

$$\text{QAIC} = \frac{-2 \text{ log likelihood}}{\text{c-hat}} + 2K$$

where , c-hat = model dispersion parameter
K = no. of parameters

Different methods were used to analyze the data taken at the single pool characterized on each block. To determine if categorical variables (substrate, water clarity) significantly differed between pools in which arroyo toad larvae were detected versus those in which larvae were not detected, we conducted chi-square and Fisher's exact tests. For the quantitative pool variables (percent plant cover, percent algae cover, water depth, and water velocity), we conducted Mann-Whitney U tests. For these analyses, values obtained from the intensive day surveys were also included. All tests were performed using Systat 10 and SPSS 11.0 statistical software.

INTENSIVE SURVEYS

We analyzed data generated for all intensive sites and survey dates to determine if the number of arroyo toad larvae was correlated to the number of adult toads. Since the data was highly skewed, we performed Spearman rank correlations. We also analyzed the data to simply determine if the presence of larvae was associated with the presence of adult toads. For this, we conducted chi-square analyses. These analyses were conducted with both time-coupled survey data (survey site and date as sample unit) and survey data combined over the season (survey site as sample unit).

In order to compare our adult night count data to that of Holland (2001), we calculated the median and the maximum of each survey block. Since the survey lengths differed (1.5 vs. 1 km), we normalized the counts to number of toads per km.

We looked up PIT-tag numbers of all recaptured toads in the Holland-Arroyo Toad Census Master database (acquired from MCBCP) to determine original capture dates and locations.

OBSERVER VARIABILITY SURVEYS

Because the accuracy of the GPS coordinates was too low to compare every marked count and observation along a site length, we combined larval counts into each of five 50 m lengths within each 250 m survey site for subsequent analysis (see Table 2). The data were analyzed in three different ways: 1) presence detection per 250 m site, 2) presence detection per 50 m stretch, and 3) counts per 50 m stretch. These can be seen as three scales of analysis of the data. For all three scales, the number of sites that were consistent between the two observers and number of sites that were inconsistent are shown in Table 3.

Data was combined across the six sites and analyses were conducted on the entire data set rather than on individual sites. Specific observer names were ignored and observer #1 and observer #2 were simply treated as visit #1 and visit #2 in the analysis. The program PRESENCE was used to estimate the percent area occupied and observer detection probabilities for 1) presence detection per 250 m site and 2) presence detection per 50 m stretch (see Table 3).

The numbers of counts per observer were too small to do a formal double observer analysis with estimates of individual observer detection probabilities (e.g. Nichols et al. 2000), and so only a rough comparison with the other methods was made.

RESULTS AND DISCUSSION

Initiation of Breeding

We observed an egg clutch on upper Talega Creek on April 1 during a survey to map potential habitat. Additionally, on April 10, during a USGS training session, we observed arroyo toad tadpoles on upper and lower San Mateo Creek, as well as several egg clutches and an arroyo toad pair in amplexus in upper San Mateo Creek (Figures 3- 5). This confirmed initiation of breeding had already occurred by the time this study was initiated.

Arroyo Toad Presence Surveys

Surveys for the presence of arroyo toad larvae averaged 31 minutes (std.dev. = 13) or 0.5 km/hr for each 250 m wet site. Seventy-eight percent of the potential habitat on MCBCP was wet (i.e. contained water) during our first survey efforts (Table 4, Figure 6). The dry areas encompassed portions of upper Talega Creek (May 22), lower Cristianitos Creek (May 13), lower San Mateo Creek (May 21), lower San Onofre Creek (May 6, May 19), upper Jardine Creek (April 29), upper San Onofre Creek (June 9, earliest access permit), and the south fork of San Onofre Creek (April 29). No areas were dry on the Santa Margarita watershed. Representative photos taken during our survey efforts throughout the watersheds are shown in Figures 7 to 14.

The volume of water moving through the Santa Margarita River during the survey period was at least 5 times greater than that moving through De Luz, San Mateo or San Onofre Creeks (uncorrected spring discharge values, USGS 2003). In addition, the volume of water moving through the Santa Margarita River remained significant up until our last visit in mid-September. At this same time, the lesser streams and watersheds were largely dry or drying.

ARROYO TOAD WET SITE OCCUPANCY

We documented the presence of arroyo toad larvae in 82% of the wet habitat (Figure 6). Presumably because of the relatively late start of the survey effort, we recorded only 6 egg clutches which were observed on the Santa Margarita River.

The probability of detecting arroyo toad larvae (presuming they are present) on any one visit to a site by a USGS survey team averaged 85.2%. By correcting for detection probability, the total wet area of MCBCP occupied by arroyo toads in 2003 was estimated at 87.4% (adj. std. error = 0.095). The greatest proportion of occupancy was recorded on the San Mateo watershed (97.9%), followed by the San Onofre (90.9%) and Santa Margarita (83.8%) watersheds (Table 4, Figure 15).

The Santa Margarita River watershed is large, covering almost 475,000 acres. The lesser amount of arroyo toad breeding documented in the Santa Margarita River (75% occupancy) in comparison to the other watersheds may have been due high water flows, even into the summer months. These high flows may have resulted in a lack of available breeding habitat during the peak breeding season. There are two main factors affecting current and future water flow in this river. First, according to model simulations, peak and total water discharge are predicted to increase by 50% with the off-base urban development projects planned for the upper Santa Margarita drainage basin (Steinitz et al. 1996). Urban development results in a greater proportion of less permeable surfaces, resulting in increased water runoff. Second, in March of 2002, a Cooperative Water Resource Management Agreement was made between MCB Camp Pendleton and the Rancho California Water District (RCWD). In order to mitigate the impacts of increased outpumping of underground water in the upper watershed, the RCWD agreed to release a minimum amount of water at the Temecula gorge to simulate flows modeled from 1931-1996. Even in drought years during summer months, this agreement guarantees a minimum flow of 3 cubic feet per second. Because of size of the watershed and these other factors, we expect this river to have increasingly higher volumes of flow during all years. In years of normal to high rainfall, this change in hydrology may result in significantly lower numbers of suitable breeding pools for the arroyo toad. In contrast, during drought years, this river may provide the only suitable breeding habitat for arroyo toads on MCBCP.

In contrast to the Santa Margarita watershed, the San Mateo and San Onofre watersheds are relatively small, 87,700 and 27,500 acres, respectively. With little runoff, they are typically dry from July to October. In drought years, they can remain mostly dry year around. The moderate rainfall that occurred from December 2002 to April 2003 (approximately 11.5 inches) left an abundance of low flow shallow pools, suitable for arroyo toad breeding. Pools remained long enough for abundant breeding, egg laying, and larval development to occur. According to model simulations, discharge in these basins is predicted to remain the same or decline in the future (Steinitz et al. 1996). We suspect that these watersheds may account for most of the breeding and recruitment of arroyo toads at MCBCP in wet or normal rainfall years, but result in little or no recruitment in periods of drought.

Overall, the occupancy of arroyo toad larvae throughout all suitable habitat within MCBCP was quite high. We expect the distribution and the density of breeding will vary from year to year based upon rainfall patterns and watershed characteristics. We also expect the variability among these watersheds will help to buffer the temporal variation in arroyo toad breeding on MCBCP as a whole.

HABITAT ASSESSMENT

The average slope of survey sites (n=357) was 1.9% with a range of 0 to 12%. Of these, 78.5% had a slope of 3% or less. Of the total arroyo toad potential habitat surveyed in 2003 on MCBCP, we defined 64.3% as excellent, 30.4% as good, 2.6% as marginal, and 1.7% as poor (Figure 16). The individual characteristics that went into these rating criteria: the presence of at least 10 m each of sandy substrate, sandy terraces, and/or channel braiding were present on 93.9%, 90.4%, and 84.3% of the habitat, respectively.

The native and non-native riparian vegetation varied within and between the watersheds (Table 5). Most areas were dominated by willow (*Salix sp.*) and/or mulefat (*Baccharis salicifolia*) with lesser components of sycamore (*Platanus racemosa*), mustard (*Brassica sp.*), and deerweed (*Lotus scoparius*) as characterized by southern willow scrub vegetation (Zedler et al. 1997). The upper Santa Margarita River also had large proportions of very dense cattails (*Typha latifolia*) and sedges (*Carex sp.*) along the river margins. It appeared that these species had a stabilizing effect on the river banks, as they were typically associated with deep narrow portions of the river (Figure 17).

Of the non-native species recorded, mustard and fennel (*Foeniculum vulgare*) were the most widespread occurring in all major drainages and watersheds. Tamarisk was observed along portions of the San Mateo and Santa Margarita watersheds, but was a dominant plant along the lower Santa Margarita. Giant reed (*Arundo donax*) has largely been eradicated due to recent removal efforts, however, new growth is present in scattered patches along parts of the San Mateo watershed and Santa Margarita River. Exotic thistle species (*Centaurea sp., Cirsium sp., Cyanara sp.,* other) were documented along the San Mateo and San Onofre watersheds. Castor bean (*Ricinis communis*) was also noted on lower San Mateo Creek.

It is suspected that the giant reed and tamarisk pose the biggest threat to the arroyo toad. These are known to stabilize banks, thus creating deeper channels and displacing potential breeding pools. They are also known to grow very quickly and densely, potentially hampering toad movement and shading previously open pool habitats. However, even native riparian vegetation can create these habitat changes if the hydrological cycle changes to continuous water flow regime (USFWS 1999).

OTHER AQUATIC SPECIES

Native

We documented larvae and adults of several other native aquatic species (Table 6, Figure 18). The Pacific tree frog (*Hyla regilla*), western toad (*Bufo boreas*), and two-striped garter snake (*Thamnophis hammondii*) were the most widespread, occurring in all or almost all drainages in the 3 watersheds. A natural predator, the two-striped garter snake, was observed feeding upon arroyo toad larvae on San Mateo Creek on April 7. Other species documented include the California tree frog (*Hyla cadavarina*), California newt (*Taricha torosa*), and Arroyo chub (*Gila orcutti*).

Non-Native

We documented larvae and adults of many non-native aquatic species in MCBCP (Table 7, Figure 19), including bull frog (*Rana catesbeiana*), mosquitofish (*Gambusia affinis*), bullhead catfish (*Ameiurus sp.*), green sunfish (*Lepomis cyanellus*), bass (*Micropterus sp.*), crayfish (*Procambarus clarkii*), Asian clam (*Corbicula fluminea*), and beaver (*Castor canadensis*). All of these species were detected in the Santa Margarita River. Only mosquitofish, bullfrog, and green sunfish were detected in parts of the San Mateo watershed. No non-native aquatic species were detected in the San Onofre watershed or De Luz and Roblar Creeks in the Santa Margarita watershed.

All of the fish species (bullhead catfish, bass, green sunfish, mosquitofish) are known to prey upon arroyo toad larvae and may account for a substantial proportion of larval mortality (USFWS 1999, Sweet 1992). The mosquitofish may be a significant predator of arroyo toad eggs (Grubb 1972) and to alter the physical and biological characteristics of arroyo toad breeding pools (Hurlbert et al. 1972). Crayfish are opportunistic omnivores known to eat amphibian eggs and tadpoles (Saenz et al. 2003) and have been associated with declines in some native fish (Warburton et al. 2003, Guan and Wiles 1997) and amphibian populations (Gamradt and Kats 1996, Riley et al. unpublished manuscript). Bullfrogs are known to prey upon juvenile and adult toads in the wild and may be responsible for declines in several amphibian populations (Moyle 1973, Sweet 1993, Jennings and Hayes 1994).

Beaver dams create deeper pools of water within stream systems which can potentially displace arroyo toad breeding pools.

The prevalence of these species in the Santa Margarita River may be linked to the presence of perennial pools of water. Perennial water may allow many non-native aquatic species to become established and compete with or prey upon native species. Since the discharge of into the Santa Margarita drainage basin water is guaranteed even in drought years (CWRMA 2002) and is predicted to increase into the future (Steinitz et al. 1996), we expect invasive aquatic species to be an ongoing problem in this watershed. Drying cycles typically result in local extirpation of many non-native aquatic species (Gasith and Resh 1999). Thus, the lack of perennial water along with several years of drought may have favored native species in the lesser watersheds and stream orders of MCBCP in 2003.

WET SITE OCCUPANCY MODELS

All occupancy models analyzed showed evidence of less than perfect fit (Goodness of fit χ^2 ; $p<0.05$). However, inclusion of several covariates in the model resulted in better fit. Of these, the absence of crayfish was the strongest predictor of the presence of arroyo toads. In 2003, arroyo toad larvae were 20 times more likely to be detected when crayfish were absent (95% adj. CI: 1.7- 249, Figure 20). The crayfish model accounted for 100% of the comparative model weights used in the model selection procedure, meaning that it far outperformed other models in predicting the presence of arroyo toad larvae. It also remained a significant predictor even after increasing standard errors for a less than perfect fit.

Of the other variables tested, presence of sand had a strong positive association that was almost significant in predicting the presence of larvae. Other covariates had weak positive associations to arroyo toad presence (absence of mosquitofish, large predatory fish, bullfrog, giant reed, and tamarisk; presence of sandy terraces and channel braiding; increased channel width; decreased slope and water velocity). These variables were not significant but still increased predictive power in comparison to the null model (no covariates). In contrast, inclusion of watershed and stream order reduced the predictive power of the models (Table 8, Figure 20).

There are several possible reasons that the models showed evidence of poor fit. First, high rates of "occupancy" in these models are known to cause poor fit (MacKenzie and Bailey, unpublished). Second, spatial correlation (or the lack of site independence) can decrease power and result in poor fit. It is expected that sites in close proximity, within the same creek or river, and within the same watershed will have some degree of spatial correlation. Because the female produces a single egg clutch per year and there is high breeding site fidelity of both males and females (Sweet 1992), the degree of correlation related to adult movement should be minimal. However, this may not be the case for larvae. It can be expected that sites downstream from where an egg clutch is deposited are more likely to be occupied by larvae, simply due to downstream movement. Third, an un-modeled covariate could account for a large proportion of the overall variation, thus resulting in a poor fit. Finally, since sites that were occupied were not revisited, there were no sites with a presence-presence (1,1) history. Simulation runs showed that inclusion of repeat visits to occupied sites greatly increased the fit of the models (Table 9). Therefore, we expect that refinement of the protocol to add repeat visits to some or all of occupied sites may improve model fit parameters in future years. Improved fit will increase the power of the models to further test for effects of habitat characteristics, non-native species, and management activities on arroyo toad breeding.

Crayfish may be negatively associated with arroyo toad larval presence for a few reasons. The first is by direct predation of toad eggs and larvae. Crayfish are known to eat amphibian eggs and tadpoles (Fernandez and Rosen 1996, Gamradt and Kats 1996, Saenz et al. 2003). Predation by crayfish is directly attributed to significant reductions populations of the California newt (Gamradt and Kats 1996). Although they prefer to hide in deep covered pools in the daytime, they typically forage in the open shallow pools at night. These pools are also favored for arroyo toad breeding, egg laying, and larval development. Secondly, crayfish are also associated with reduced arroyo toad breeding habitat quality. They thrive in areas with increased water flow, depth, and longevity, as was characteristic of the Santa Margarita River in 2003. Thus, they may be an indirect indicator of lower arroyo toad habitat value. This indirect relationship has been proposed for the significant negative correlation between the presence of crayfish and numbers of Pacific treefrogs (*Hyla regilla*), (Riley et al. unpublished manuscript). Additional year(s) of data will be needed to determine the strength of this interaction and whether the association is direct or indirect.

Arroyo Toad Intensive Surveys

Egg clutches and larvae were counted during day surveys of blocks, while adults were counted during night surveys. The day surveys averaged 31 minutes (std.dev. = 13) per 250 m site length or 0.5 km/hr, while the night surveys averaged 25 minutes (std.dev. = 13) per 250 m site length or 0.6 km/hr. Data were not generated for the lower San Onofre block (29), as it was dry throughout the survey period.

All age classes (larvae, metamorphs/juveniles, adults) were detected in the remaining seven blocks (Figures 21 to 27). Larval counts averaged 465.5 individuals per 250 m over the survey effort, with the greatest numbers recorded on the San Mateo and San Onofre watersheds (Figure 28A). Peak larvae counts were obtained in the first weeks of May in both the San Mateo and San Onofre watersheds and in De Luz creek (Figures 21-24, 27), but not until late May in the Santa Margarita River (Figures 25 and 26). During May and early June, larvae were typically found in characteristic breeding pools as described. In later June and early July, as temperatures increased, larvae were often found under algal mats that grew over the open pools. This pattern has been previously noted (Sweet 1992). Representative photos of larvae at different stages of development are presented in Figure 29.

Metamorphs/juveniles were documented starting in late May and early June in all watersheds (Figures 21-27) and were typically observed either on wet banks or on top of floating algal mats. Metamorph/juvenile counts averaged 8.0 per 250 m, with the greatest numbers recorded on the San Mateo and Santa Margarita watersheds (Figure 28B). Metamorphs and juveniles have a fairly short period of diurnal activity which may be highly variable. Thus, the results may depend upon the date of the survey effort and numbers should be interpreted with caution. There were no obvious deformities on any of these animals. Representative photos of metamorphs and juveniles at different stages of development are presented in Figure 30.

Adult counts averaged 1.2 per 250m, with the greatest numbers recorded in De Luz Creek in the Santa Margarita watershed (Figure 28C). All adults were observed calling in the water or moving and/or foraging on the sandy banks and terraces. Representative photos of adults documented in MCBCP are presented in Figure 31.

These results show that there was successful breeding and recruitment of juvenile arroyo toads in all of the watersheds surveyed in 2003. There was also a two to three week delay in arroyo toad breeding along the Santa Margarita River, in comparison to the lower order streams and watersheds.

CORRELATIONS BETWEEN LARVAE AND ADULTS COUNTS VS. PRESENCE/ABSENCE.

Our analysis of the time-coupled intensive survey data (n=132) revealed no significant correlation (Spearman's rho= 0.106, p= 0.226) or association ($\chi^2_{3df} = 0.657$, p = 0.418) between the numbers or presence of larvae observed during the day and the numbers or presence of adults observed that same evening. We then uncoupled the day/night surveys and analyzed the combined results over the season (average number of repeat surveys per site = 4, total n=44). There was still no correlation in the numbers of larvae to adult toads (Spearman's rho= -0.0729, p= 0.638), however, we did find a significant association between the presence of larvae and presence of adults ($\chi^2_{3df} = 6.356$, $p = 0.012$). Therefore, if an adult arroyo toad was observed on at least one occasion during the breeding season, there was a significantly higher likelihood of observing larvae within the same survey site sometime during the breeding season.

The negative results are not unexpected, as it is well documented that there is significant variability in 1) the numbers of larvae over time, 2) the activity of adults over time, and 3) the peaks in activity of larvae versus adults. First, although larvae are easily detectable when present, their numbers can vary greatly through time. Like many anurans, once thousands of larvae hatch from an egg mass, their numbers can decrease in orders of magnitude each day due to low survivorship at this life stage (Licht 1974, Sweet 1992). In fact, less than 1% of arroyo toad larvae are expected to reach the juvenile stage, primarily due to excessive predation (Sweet 1992). Second, although adult numbers are expected to be relatively constant within a season due to high survivorship, the probability of detecting adults on any single survey is low (46.4% in this study). In order for an adult to be counted during a survey, it must be active and above ground, which can be highly variable depending upon environmental and other unknown factors. Finally, the peak activity of adults and larvae are expected to differ on a temporal scale. Increased numbers of adults are typically recorded during peaks in breeding activity in the early spring. However, larval numbers may be greatest several weeks later, when breeding activity has already subsided.

The positive result is also not surprising. By uncoupling the day/night surveys and combining data from four surveys throughout the season, we effectively minimized the effect of temporal variability and maximized our detection probabilities of adult toads. This resulted in a simple confirmation that, within the intensive survey blocks on MCBCP in 2003, the presence of arroyo toad larvae was positively associated with the presence of adult toads. In addition, these data also confirmed the original monitoring protocol assumption that arroyo toad larvae are more easily detected than adults (Atkinson, et al. 2003).

The fact that count data for larvae and adults did not correlate after uncoupling the surveys could be attributed to several factors. We may have missed peak numbers of active adults in the lesser watersheds due to the delayed start in surveys (see below). Alternatively, it may be attributed to a general high variability in larval numbers, adult activity, and/or other unknown factors as previously described.

COMPARISON TO 1996-2000 HOLLAND RESULTS

On the wet intensive survey blocks in 2003, average adult counts at night ranged from 0.8 to 28.3 animals per km, while maximum adult counts ranged from 1 to 42 animals per km. From 1996 to 2000 in all transects, average adult counts ranged from 0.5 to 15.5 animals per km, while maximum adult counts ranged from 1 to 73 animals per km (Holland et al. 2001). In general, 2003 adult counts were low on most intensive blocks (≤6 animals/km), but comparable to the lower numbers recorded in previous years. The exception was De Luz Creek, which had very high counts on all 3 night surveys conducted. This block, however, overlays only approximately one third of Holland's' 1996-2000 Roblar Creek transect, so direct comparisons should be made with caution. The results of all past and present surveys (1996-2000 and 2003), including mean and maximum arroyo toad counts, are presented in Figures 32 to 39.

Although larval counts were high, there were very few adults observed on the San Mateo and San Onofre watersheds in 2003. This may be attributable to the late start of the surveys in comparison to previous years. The combination of high larval numbers and lack of egg clutches recorded in our earliest surveys indicates that peak breeding activity in the two northern watersheds likely took place in late March and/or early April, before the initiation of our survey efforts. Thus, we expect to have recorded greater numbers of animals in these watersheds if surveys began at an earlier date. In contrast, there was evidence of later onset of breeding in the Santa Margarita watershed (peak larval counts were recorded at least 3 weeks after peak counts for other watersheds). At these sites, we observed greater numbers of adults (especially calling males) and counts were more consistent with previous years.

RECAPTURES OF PIT-TAGGED TOADS

A total of five PIT-tagged arroyo toads were found across all three watersheds during the intensive night surveys. These toads were originally PIT-tagged during studies conducted from 1998 through 2000 on MCBCP (Holland et al. 2001, Holland and Sisk 2001). A list of PIT tag numbers, capture locations, dates, and original capture information are provided in Table 10. Four out of five of the PIT tag numbers were found in the USGS copy of the Holland MCBCP master database. Two toads were originally captured in pitfall traps (Holland and Sisk 2001), while two were originally captured on walking census transects (Holland et al. 2001).

Of these, three arroyo toads were PIT-tagged in the year 2000 at snout to vent lengths ranging from 50.5 to 54.0 mm. Because it is estimated to take at least one year to obtain this length (Sweet 1993), we conclude that these toads were all at least 4 years of age upon recapture in 2003. The 4th toad was PIT-tagged in April of 2000 at a length of 64mm. The earliest a sub-adult toad is known to reach 64mm would be in late breeding season of the year following metamorphosis (Sweet 1993). Since this toad was captured early in the breeding season, we conclude that this toad was at least 2 years of age upon first capture and, therefore, at least 5 years of age upon recapture in 2003. These only are minimum age estimates, however, because once arroyo toads grow to a mature size (approx. 50-75 mm), their growth rate decreases and they tend to remain relatively stable in size throughout their adult life (Sweet 1993). Because of this, these animals could potentially be older than reported.

For the two toads originally captured on census transects, we were able to estimate movement distances over the 3 year time period. The first toad that was originally PIT-tagged on April 8, 2000 within the Cristianitos creek transect in the lower San Mateo watershed was found again on May 22, 2003 approximately 100 m down the creek. The second toad was originally PIT-tagged on April 9, 2000 within lower Roblar creek. We subsequently found this toad in Deluz creek, by the Roblar creek confluence, approximately 320 m away.

On MCBCP, arroyo toads have been found up to move up to 1.2 km to upland habitats (Holland and Sisk 2001) and up to 625 m within riparian breeding habitat (Griffin et al. 1999, Griffin and Case 2001). Sweet (1993) also observed frequent up and downstream movement of arroyo toads in the Los Padres National Forest ranging from approximately 0 to 500 meters. Our results are consistent with these findings.

We believe the 5th toad with no original capture information was probably PIT-tagged in the lower San Mateo creek transect on March or April, 2000, as these data were missing from the USGS copy of the Holland database. Likewise, the movement distances for toads captured in pitfall traps could not be calculated due to missing metadata. We will attempt to reacquire this data in the near future so that these information gaps can be filled in. Meanwhile, recapture information from the toads marked by Holland in 2000 have already attained (and perhaps surpassed) the survivorship estimate of 5 years by Sweet (1991). Further years of night survey efforts along with skeletochronology studies currently underway by the USGS should contribute valuable data on longevity and site fidelity of this species.

Arroyo Toad Pool Characterization

Using data generated from all (presence and intensive) surveys, we characterized 220 arroyo toad occupied pools and 42 unoccupied pools. The water in the median arroyo toad occupied pool was clear, 23 ºC, and 6.5 cm deep with a surface flow of 2.0 cm/sec. The median occupied pool had a sandy bottom with 7.5% algae cover and no plant cover. The water in the median unoccupied pool was clear, 24 ºC, and 6.0 cm deep with a surface flow of 2.1 cm/sec. The median unoccupied pool had a sandy bottom with 20.0 % algae cover and 10% plant cover. There were no significant differences in water clarity, substrate type, water depth, water velocity, water temperature or algae cover between occupied and unoccupied pools (Figures 41 to 46). However, plant cover was significantly greater at the unoccupied pools ($\chi^2 = 4.886$, $p = 0.027$). Pools containing arroyo toad larvae averaged 8% more cover than those that did not (Figure 47).

The main characteristics of arroyo toad pool morphology have been fairly well characterized (Sweet 1992, Holland 2001). Slow flow pools are known to be favored which are shallow, have sandy bottom substrate, and little vegetative cover. Since only pools that exhibit these attributes are characterized using this protocol, we may be able to discern finer-scale differences in arroyo toad breeding pool morphology than previous efforts. In this case, with only one year of data, we have found that arroyo toads are significantly less likely to breed in a pool with only a small percentage of additional plant cover. Additional data generated in future years will only increase the power of these analyses.

Observer Variability Surveys

By conducting surveys consecutively, we were able to separate out differences in detection probability caused by observer variability from other possible sources of variation such as timing of breeding. This allowed us to examine the consistency of our protocol and how well it is standardized across observers.

1) Presence detection per 250 m site:

The observers were 100% consistent at detecting presence at the scale of the 250 m sites and thus the detection probability was estimated at 1.000 (Table 3). However, only 6 surveys were included in this analysis and the true detection probability is probably slightly lower.

2) Presence detection per 50 m stretch:

Twenty-eight of the thirty 50 m stretches were recorded consistently between pairs of observers. The estimated detection probability for a single observer in a 50 m stretch was estimated at 0.9333 by the program PRESENCE. Thus for two observers sampling the same site, the estimated detection probability would be $(1-(1-.9333)^2) = 0.9956$ (Table 3).

3) Non-zero counts of larvae per 50 m stretch:

Counts of larvae varied considerably among observers and as one would expect, differences appeared to increase as the count size increased (See Table 2, Figure 48).

This pilot study suggests that by using this presence detection protocol with two trained observers, arroyo toad larvae presence should be detected with little variability from observer pair to observer pair (<1%), even if found in only 50 m of the 250 m site. Reductions in detection probability in the percent area occupied analysis described later in this report are therefore assumed to be largely due to other sources of variation such as environmental conditions and timing of breeding. In contrast, counts of larvae show much greater variability among observers. If larvae counts were to be adopted as the principle protocol, variability may be reduced with further training, protocol standardization, and would likely require an estimation of observer bias for each observer. However, the variability in larvae counts may be partly explained by differences in detectability. For example, larvae may move positions along the stretch or hide under cover between observers.

RECOMMENDATIONS

In 2003, we focus our recommendations on refining and improving the survey protocol. Proposed changes to the protocol involve discontinuing some of the non "core" protocol elements in which the primary questions were answered in 2003, adding and refining field data requirements in order to address questions and/or issues raised by the 2003 data and finally, adjusting and adding repeat surveys to improve the fit of the model. Some recommendations are also presented for data analysis and continued management.

Survey Protocol

There are several refinements to the protocol that are recommended for the following year:

1. Discontinue time-coupled intensive surveys. The purpose of conducting these surveys on the same day and night was to determine whether results were correlated. We found no correlations between numbers or presence of adults and larvae. Biologically, we also expect numbers of the different age classes to peak at different times of the year.

2. Continue a reduced effort of night intensive surveys (2 surveys per year). Continuation of night intensive surveys during early breeding season will allow for further documentation of recaptured toads. Toads are thought to live to 5 years of age. In 2004, recaptured toads from Holland et al. (2001), will be at least 5 years of age. This life history data is sorely needed. Secondly, night counts of adults should continue to document the presence of adult toads in dry reaches and in years of drought, when larvae are not present.

3. Discontinue intensive day surveys. Numbers of tadpoles and metamorphs are highly variable over time and space. Continue to survey presence in the permanent and yearly intensive sites 4 times yearly. This will decrease day intensive survey efforts by 75% but retain our ability to monitor recruitment throughout MCBCP by documenting the presence/absence of different age classes. It will also continue to increase our estimate of detection probability and power in the analyses.

4. Increase presence survey repetitions. Resurvey at least 20 of the sites that are occupied by arroyo toad larvae upon the first visit. This was shown to greatly increase the fit of the models (Table 9).

5. Conduct surveys in areas known to dry first. Although a random choice of survey sites and dates is preferable for the model, it is not entirely practical. The cost is possibly losing data because the survey is conducted after an area has dried. In low rain years, this is especially troublesome. Therefore, a stratified random effort should be followed. First, fast drying sites should be surveyed randomly, followed by longer lasting wet sites.

6. Refine some of the elements of the protocol that did not prove fruitful in the first year and add needed elements. For example, we recorded the number of potential arroyo toad breeding pools under 2 feet in depth as written in the 2003 protocol, however, our biologists experienced difficulties in interpretation under actual field conditions. A pool in a continuous watershed could be a small side-pool or a continuous area of still water along the edge of the bank. Therefore, this data did not properly represent the overall amount of potential breeding habitat that was available for the toads. Next year, the protocol will be changed to record the percentage of the site containing potential arroyo toad breeding pools under 2 feet in depth. Similarly, we may want to add some measures. For example, although we did record the surface water velocity in pools within each site, a water velocity measure of the main channel may also be valuable in predicting the occurrence of arroyo toad larvae. Therefore, inclusion of a simple velocity and depth measure is recommended for the following year. A meeting will be held with MCBCP to review the protocol and discuss any recommended changes and/or additions before the survey efforts begin for 2004.

Analysis

Arroyo toads are dependant upon the availability of ephemeral pools for breeding and recruitment. Because dry areas are not included in the model site occupancy estimates, the availability of water and any trends in drying that may be linked to natural as well as military activities should be closely monitored. Thus, rather than monitoring only percent site occupancy, we recommend tracking three indices over time: 1) Percentage of sites in which breeding occurs, 2) Percentage of sites that are wet, and 3) Percentage of wet sites in which breeding occurs.

A large possible threat to arroyo toad populations on MCBCP are the changes in hydrology, water quality, and soil moisture due to off-base development and land conversion (Steinitz et al. 1996). Unfortunately, MCBCP has limited control over these processes. However, an effort should be made to incorporate these measures in the arroyo toad monitoring and analysis in order to identify these causal effects if and when they occur.

Management

Specific management recommendations resulting from the 2003 arroyo toad survey efforts are not presented this year. Although we found a significant negative association between the presence of arroyo toad larvae and the presence of crayfish, another year of data should help in more accurately assessing the strength of this relationship. By adding more power to simultaneously analyze multiple variables, this should also help in determining whether crayfish have a direct effect on arroyo toads or are an indicator of habitat suitability. Thus, additional data generated in the years ahead will provide for more robust analyses which will enable us to provide sound, accurate, and science based recommendations for continued arroyo toad management and monitoring efforts. Several recommendations are presented, however, that will allow for more complete data acquisition and/or address general and ongoing management practices.

1. Acquire a complete version of the Holland arroyo toad database. This will enable us to generate complete information on movement and age of toads that were originally PIT-tagged in 1998 to 2000 (Holland et al. 2001, Holland and Sisk 2001).
2. Continue eradication efforts of non-native species, particularly those that alter the natural hydrology of the arroyo toad occupied watersheds.
    a. Continuation of the giant reed (*Arundo donax*) removal program on MCBCP is expected increase available habitat for the arroyo toads by opening up the vegetation allowing for toad movement. By destabilizing stream banks, restoration of natural stream flow dynamics on which the toad is dependant should occur.

b. A beaver and a beaver dam were documented on the upper Santa Margarita. These dams can increase water levels potentially resulting in a reduction of adjacent breeding pools and creation of suitable habitat for invasive aquatic species. These dams may also inhibit upstream and downstream movement of larvae and adult toads. Continuation of the exotic beaver removal program is recommended.

3. Investigate whether the pumping of ground water for agriculture, domestic, and industrial use is at sustainable levels. This may be especially important in the San Onofre and San Mateo watersheds where loss of surface water due to pumping may greatly reduce the hydroperiods for these ephemeral streams. As a result, this may result in lack of arroyo toad breeding and recruitment success in affected areas documented in the spring of 2000 in lower San Mateo creek (Holland et al. 2001).

4. Manage nighttime training activities in riparian areas during the early breeding season (February- April) to avoid and/or minimize direct trampling of active adult arroyo toads by vehicles and/or troops.

5. Manage training activities in wet areas during the larval development period (March-July) to avoid direct take of arroyo toad larvae and juveniles. To minimize loss, if training activities cannot be avoided, we recommend confining training to small area(s) and to minimize activities on the immediate stream edges and banks where larvae and juveniles aggregate.

6. Avoid and/or minimize habitat loss of uplands, where adult toads over-winter, within a kilometer of known arroyo toad breeding areas.

7. Continue to educate MCBCP training personnel in the identification and basic biology of the arroyo toad. Stress that good environmental stewardship includes the avoidance of toads and their habitat when possible.

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Table 1. Designation of blocks and site lengths within arroyo toad potential habitat.

Watershed	River/Creek[1]	Length of potential habitat	No. blocks (1.5 km each)	No. site lengths[2] (250 m)	Designated[3] block/site nos.
San Mateo		32.3	21.5	129.0	39A-60F
	Lower San Mateo Creek	4.5	3.0	18.0	39A-41F
	Upper San Mateo Creek	12.8	8.5	51.0	42A-50C
	Cristianitos Creek	4.2	2.8	17.0	51A-53E
	Talega Creek	10.8	7.2	43.0	53F-60F
San Onofre		18.0	12.0	72.0	27A-38F
	Lower San Onofre Creek	9.0	6.0	36.0	27A-32F
	Upper San Onofre Creek	4.5	3.0	18.0	33A-35F
	South fork San Onofre Creek	1.2	0.8	5.0	36A-36E
	Jardine Canyon Creek	3.3	2.2	13.0	36F, 37A-38F
Santa Margarita		39.0	26.0	155.9	1A-26F
	Lower Santa Margarita River	15.0	10.0	60.0	1A-10F
	Upper Santa Margarita River	14.5	9.7	58.0	11A-20E (-12F)
	Deluz Creek	7.2	4.8	29.0	12F, 21A-25D
	Roblar Creek	2.3	1.5	9.0	26A-26F, 20F, 25E, 25F
Total		89.2	59.5	356.9	1A-60F

[1]"upper" and "lower" designations are arbitrary and primarily based upon location within MCBCP, stream order, and/or vegetation characteristics.

[2] six site lengths are designated within each block. They are labelled with the block number followed by the letter A, B, C, D, E, or F.

[3] Because not all waterways of the defined potential breeding habitat were perfectly divisible into a whole number of 1.5 km blocks, some blocks were split up between the upper end of creeks within the same watershed.

Table 2. Variability in arroyo toad larvae detection and counts among observers.

Watershed	Date	Observers & Minutes	Stretch	OBSERVER 1 Tadpole presence	OBSERVER 1 Tadpole Count*	OBSERVER 2 Tadpole presence	OBSERVER 2 Tadpole Count*	Maximum of both observers Tadpole presence	Maximum of both observers Tadpole Count*
San Onofre	5/8/03	SLC/MBM	1	1	--	1	--	1	--
		57 min total	2	1	--	1	--	1	--
			3	1	--	1	--	1	--
			4	1	--	1	--	1	--
			5	1	--	1	--	1	--
			Totals	5		5		5	
Lower Santa Margarita	5/27/03	CSB/BY	1	1	60	1	--	1	--
		24min/32min	2	1	35	1	--	1	--
			3	0	0	0	--	0	--
			4	1	5	0	--	1	--
			5	0	0	0	--	0	--
			Totals	3		2		3	
Lower Santa Margarita	6/16/03	CSB/DDP	1	1	5	1	3	1	5
		35min/52min	2	0	0	0	0	0	0
			3	0	0	0	0	0	0
			4	0	0	0	0	0	0
			5	0	0	0	0	0	0
			Totals	1	5	1	3	1	5
De Luz	6/25/03	SLC/LG	1	1	5	1	1	1	5
		43min/35min	2	1	9	1	2	1	9
			3	1	11	1	4	1	11
			4	0	0	0	0	0	0
			5	1	1	0	0	1	1
			Totals	4	26	3	7	4	26
Lower Santa Margarita	6/30/03	CSB/DDP	1	0	0	0	0	0	0
		26min/29min	2	0	0	0	0	0	0
			3	0	0	0	0	0	0
			4	0	0	0	0	0	0
			5	0	0	0	0	0	0
			Totals	0	0	0	0	0	0
Lower Santa Margarita	7/3/03	SLC/LG	1	1	2	1	8	1	8
		42min/40min	2	0	0	0	0	0	0
			3	0	0	0	0	0	0
			4	1	4	1	3	1	4
			5	1	1	1	1	1	1
			Totals	3	7	3	12	3	13

* Only presence absence data recorded on San Onofre survey on 5/8/03 and by Observer 2 on Lower Santa Margarita Survey on 5/27/03

Table 3. Variability in detection probabilities among observers.

		Raw calculations			*Program PRESENCE output*		
Scale	**N**	**No. Consistent records between observers**	**No. Inconsistent records between observers**	**Percent consistent records / total**	**Proportion area occupied**	**SE**	**Detection Probability P**
Presence detection per 250 m	6	6	0	100%	0.8333	0.1521	1.0000
Presence detection per 50 m	30	28	2	93.3%	0.5357	0.0916	0.9333
Non-zero Counts per 50 m	8	1	7	12.5%	--	--	--

Table 4. Results of presence surveys for arroyo toad larvae.

		Santa Margarita	Watershed San Onofre	San Mateo	All Combined
	No. sites surveyed (250 m)	52	24	44	120
	Total length (km)	39	18	32	89
Raw survey results					
Area wet	No. Sites	52	11	31	94
	% of Total	100%	46%	70%	78%
Arroyo Toad larvae	No. Sites	39	10	28	77
	% of Total Wet Area	75%	91%	90%	82%
PRESENCE model estimates[1]					
Percent Wet Area Occupied		83.8%	90.9%	97.9%	86.2%
Standard error[2]		-	-	-	8.0%
Detection Probability		73.2%	100.0%	92.3%	85.2%

[1] corrected for detection probabilities, no covariates

[2] adjusted using dispersion parameter

Table 5. Summary of native and non-native vegetation recorded within arroyo toad survey sites.
Size classes for non-native plants were recorded as few plants (F), scattered small patches (S), or large contiguous stands (L).

	Block nos.	Dominant native plants*	Non-native plants recorded*					
			Giant reed	*Non-native grasses*	*Tamarix*	*Fennel*	*Non-native thistle*	*Castor bean*
San Mateo								
Lower	39-41	Mulefat, willow, hemlock		S		F	F	F
Upper	42-50	Mulefat, willow, sycamore	F	L	S	F	S	
Cristianitos	51-53	Mulefat, deerweed	F		S	F	S	
Talega	54-60	Mulefat, sycamore, deerweed		L		S	S	
San Onofre								
Lower	27-32	Mulefat, willow, sycamore		L		L	S	
Upper	33-35	Mulefat, sycamore		L		S		
South fork	36	Willow, poison oak, mulefat		S			F	
Jardine	37-38	Mulefat, sycamore		L		S	F	
Santa Margarita								
Lower	1-10	Willow, mulefat	S	L	L	S		
Upper	11-20	Willow, cattail, sedge, mulefat	S	L	F	F		
Deluz	21-25	Willow, mulefat, sycamore		L	F			
Roblar	26	Willow, mulefat, sycamore		S	F	F		

*scientific names for plants provided on pages 17 and 18.

Table 6. Non-target native aquatic species recorded in 2003 arroyo toad surveys.

			San Mateo				**San Onofre**			**Santa Margarita**			
	Common Name	Scientific Name	Lower	Upper	Crist-ianitos	Talega	Lower	Upper	Jardine	Lower	Upper	Deluz	Roblar
Amphibians	Western toad	*Bufo boreas*	X	X	X	X	X		X	X	X	X	
	California tree frog	*Hyla cadavarina*					X					X	X
	Pacific chorus frog	*Hyla regilla*	X	X	X	X	X	X	X	X	X	X	X
	California newt	*Taricha torosa*											X
Fish	Arroyo chub	*Gila orcutti*								X	X		
Mammal	Mountain lion	*Felis concolor*									X		X
Reptile	Two-striped garter	*Thamnophis hammondii*		X	X	X	X		X	X		X	X

Table 7. Non-target non-native aquatic species recorded in 2003 arroyo toad surveys.

			San Mateo				**San Onofre**			**Santa Margarita**			
	Common Name	Scientific Name	Lower	Upper	Crist-ianitos	Talega	Lower	Upper	Jardine	Lower	Upper	Deluz	Roblar
Amphibian	Bull frog	*Rana catesbiana*	X	X						X	X		
Fish	Catfish	*Ameiurus sp.*								X	X		
	Common carp	*Cyprinus carpio*								X			
	Mosquitofish	*Gambusia affinis*	X	X	X	X				X	X		
	Green sunfish	*Lepomis cyanellus*		X							X		
	Bass	*Micropterus sp.*								X	X		
Invertebrates	Asian clam	*Corbicula fluminea*									X		
	Crayfish	*Procambarus clarkii*								X	X		
Mammal	Beaver	*Castor canadensis*									X		

Table 8. Summary of arroyo toad occupancy model selection and goodness of fit parameters.
Models are presented in the order of best fit. AIC is Akaike's Information Criterion, QAIC is quasi-likelihood AIC that is corrected for increased variance over that expected in the model (c-hat/ dispersion parameter). ΔQAIC is the difference between each model QAIC versus that of the best fitting model. w is the model weight, K is number of parameters, X^2 is the Pearson chi-square test statistic with corresponding p-value. ψ is the estimated proportion of sites occupied and with the c-hat adjusted standard error. The best fitting models will have lower AIC, QAIC, ΔQAIC, and X^2 values; larger p-values (0.2-1.0 is ideal), and lower c-hat values (1 is ideal). More complex models were not included due to a lack of success in computing variance-covariance matrices for models with multiple covariates.

Model	Covariate(s)	AIC	QAIC	ΔQAIC	QAIC w	K	X^2	p-value	c-hat	ψ	adj SE (ψ)
Survey specific											
1	**Crayfish presence**	**117.65**	**50.66**	**0.00**	**1.00**	**3**	**39.07**	**0.031**	**2.56**	**0.89**	**0.069**
2	Mosquitofish presence	130.01	55.60	4.94	0.00	3	75.82	0.025	3.86	0.89	0.088
3	Large predatory non-native fish*	134.21	57.29	6.63	0.00	3	82.67	0.013	4.06	0.89	0.084
4	Bullfrog presence	134.51	57.40	6.74	0.00	3	76.21	0.029	3.42	0.88	0.081
5	Water velocity (best pool)	135.53	57.81	7.15	0.00	3	78.69	0.013	3.77	0.88	0.084
Site Specific											
1	Sand (Y/N)	135.55	57.82	7.16	0.00	3	52.67	0.019	3.74	0.84	0.069
2	Giant reed	135.68	57.87	7.21	0.00	3	78.31	0.024	3.67	0.88	0.085
3	Tamarix	135.68	57.87	7.21	0.00	3	79.19	0.015	4.01	0.88	0.089
4	Channel Width Class (0-5)	136.31	58.12	7.46	0.00	3	43.42	0.049	2.59	0.87	0.051
5	Giant reed & tamarix	137.66	59.86	9.20	0.00	4	78.81	0.015	3.95	0.88	0.089
6	Braiding (Y/N)	143.63	61.05	10.39	0.00	3	52.56	0.026	3.66	0.83	0.081
7	Sandy terrace (Y/N)	144.55	61.42	10.76	0.00	3	47.35	0.033	3.22	0.85	0.072
8	**None**	**148.70**	**61.88**	**11.22**	**0.00**	**2**	**52.17**	**0.022**	**3.46**	**0.86**	**0.080**
9	Percent slope change	146.86	62.34	11.68	0.00	3	50.07	0.043	2.82	0.87	0.064
10	Watershed	149.06	65.22	14.56	0.00	4	49.03	0.037	3.18	0.88	0.066
11	Stream order	160.48	67.79	17.13	0.00	3	66.12	0.005	3.78	0.97	0.049

* catfish, carp, sunfish, bass

Table 9. Change in model fit parameters as a result of hypothetically increasing the number of occupied sites that are revisited.

	Model Fit Statistics		
Model	X^2	p-value	c-hat
Good Fit Model (hypothetical)	<20	>0.20	1.00
2003 Data (actual)	52.17	0.02	3.46
2003 Data (hypothetical):			
w/5 occupied sites revisited	38.19	0.05	2.55
w/10 occupied sites revisited	29.51	0.08	2.06
w/15 occupied sites revisited	29.51	0.10	1.85
w/20 occupied sites revisited	20.08	0.18	1.37
w/25 occupied sites revisited	17.68	0.24	1.23
w/30 occupied sites revisited	16.36	0.23	1.10
w/20 occupied sites revisited + crayfish absence	13.78	0.27	0.91

Table 10. Records of arroyo toads found in 2003 that contained PIT tags from a 1996 to 2000 arroyo toad marking effort on Camp Pendleton.

2003 Capture Records			Original Capture Information[1]						Capture/ Recapture Comparison	
Date	Tag No.	Location[2]	Date Tagged	Location	Survey Type	Sex	SV Length (mm)	Weight (g)	Travel dist. (m)	Estim. age (yr)
22-May-03	501D302704	CR	08-Apr-00	CR	TC	F	50.5	18.3	100	• 4
28-May-03	4255702E77	LSMAT								• 4
3-Jun-03	425639594F	CR	16-Oct-00	CR	PT	M	53.0	20.0		• 4
9-Jun-03	501D260C51	DEL	09-Apr-00	ROB	TC	F	54.0	17.5	320	• 4
6-Aug-03	4238200530	USMARG	09-Apr-00	USMARG	PT	F	65.0	40.0		• 4

[1](Holland et al. 2001, Holland and Sisk 2001)

[2] Location abbreviations: CR= Cristianitos creek, LSMAT= lower San Mateo creek, DEL= Deluz creek, USMARG= upper Santa Margarita River, ROB= Roblar Creek

Blank= Not in USGS copy of Holland database

Table 10. Records of arroyo toads found in 2003 that contained PIT tags from a 1996 to 2000 arroyo toad marking effort on Camp Pendleton.

	Original Capture Information[1]						2003 Capture Information[2]				Capture/ Recapture Comparison	
PIT Tag No.	Date Tagged	Location[3]	Survey Type[4]	Sex	Length[5] (mm)	Weight (g)	Date	Location[3]	Length[5] (mm)	Weight (g)	Travel dist. (m)	Estim. age (yr)
501D302704	08-Apr-00	CR	TC	F	50.5	18.3	22-May-03	CR	59.0	29.0	100	• 4
4255702E77							28-May-03	LSMAT				• 4
425639594F	16-Oct-00	CR	PT	M	53.0	20.0	3-Jun-03	CR	60.0	27.0		• 4
501D260C51	09-Apr-00	ROB	TC	F	54.0	17.5	9-Jun-03	DEL			320	• 4
4238200530	09-Apr-00	USMARG	PT	F	65.0	40.0	6-Aug-03	USMARG				• 5

[1](Holland et al. 2001, Holland and Sisk 2001)

[2]Weight and length measures were not included in 2003 monitoring protocol. Two toads with 2003 information were measured and weighed by FWS permitted biologists as part of USGS/MCBCP skeletochronology project.

[3] Location abbreviations: CR= Cristianitos Creek, LSMAT= lower San Mateo Creek, DEL= Deluz Creek, USMARG= upper Santa Margarita River, ROB= Roblar Creek

[4] Survey Type: TC= Transect Census, PT= pitfall trap

[5] Snout to vent length

Blank= Not in USGS copy of Holland database or data not available

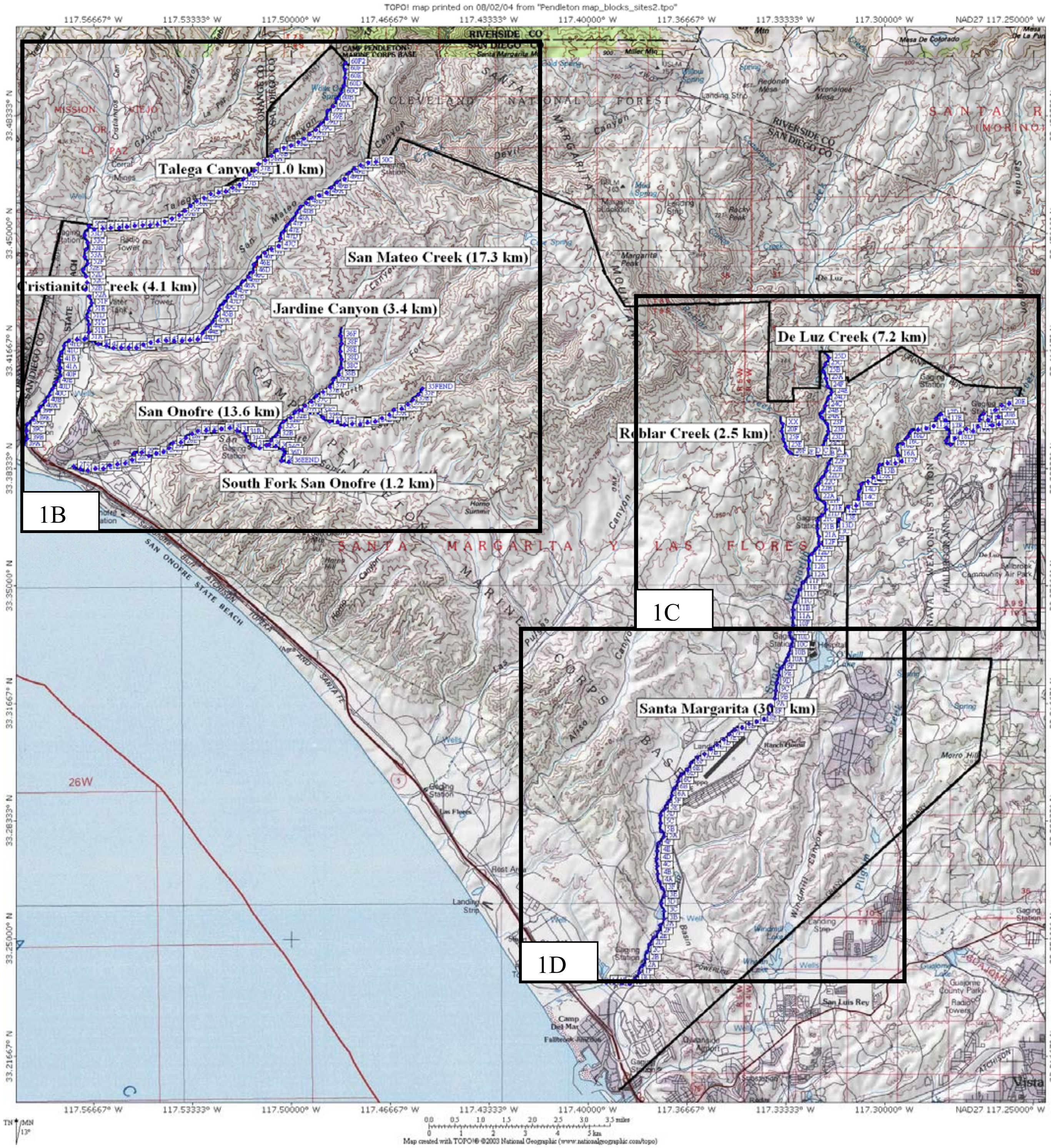


Figure 1A. Arroyo toad survey sites mapped out over 89 km of potential habitat on MCBCP. Boxed areas are magnified in the following Figures (1B, 1C, and 1D)

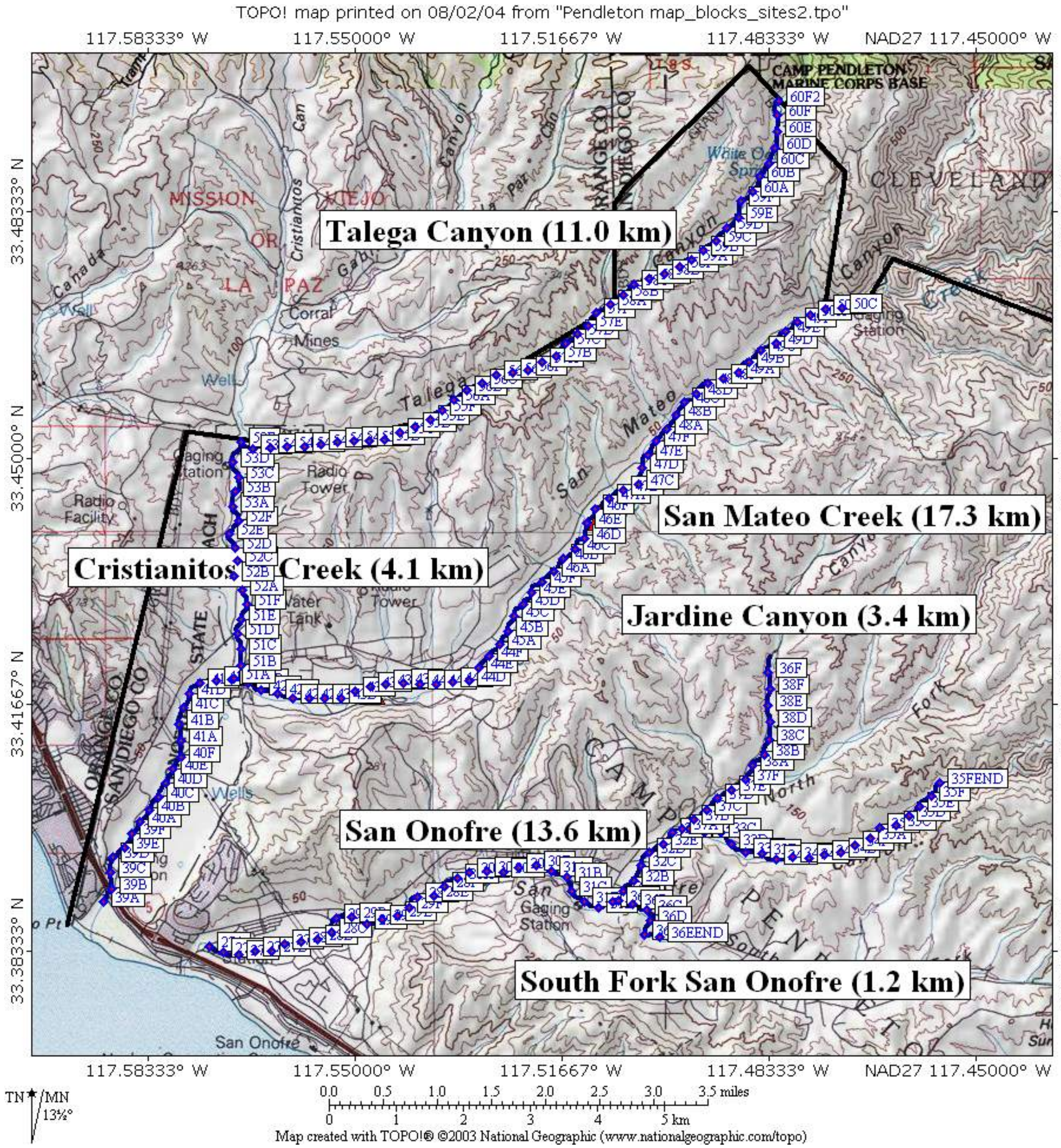


Figure 1B. Arroyo toad survey sites in the San Mateo and San Onofre watersheds.

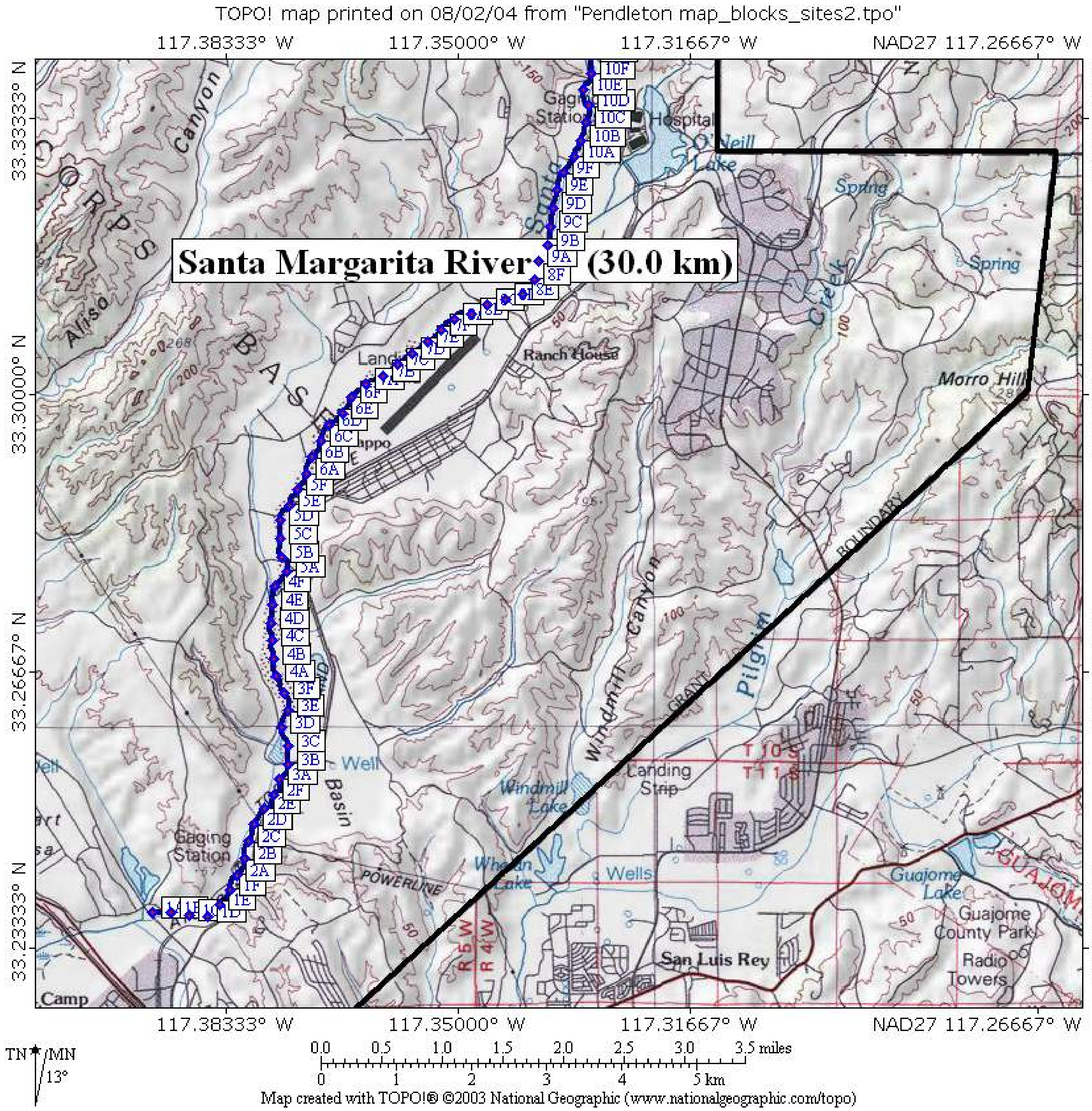


Figure 1C. Arroyo toad survey sites in the lower Santa Margarita River.

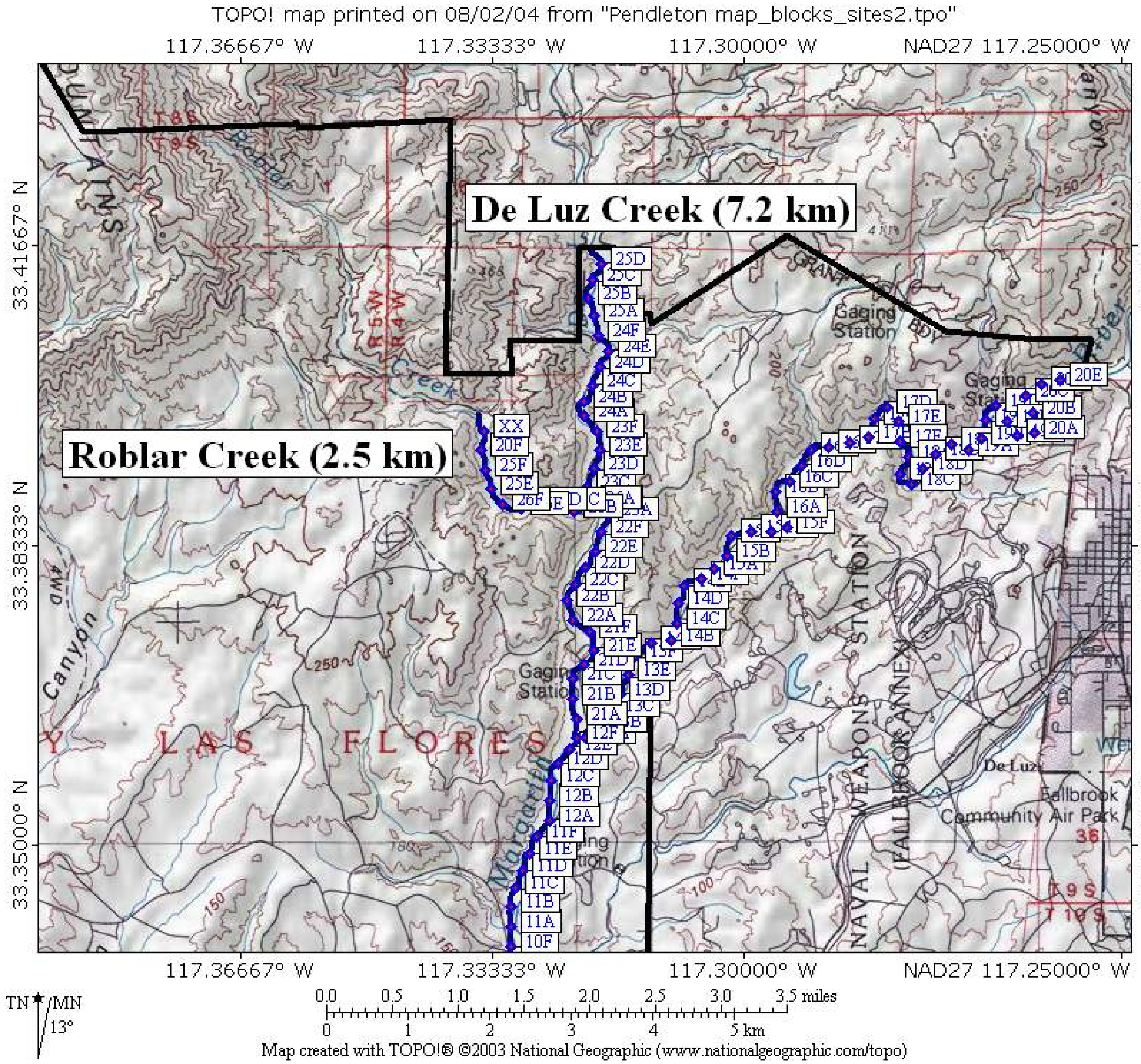


Figure 1D. Arroyo toad survey sites in the upper Santa Margarita watershed.

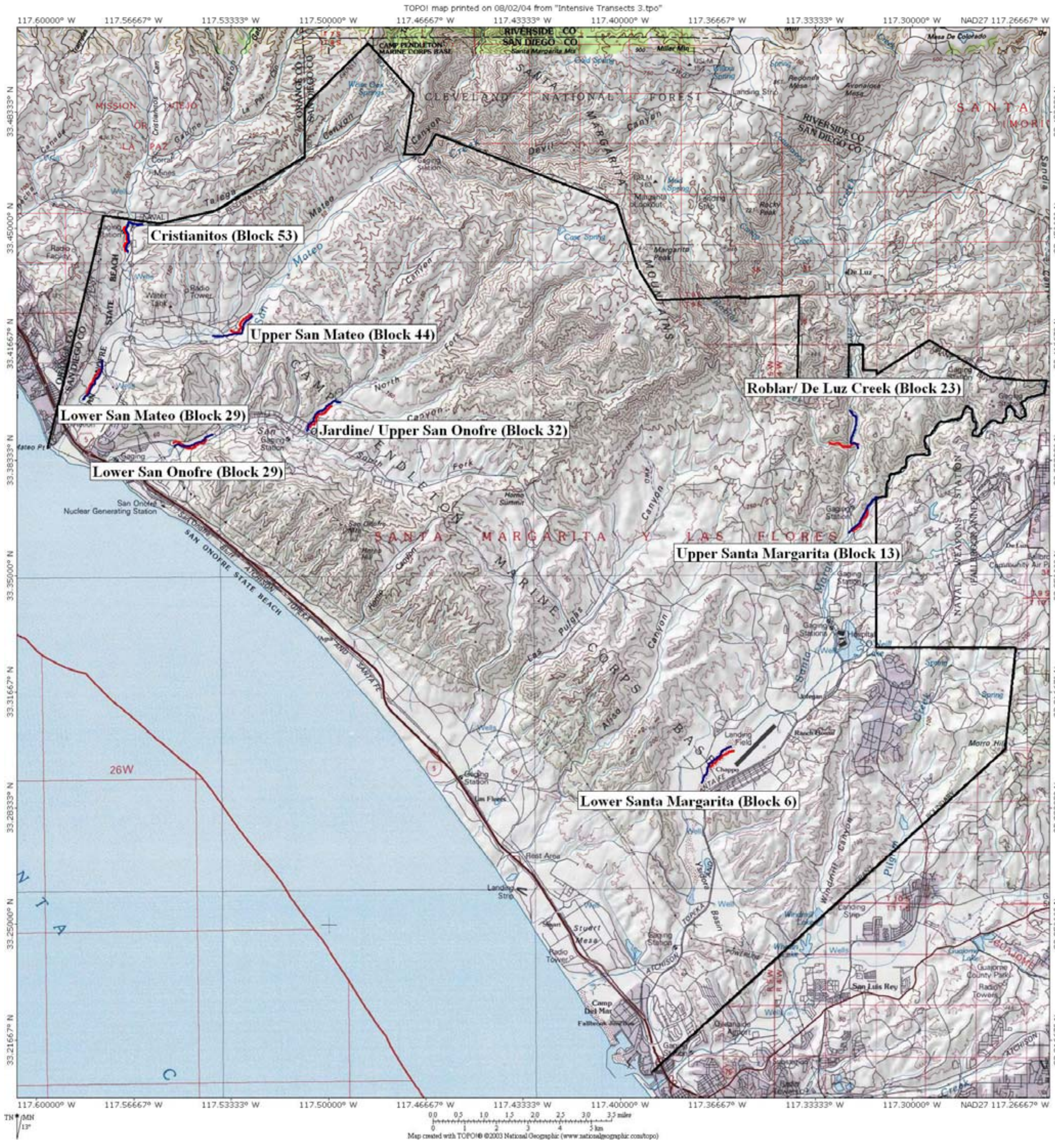


Figure 2. Locations of the 2003 intensive survey blocks (1.5 km, blue lines) in comparison to the Holland 1996-2000 transects (1.0 km, red lines).

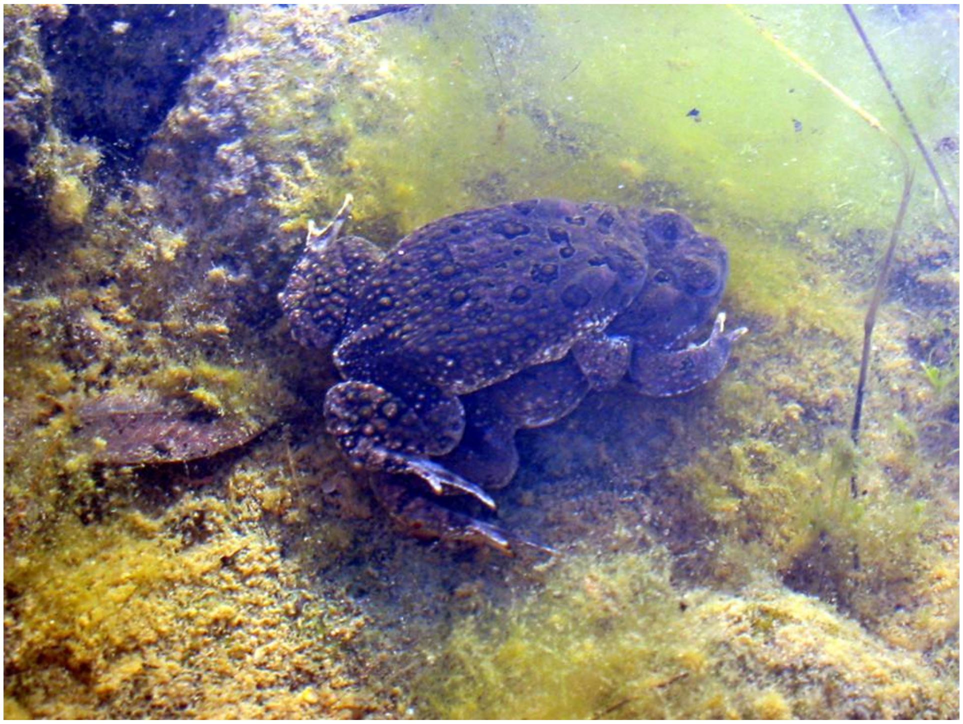


Figure 3. A pair of amplexing arroyo toads observed in upper San Mateo Creek on April 10.

Figure 4. An example of a suspected arroyo toad egg clutch observed in upper San Mateo Creek on April 10.

A.

B.

Figure 5. Two to three week old arroyo toad larvae observed in lower San Mateo Creek on April 10 (A). The white spot on the operculum is apparent when the tadpoles are observed close-up (B).

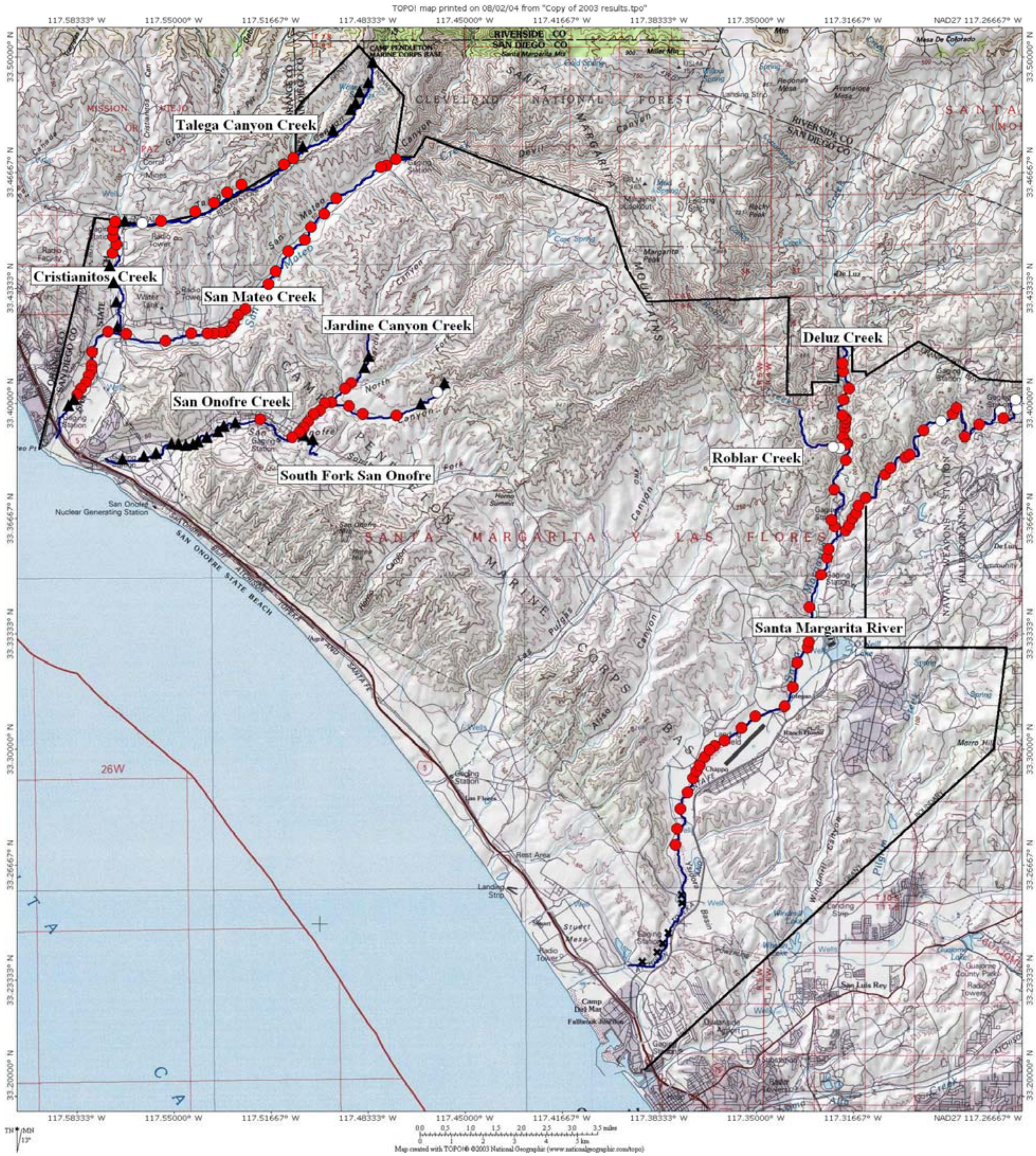


Figure 6. Results of the 2003 arroyo toad surveys.
Each 250 m site length scheduled for 2003 was either dry upon the first visit (black triangle), was wet with no toad larvae observed after 2 visits (white circle), was wet with toad larvae observed after 1 or 2 visits (red circle), or was not visited due to inaccessibility (black cross).

Figure 7. Photograph taken within upper San Mateo Creek intensive block (44) on April 30.

Figure 8. Photograph taken within lower San Mateo Creek intensive block (40) on May 28.

Figure 9. Photograph taken within the Cristianitos Creek intensive block (53) on May 22.

Figure 10. Photograph taken within upper San Onofre Creek intensive block (32) on April 31.

Figure 11. Photograph taken within lower San Onofre Creek intensive block (29) on May 20.

Figure 12. Photograph taken within upper Santa Margarita River intensive block (13) on June 16.

Figure 13. Photograph taken within De Luz Creek intensive block (23) on May 20.

Figure 14. Photograph taken within lower Santa Margarita River intensive block (6) on May 30.

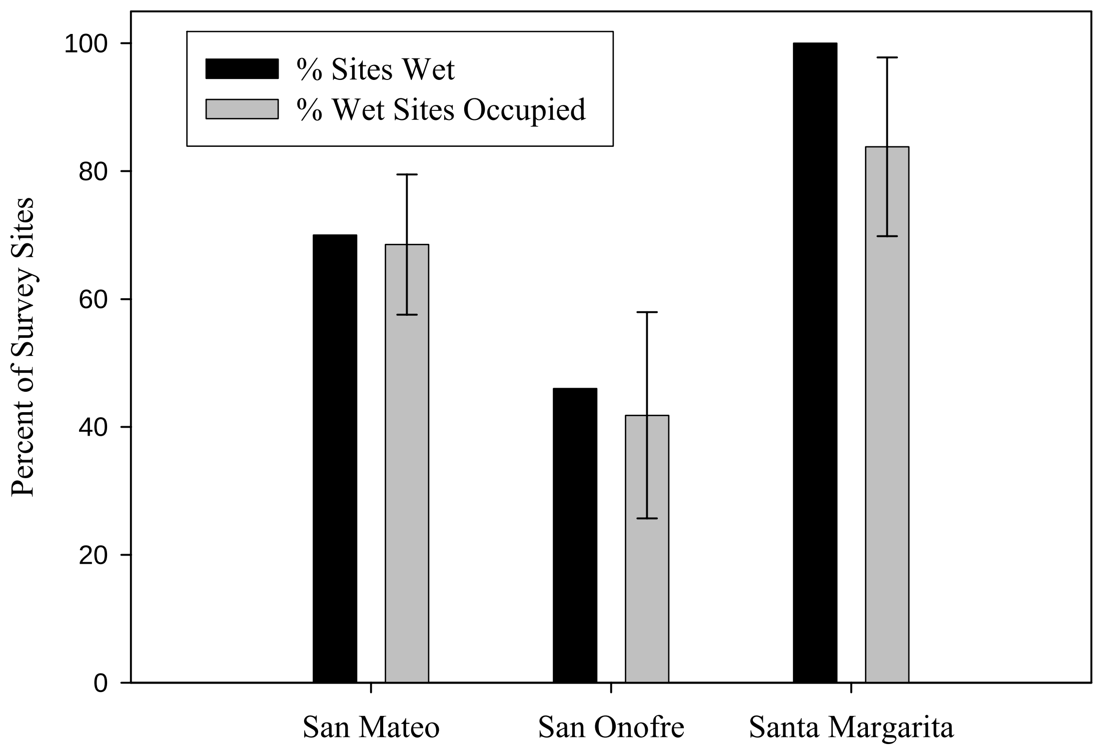


Figure 15. Percentage of wet area occupied by arroyo toad larvae for each watershed. Graph shows percentage of sites that were wet upon first visit and percentage of the wet sites (+/- 1 se) in which arroyo toad larvae were detected. Occupancy estimates are corrected for individual detection probabilities.

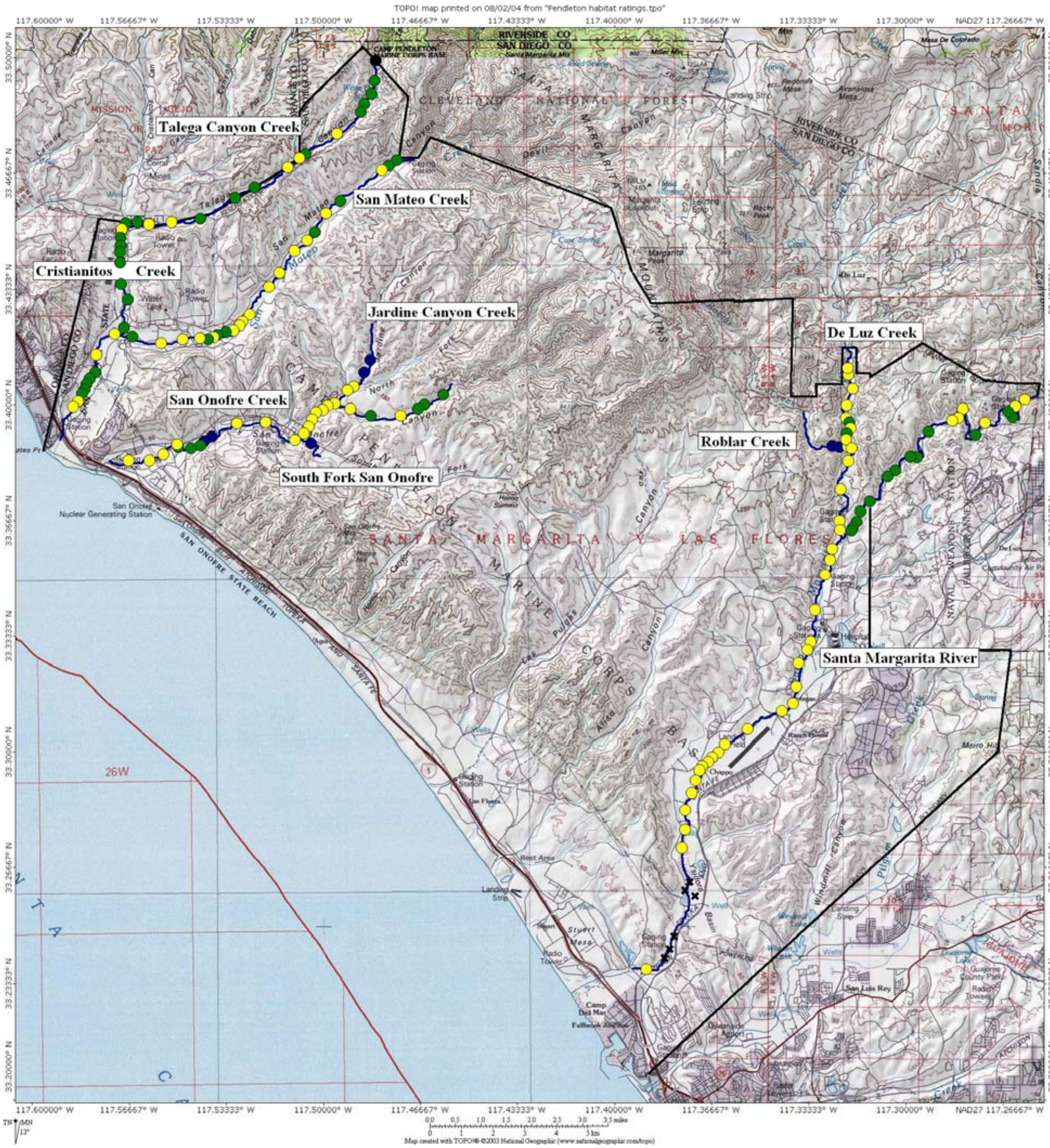


Figure 16. Site quality assessment of potential arroyo toad habitat surveyed in 2003. Site quality was assessed by presence of three stream-related habitat variables (sandy substrate, sandy terraces, and channel braiding) that are known to be associated with most arroyo toad populations (USFWS 1999). The presence of all 3 variables resulted in an “excellent” rating (yellow circle), while the presence of 2, 1, or 0 variables resulted in ratings of good (green circle), marginal (blue circle), or poor (black circle), respectively.

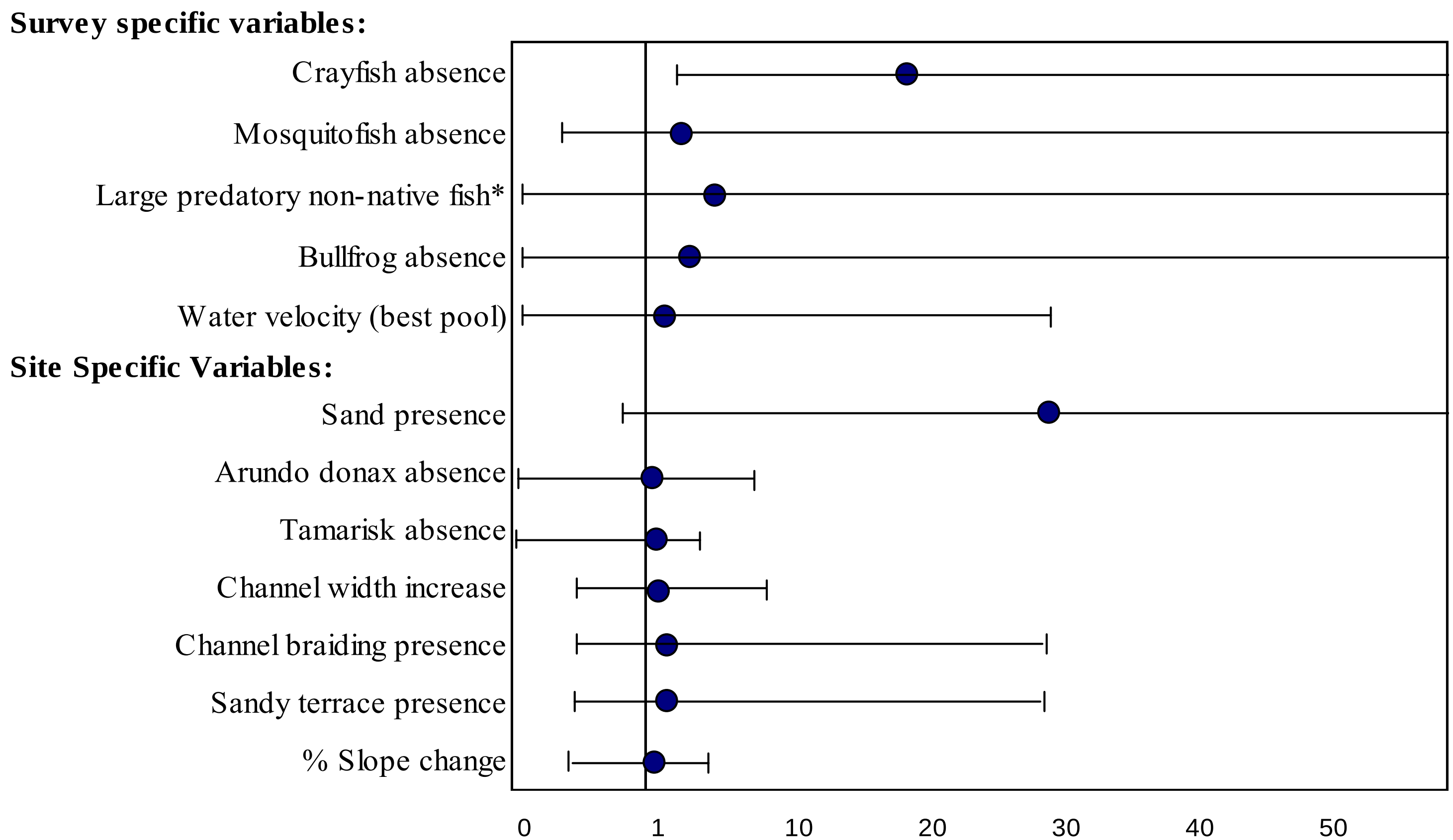
Figure 17. Dense growth of cattails and sedges along the upper Santa Margarita River. These portions of the river were associated with narrower channels and deeper and faster waters.

Figure 18. Examples of native aquatic species detected on MCBCP in 2003.
Photographs show: A) western toad, B) Pacific treefrog, C) California newts in amplexus with egg masses, D) California treefrog, and E) two-striped garter snake.

A.
B.
C.
D.

Figure 19. Examples of non-native aquatic species detected on MCBCP in 2003. Photographs show: A) green sunfish, B) mosquitofish, C) crayfish, and D) beaver dam (note: photo insert of incisor marks on dam branch in upper left hand corner). Other species detected but not shown include bullfrog, catfish, bass, and Asian clam.

Figure 20. Odds ratios (+/- 95% confidence limits) of observing arroyo toad larvae within a 250m site for 12 site and survey variables. An odds ratio of 2.0 means that we were 2 times more likely to observe arroyo toad larvae given the specified variable. Confidence limits that cross an odds ratio of 1 are not significant at the 95% confidence level.



* catfish, carp, sunfish, and bass

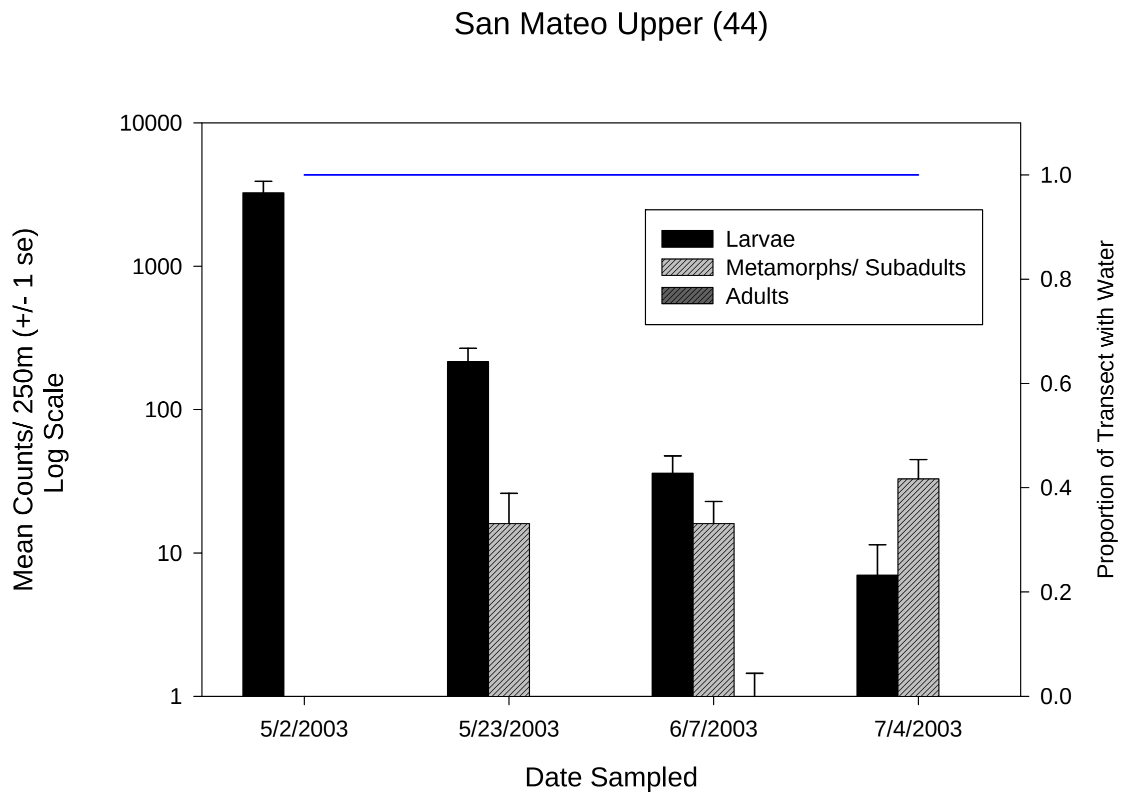


Figure 21. Numbers of arroyo toad age/size classes observed over time on the upper San Mateo intensive block. Second y-axis (blue line) shows proportion of transect with water over time.

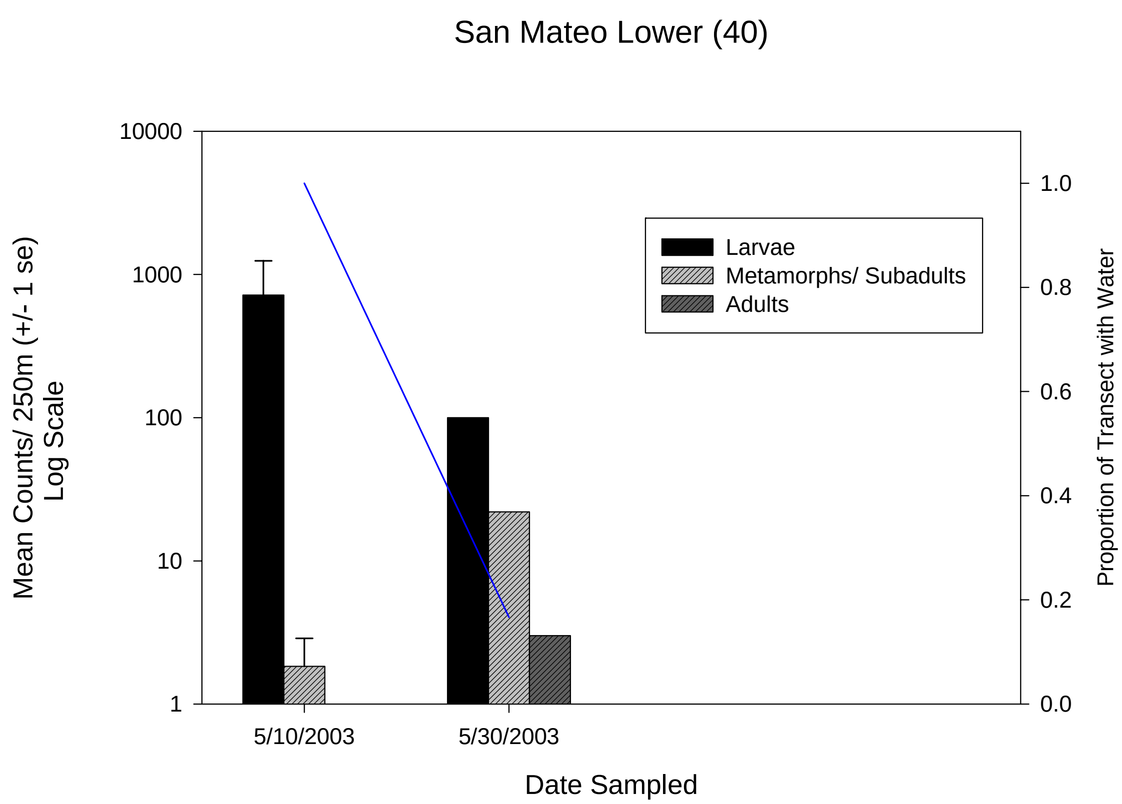


Figure 22. Numbers of arroyo toad age/size classes observed over time on the lower San Mateo intensive block. Second y-axis (blue line) shows proportion of transect with water over time.

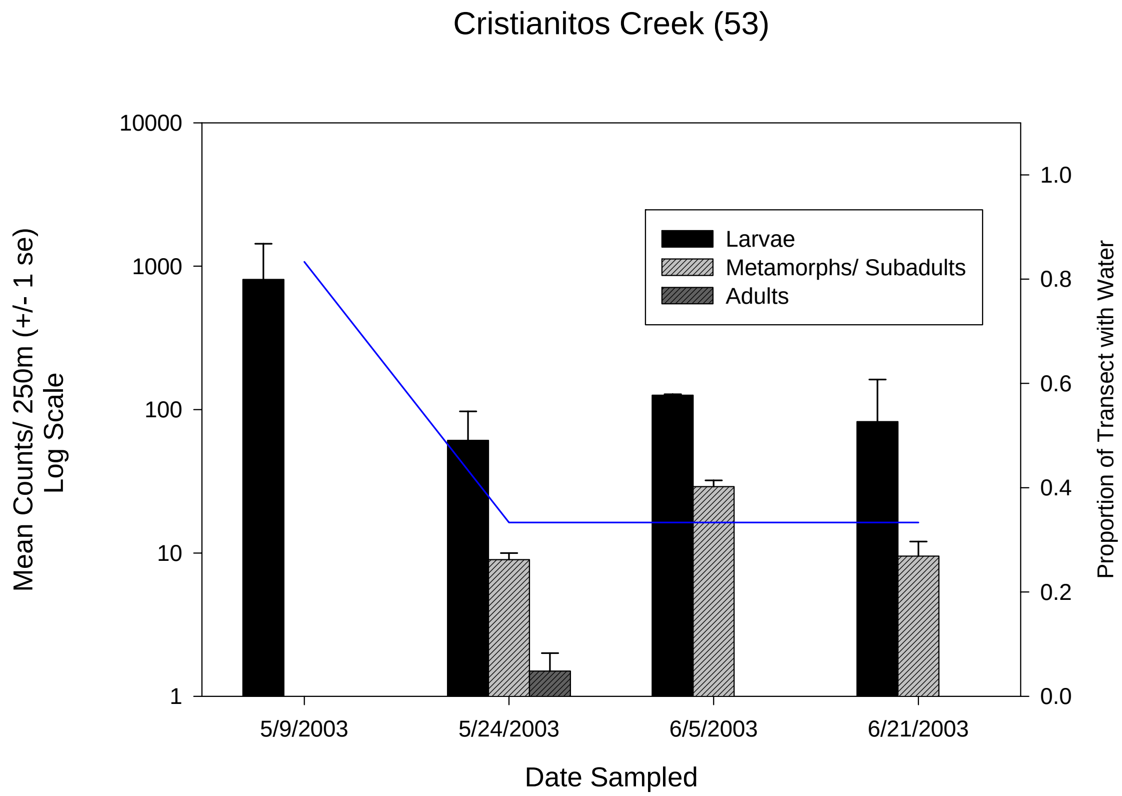


Figure 23. Numbers of arroyo toad age/size classes observed over time on the Cristianitos Creek intensive block. Second y-axis (blue line) shows proportion of transect with water over time.

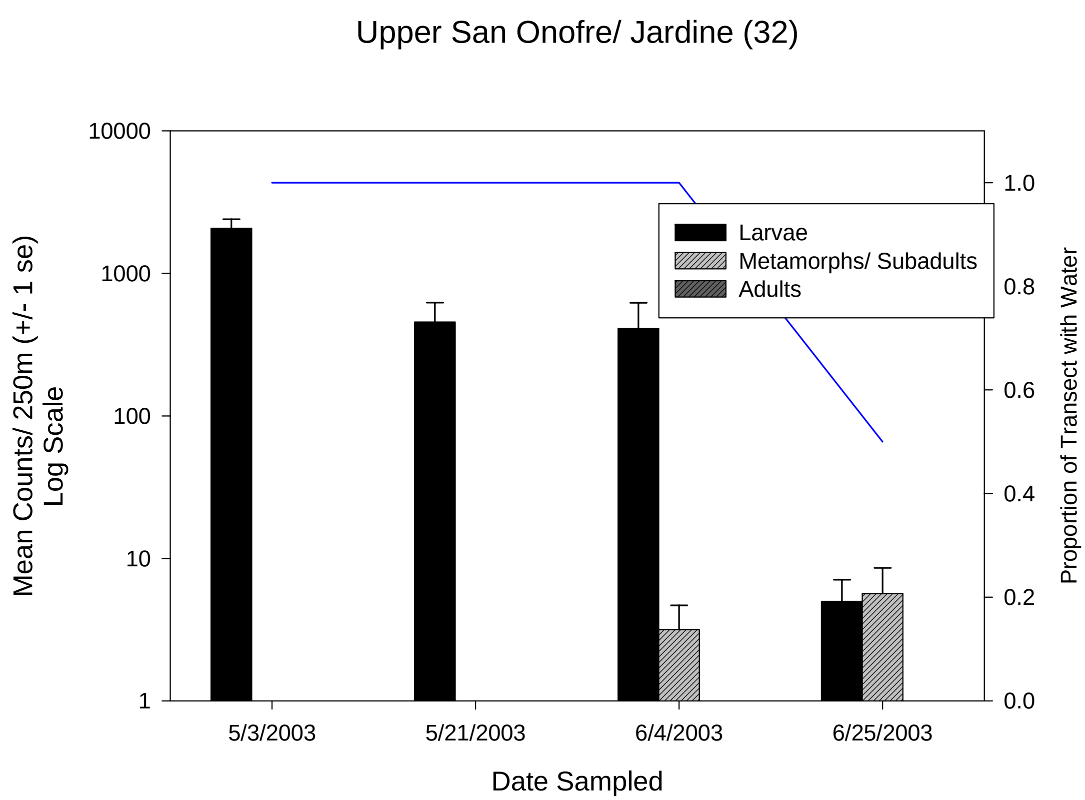


Figure 24. Numbers of arroyo toad age/size classes observed over time on the upper San Onofre intensive block. Second y-axis (blue line) shows proportion of transect with water over time. Lower San Onofre was not surveyed because it was dry during throughout the survey period.

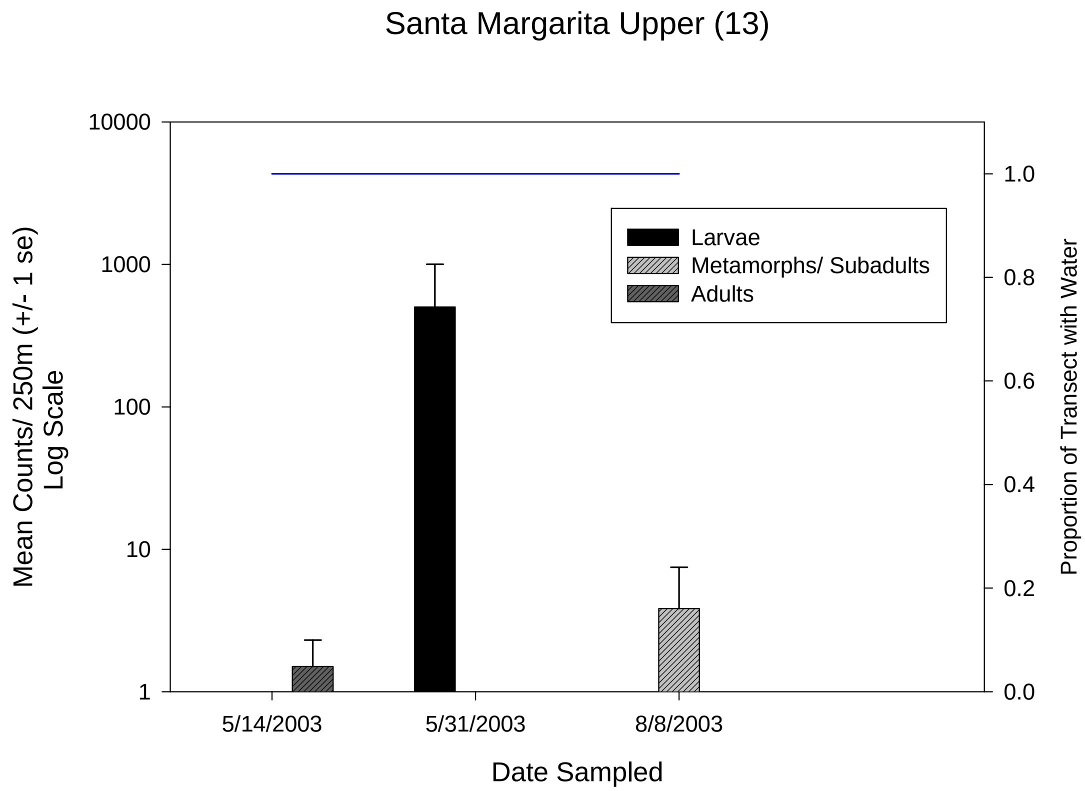


Figure 25. Numbers of arroyo toad age/size classes observed over time on the upper Santa Margarita intensive block. Second y-axis (blue line) shows proportion of transect with water over time.

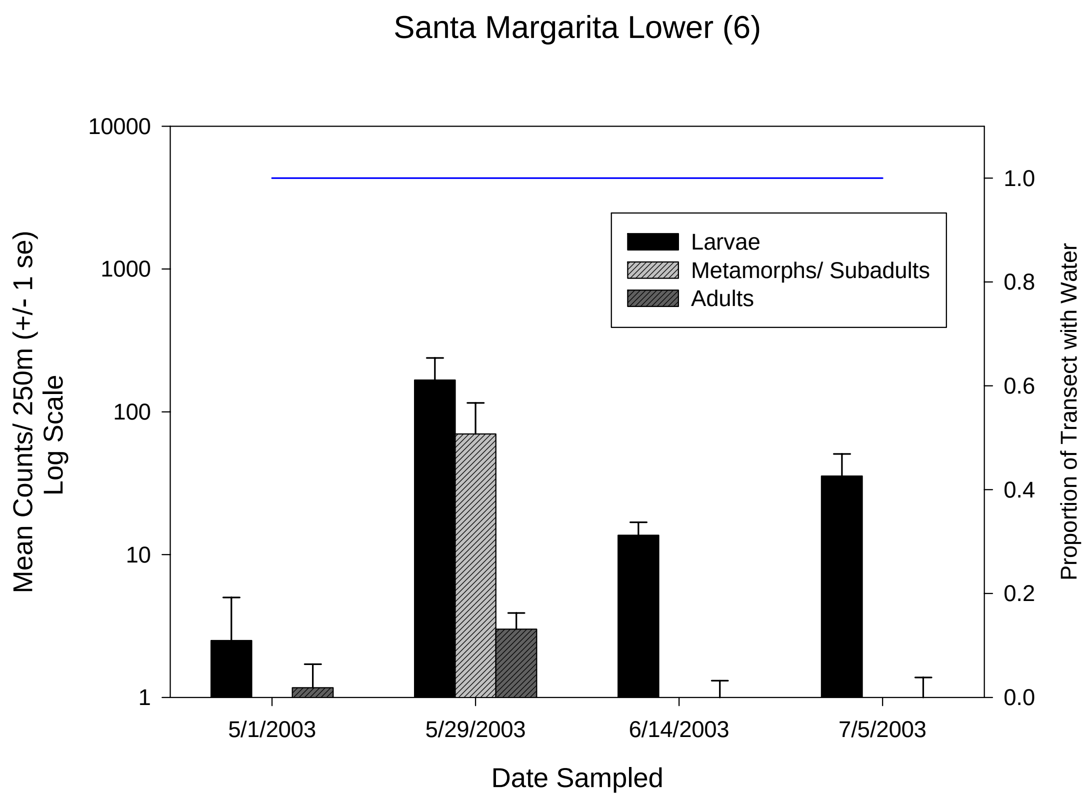


Figure 26. Numbers of arroyo toad age/size classes observed over time on the lower Santa Margarita intensive block. Second y-axis (blue line) shows proportion of transect with water over time.

De Luz Creek (23)

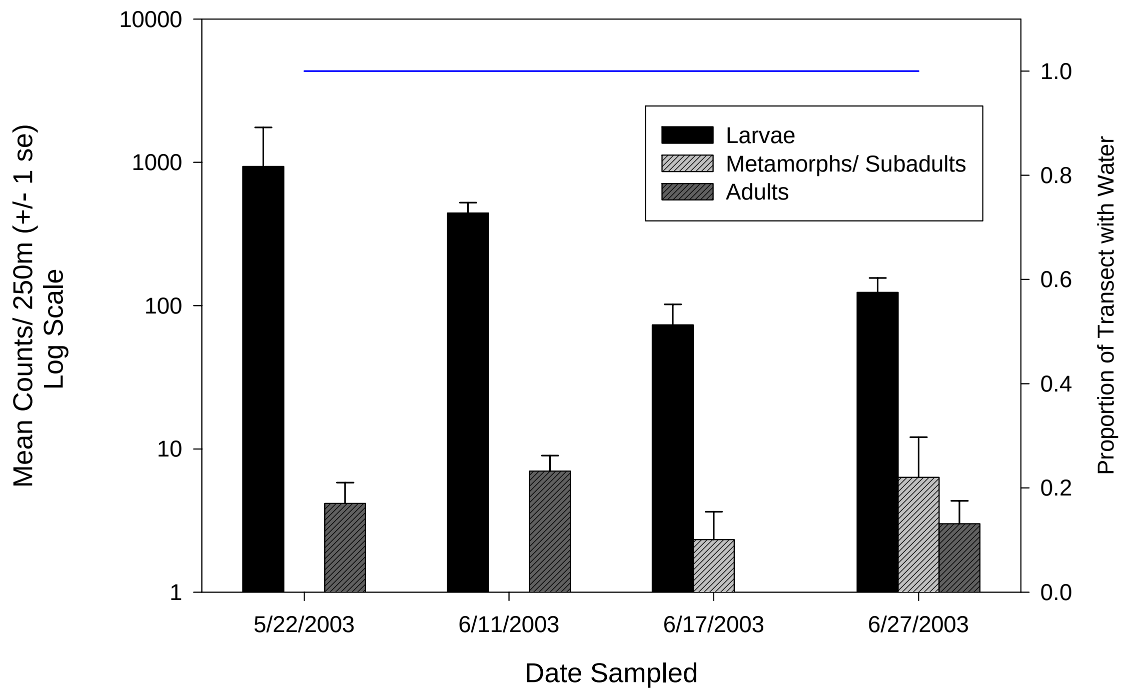


Figure 27. Numbers of arroyo toad age/size classes observed over time on the De Luz Creek intensive block. Second y-axis (blue line) shows proportion of transect with water over time.

Figure 28. Representative photos of arroyo toad larvae observed on MCBCP at different stages of development. Larvae shown are approximately 16 to 24 days old (A and B), a mixture of ages ranging from 24 to 65+ days (C), and 52 to 65+ days old with hindlimbs (D and E). Ages are based on Sweet 1992). Growth and development rates will vary depending upon genetic and environmental variables.

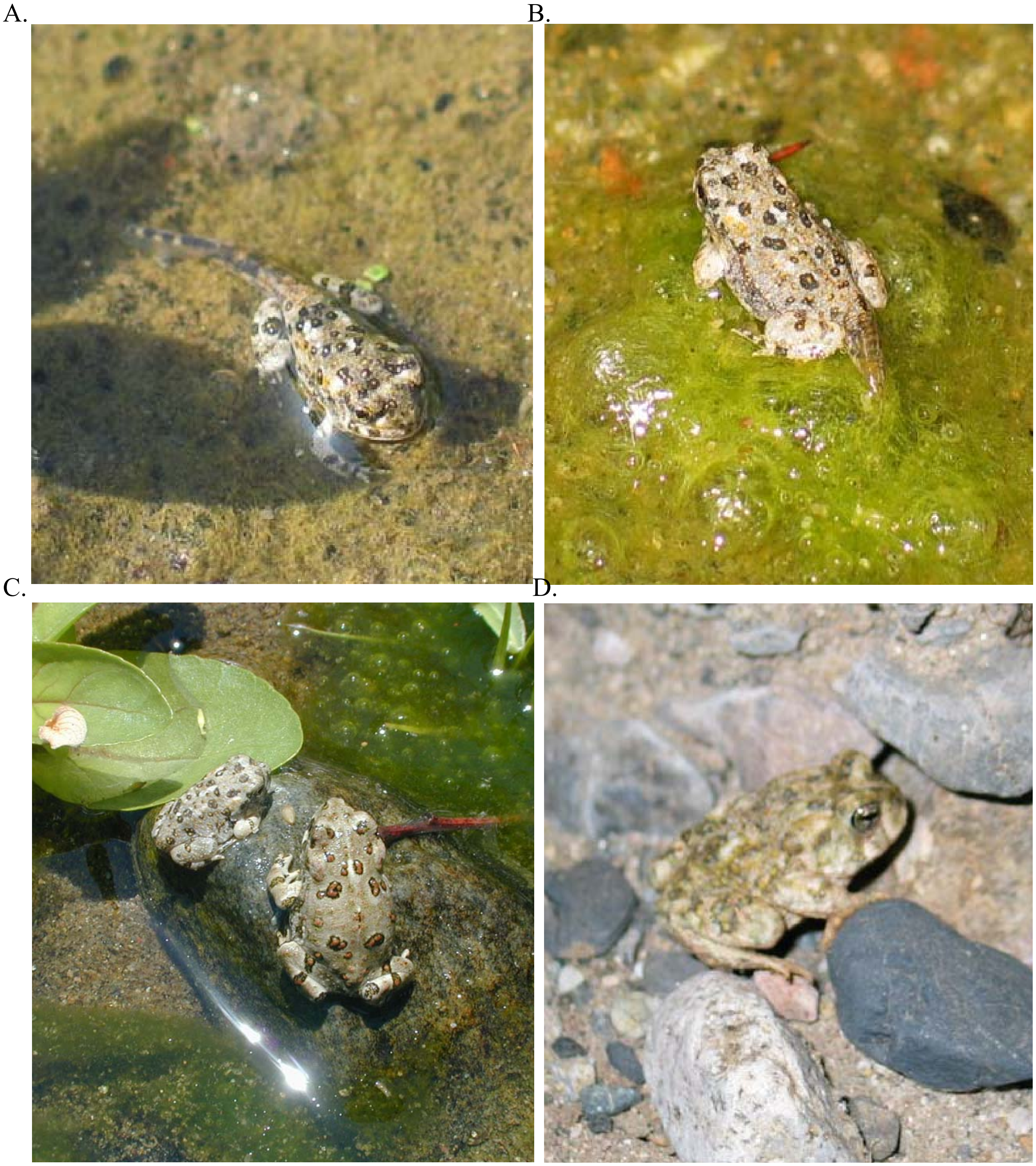


Figure 29. Representative photos of arroyo toad metamorphs and juveniles observed on MCBCP. The forelimbs erupt and pale "V" appears on the eyelids at approximately 67 days in age (A), followed by tail re-absorption (70 days, B) and complete metamorphosis (72 days, juveniles, C and D). Ages based on Sweet (1992). Growth and development rates will vary depending upon genetic and environmental variables.

A. B. C. D.

Figure 30. Representative photos of arroyo toad adults observed on MCBCP.
Adult males are calling from a shallow side pool (A) and on top of a rock within De Luz Creek (B). A male/female pair in amplexus (C) and adult moving along a sandy terrace (D) are also shown.

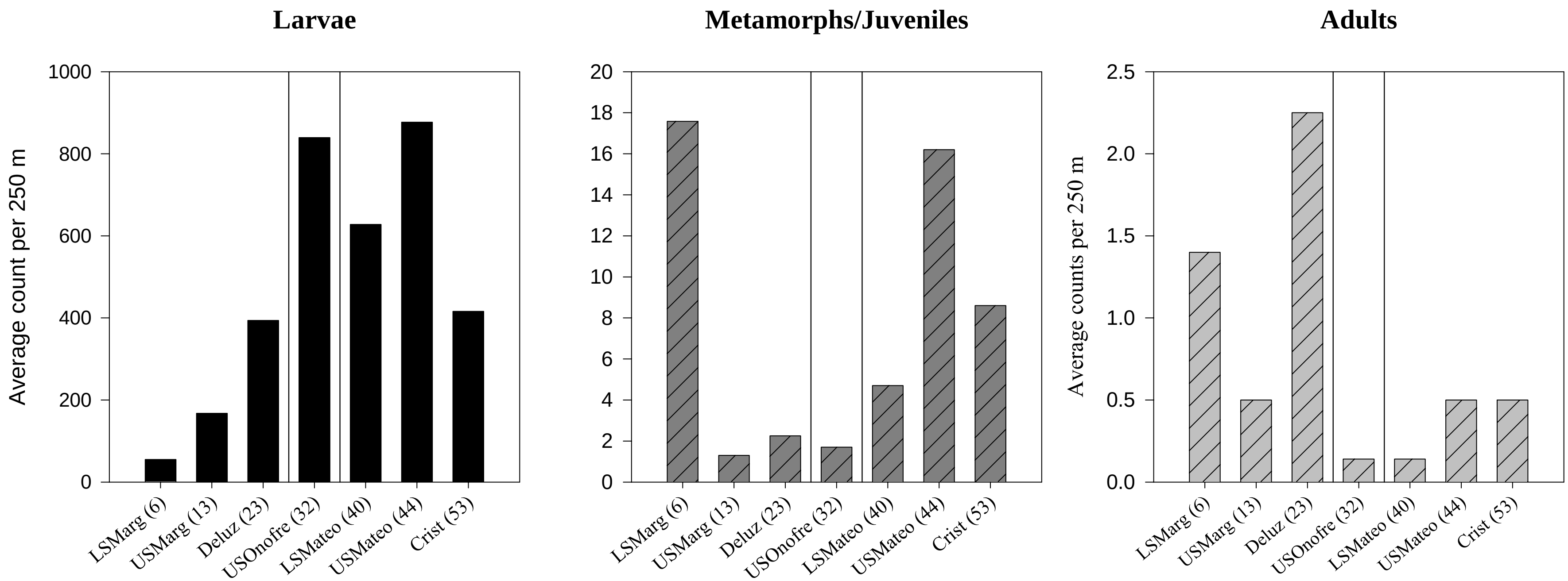


Figure 31. Average counts of different age classes observed in each of the intensive blocks surveyed in 2003. The intensive blocks surveyed were the lower Santa Margarita River (LSMarg 6), upper Santa Margarita River (USMarg 13), De Luz Creek (Deluz 23), upper San Onofre Creek (USOnofre 32), lower San Mateo Creek (LSMateo 40), upper San Mateo Creek (USMateo 44), and Cristianitos Creek (Crist 53). Surveys were dependant upon the presence of water. Vertical lines separate watersheds.

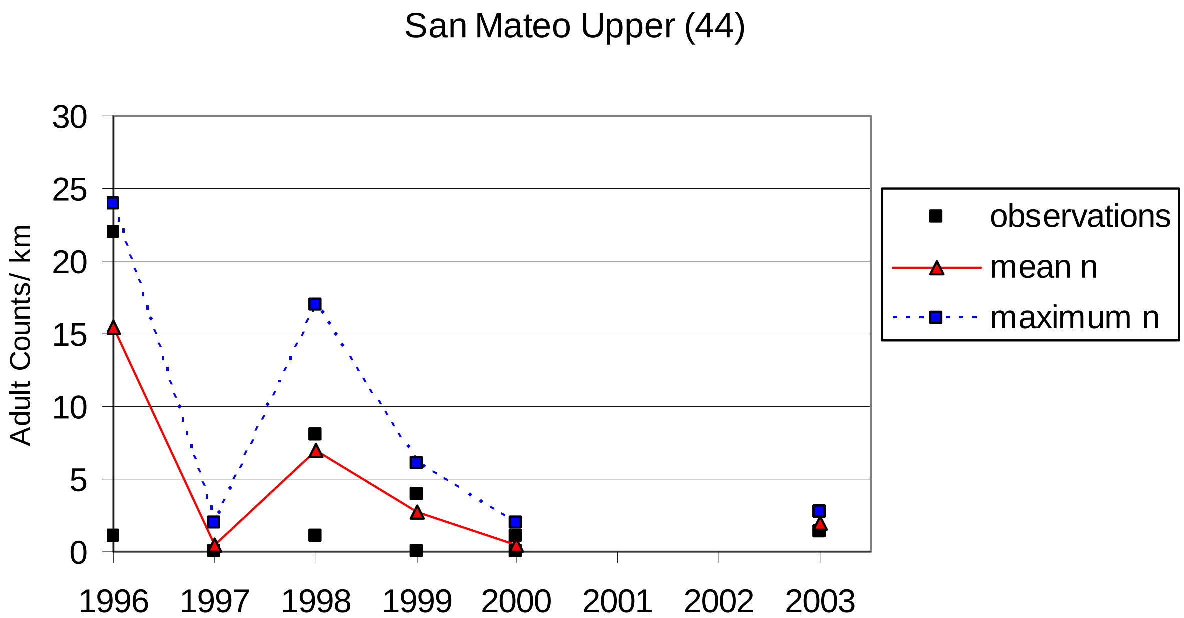


Figure 32. Numbers of adult arroyo toads observed on the upper San Mateo intensive block/transect in 2003 in comparison to 1996-2000.

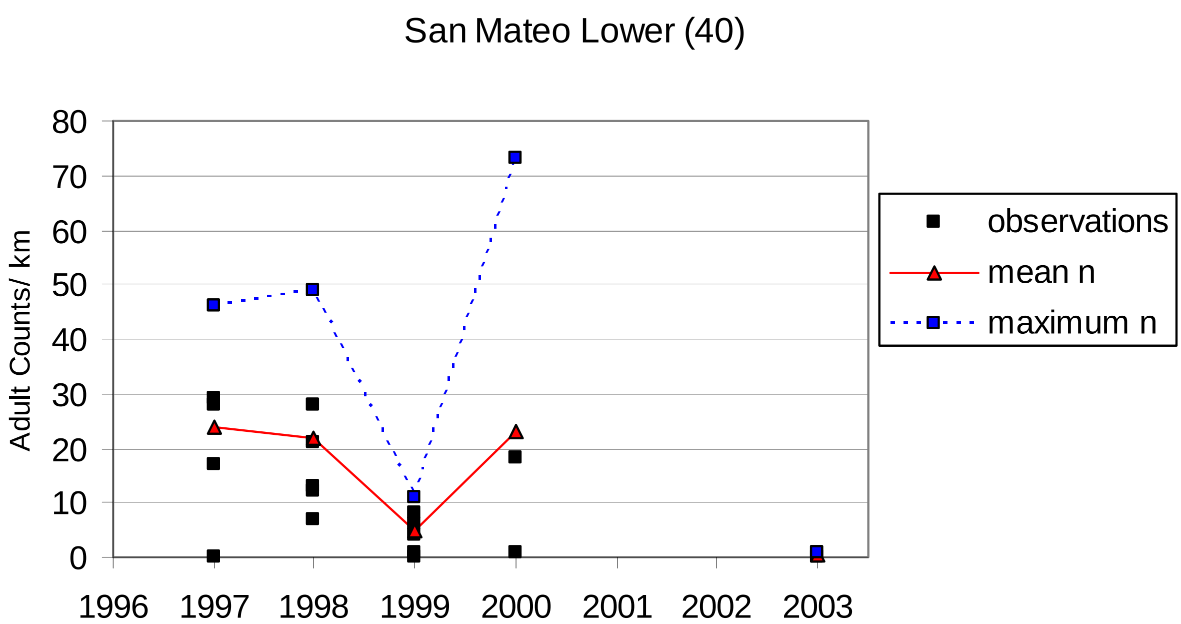


Figure 33. Numbers of adult arroyo toads observed on the lower San Mateo intensive block/transect in 2003 in comparison to 1996-2000.

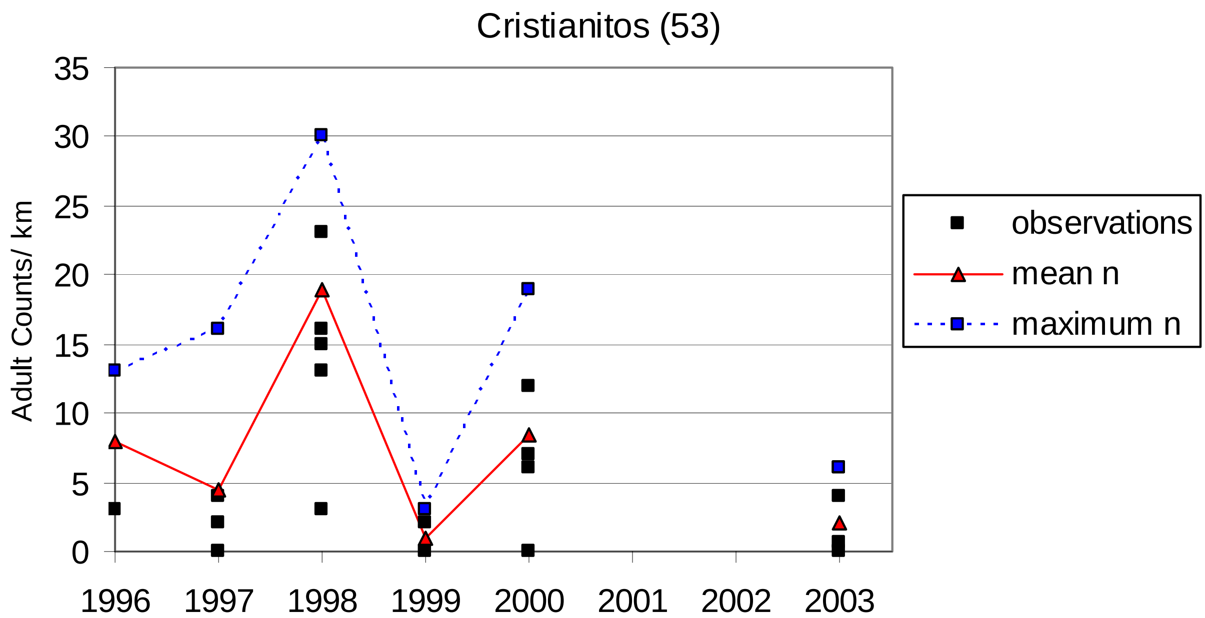


Figure 34. Numbers of adult arroyo toads observed on the lower Cristianitos Creek intensive block/transect in 2003 in comparison to 1996-2000.

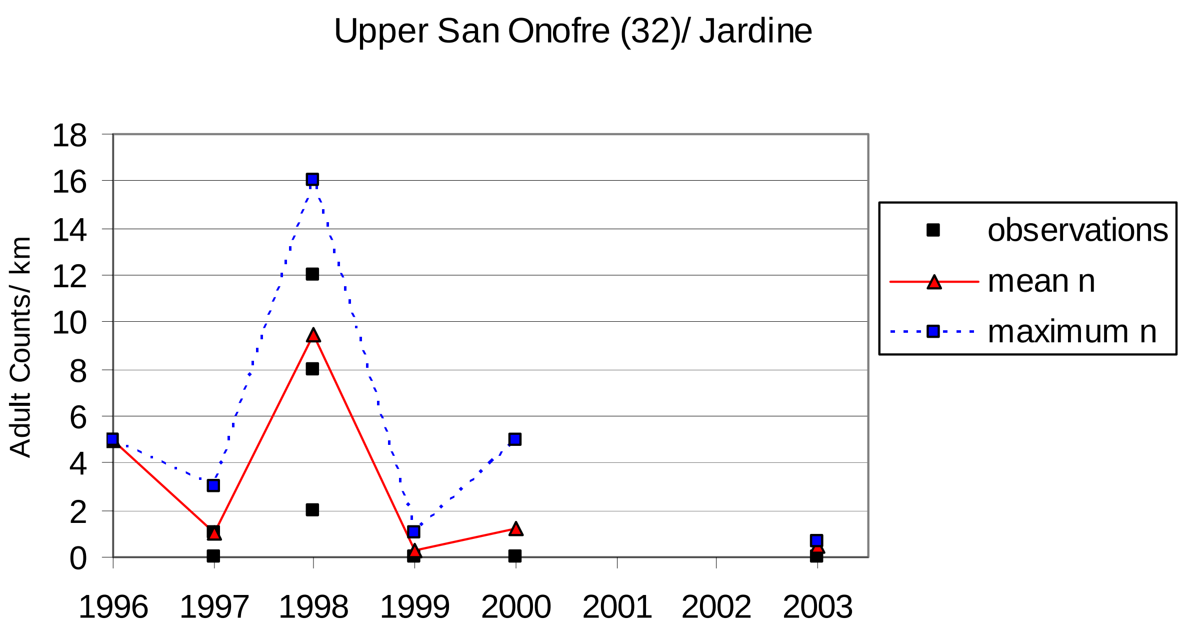


Figure 35. Numbers of adult arroyo toads observed on the upper San Onofre intensive block/transect in 2003 in comparison to 1996-2000.

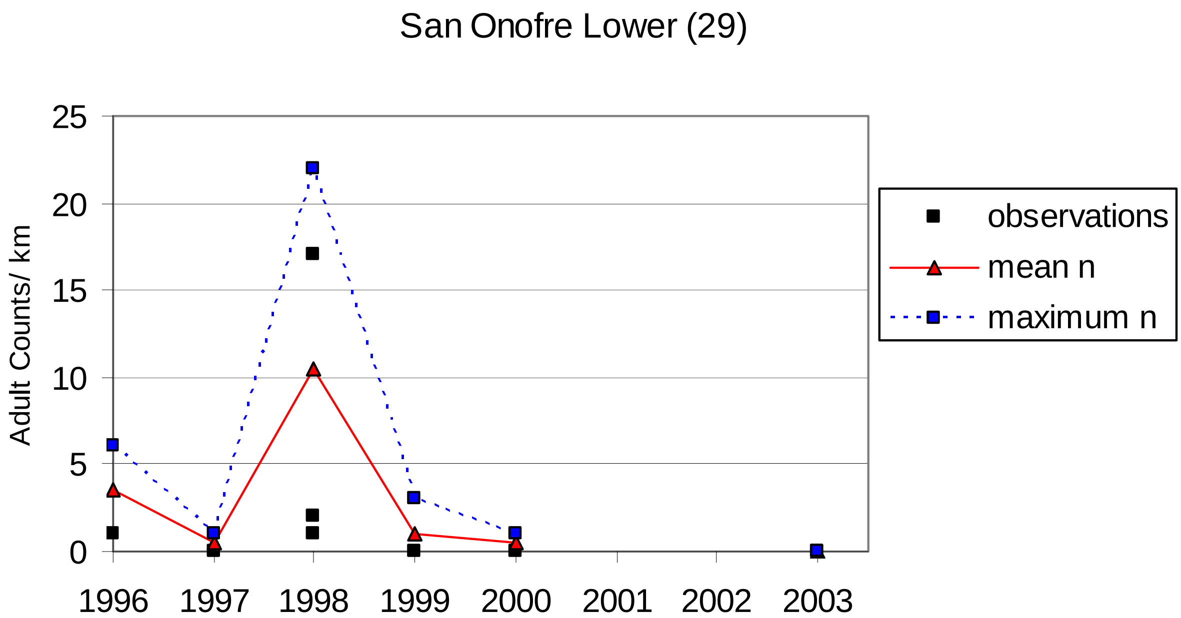


Figure 36. Numbers of adult arroyo toads observed on the upper San Onofre intensive block/transect in 2003 in comparison to 1996-2000. We conducted one night survey only because the transect was dry throughout the survey period.

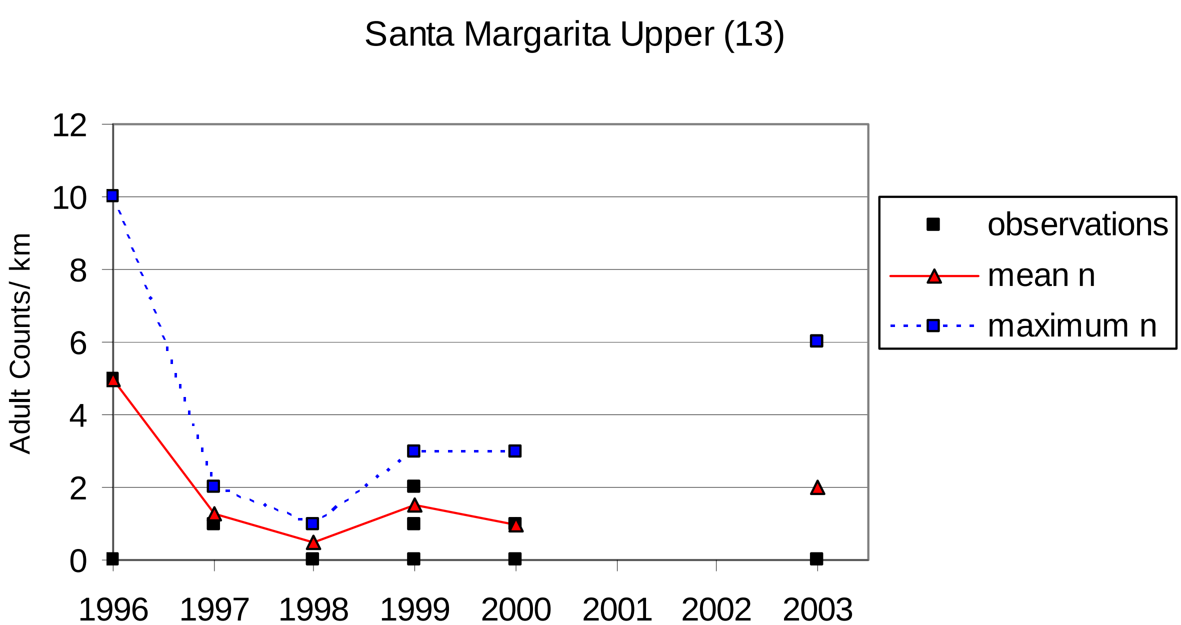


Figure 37. Numbers of adult arroyo toads observed on the upper Santa Margarita intensive block/transect in 2003 in comparison to 1996-2000.

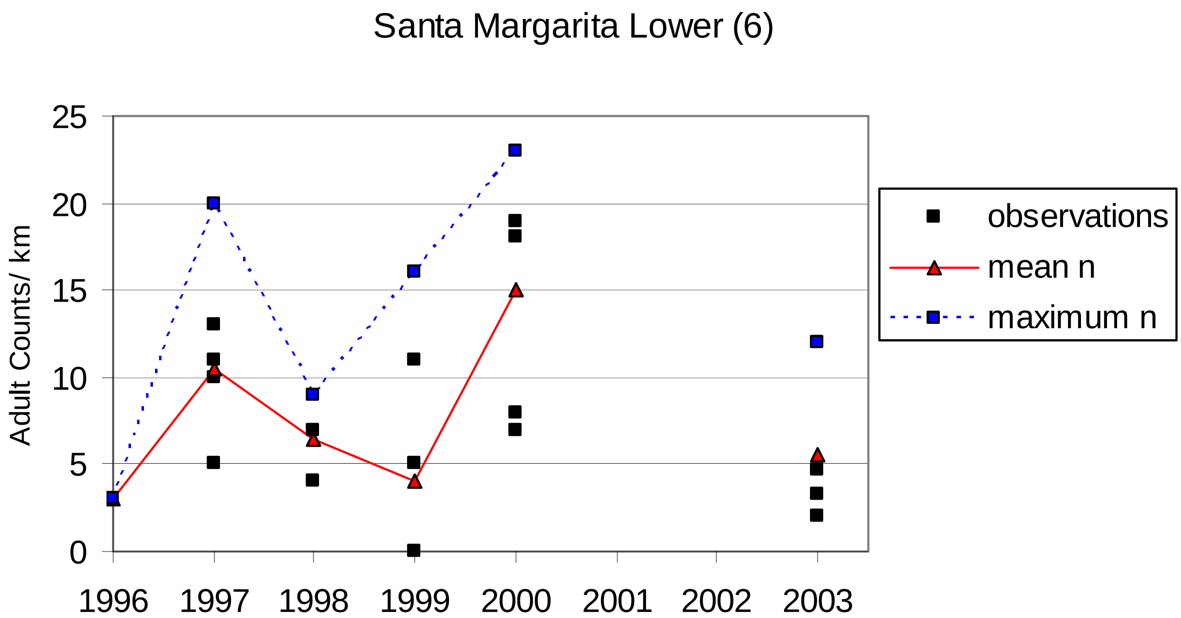


Figure 38. Numbers of adult arroyo toads observed on the upper Santa Margarita intensive block/transect in 2003 in comparison to 1996-2000.

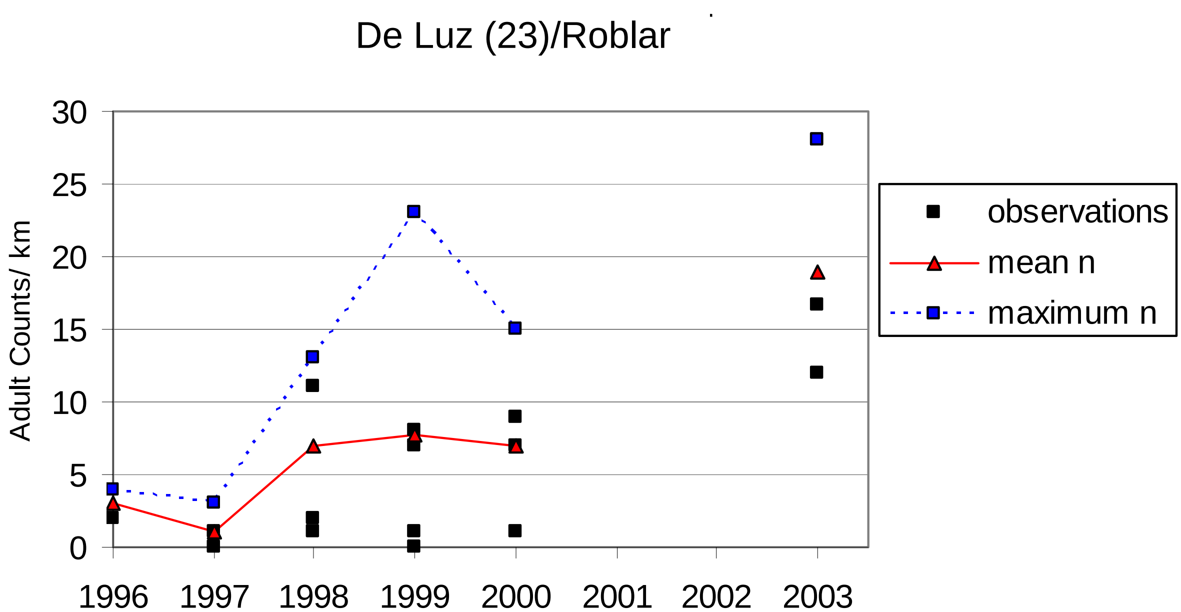


Figure 39. Numbers of adult arroyo toads observed on the De Luz Creek intensive block/transect in 2003 in comparison to 1996-2000. This block overlaps approximately 0.33 km of the Holland 1996-2000 Roblar transect.

Figure 40. Adult arroyo toad with PIT tag (No. 501D302704) found in Cristianitos Creek. The toad is being held by a permitted biologist. This toad is at least 4 years of age and has moved approximately 100 m from its original location recorded in April, 2000.

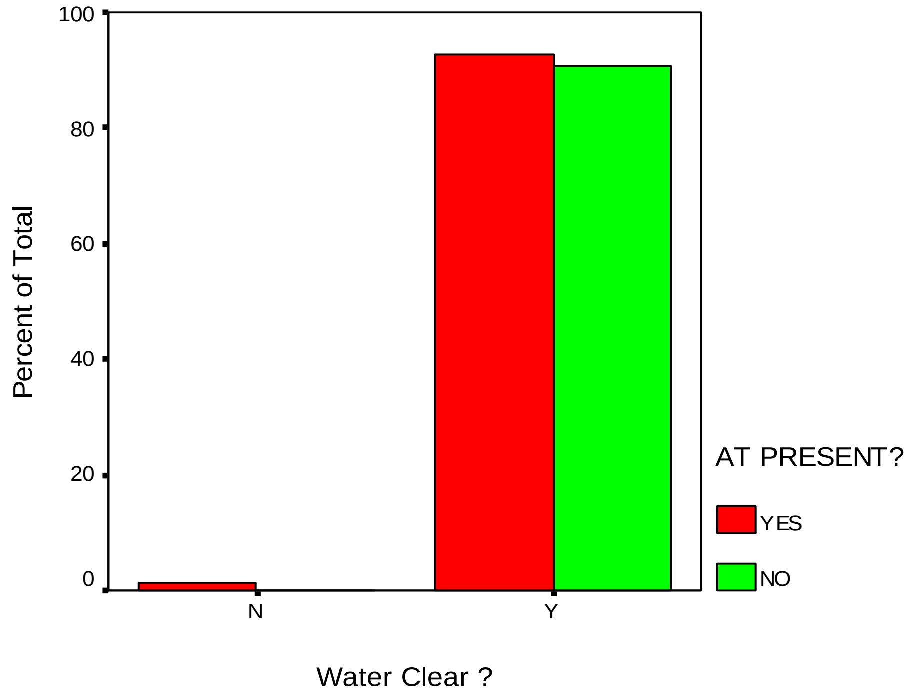


Figure 41. Water clarity classifications of occupied (AT present) versus unoccupied potential arroyo toad breeding pools. There was no significant difference between water clarity in the occupied vs. unoccupied pools (Fisher's Exact test, p=0.597)

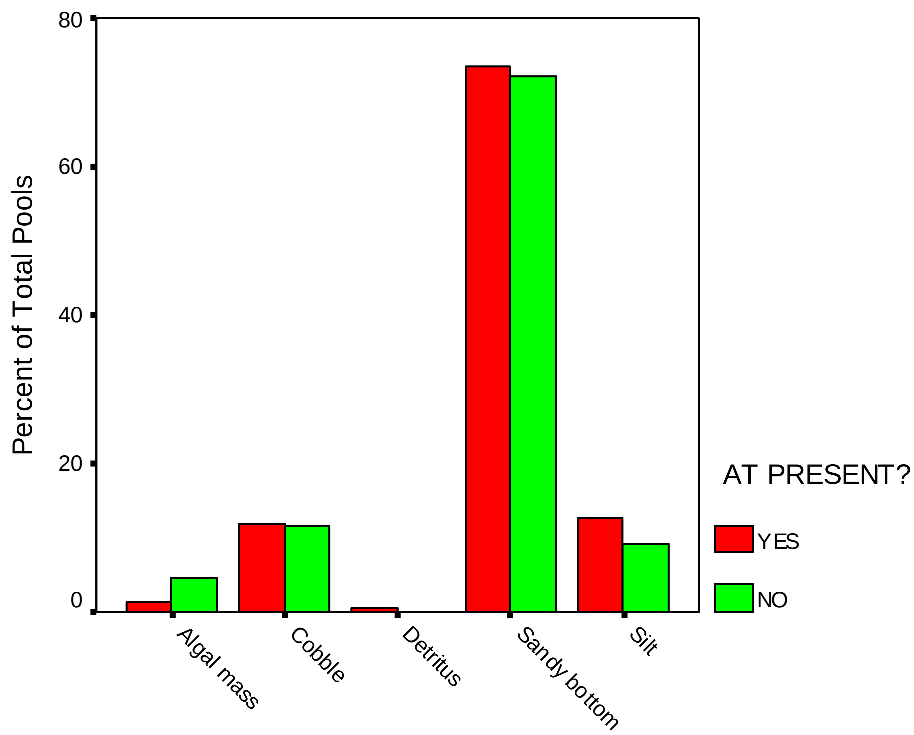


Figure 42. Substrate of occupied (AT present) versus unoccupied potential arroyo toad breeding pools. There was no significant difference between the proportions of different substrates found in occupied vs. unoccupied pools ($\chi2 = 2.64$, df =4, p= 0.620)

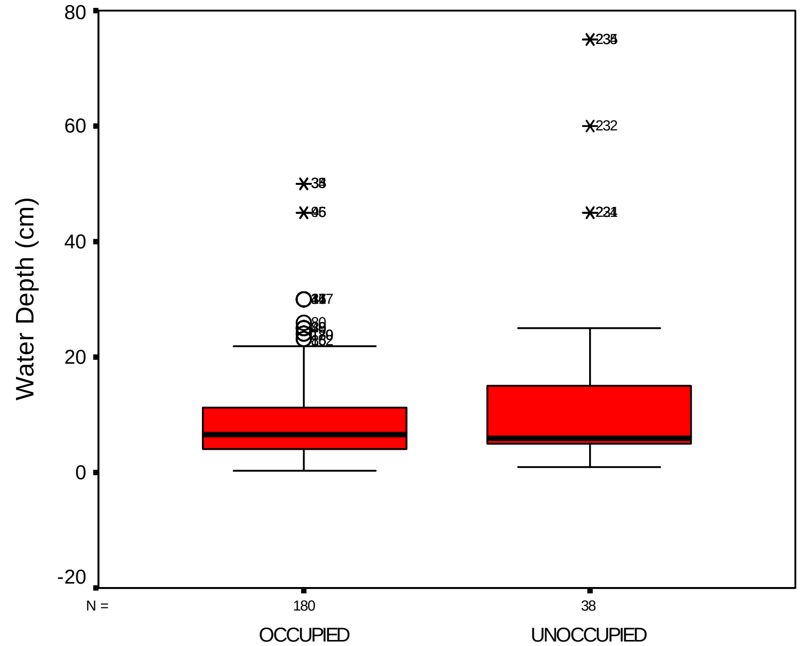


Figure 43. Water depth of potential arroyo toad breeding pools.
There were no significant differences between pools that were occupied versus those that were not occupied by arroyo toads (Mann-Whitney U = 3641, p= 0.321). Box plots show median and interquartile ranges.

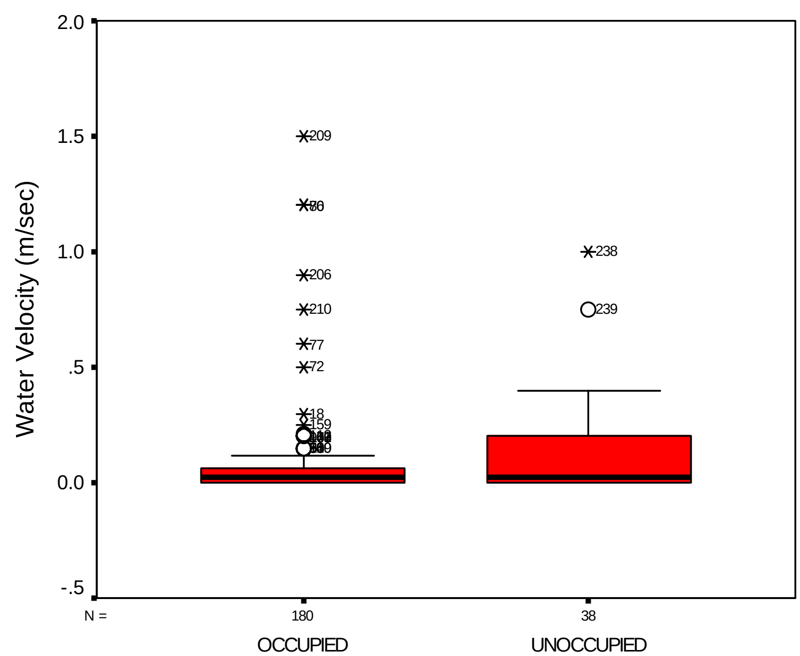


Figure 44. Surface water velocity of potential arroyo toad breeding pools.
There were no significant differences between pools that were occupied versus those that were not occupied by arroyo toads (Mann-Whitney U = 3541.5, p= 0.379). Box plots show median and interquartile ranges.

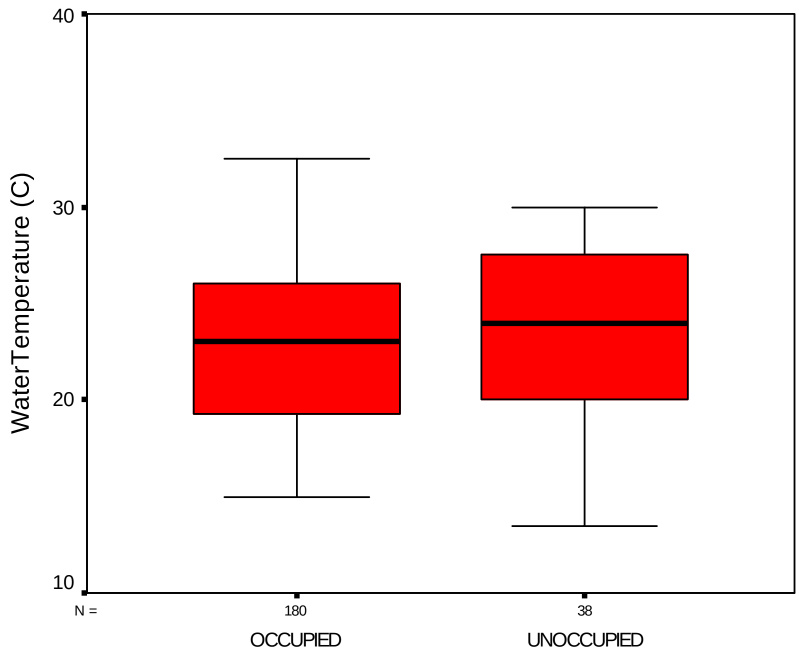


Figure 45. Water temperatures of potential arroyo toad breeding pools.
There were no significant differences between pools that were occupied versus those that were not occupied by arroyo toads (Mann-Whitney U = 3389, p= 0.728). Box plots show median and interquartile ranges.

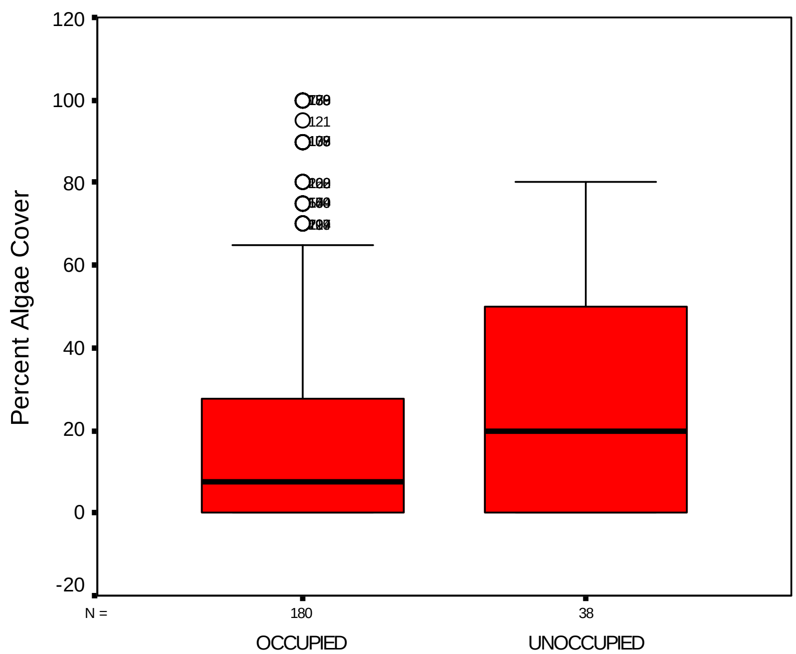


Figure 46. Percent algae covering potential arroyo toad breeding pools.
There were no significant differences between pools that were occupied versus those that were not occupied by arroyo toads (Mann-Whitney U = 3541.5, p= 0.379). Box plots show median and interquartile ranges.

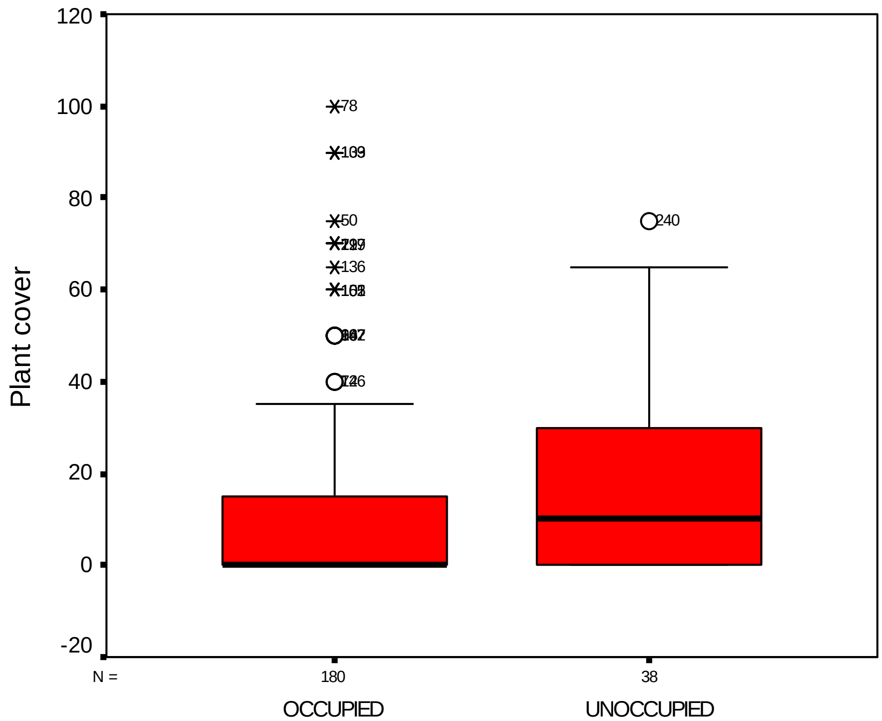


Figure 47. Percent plant cover shading potential arroyo toad breeding pools. There was a significant difference between pools that were occupied versus those that were not occupied by arroyo toads (Mann-Whitney U = 3700, p= 0.027). Box plots show median and interquartile ranges.

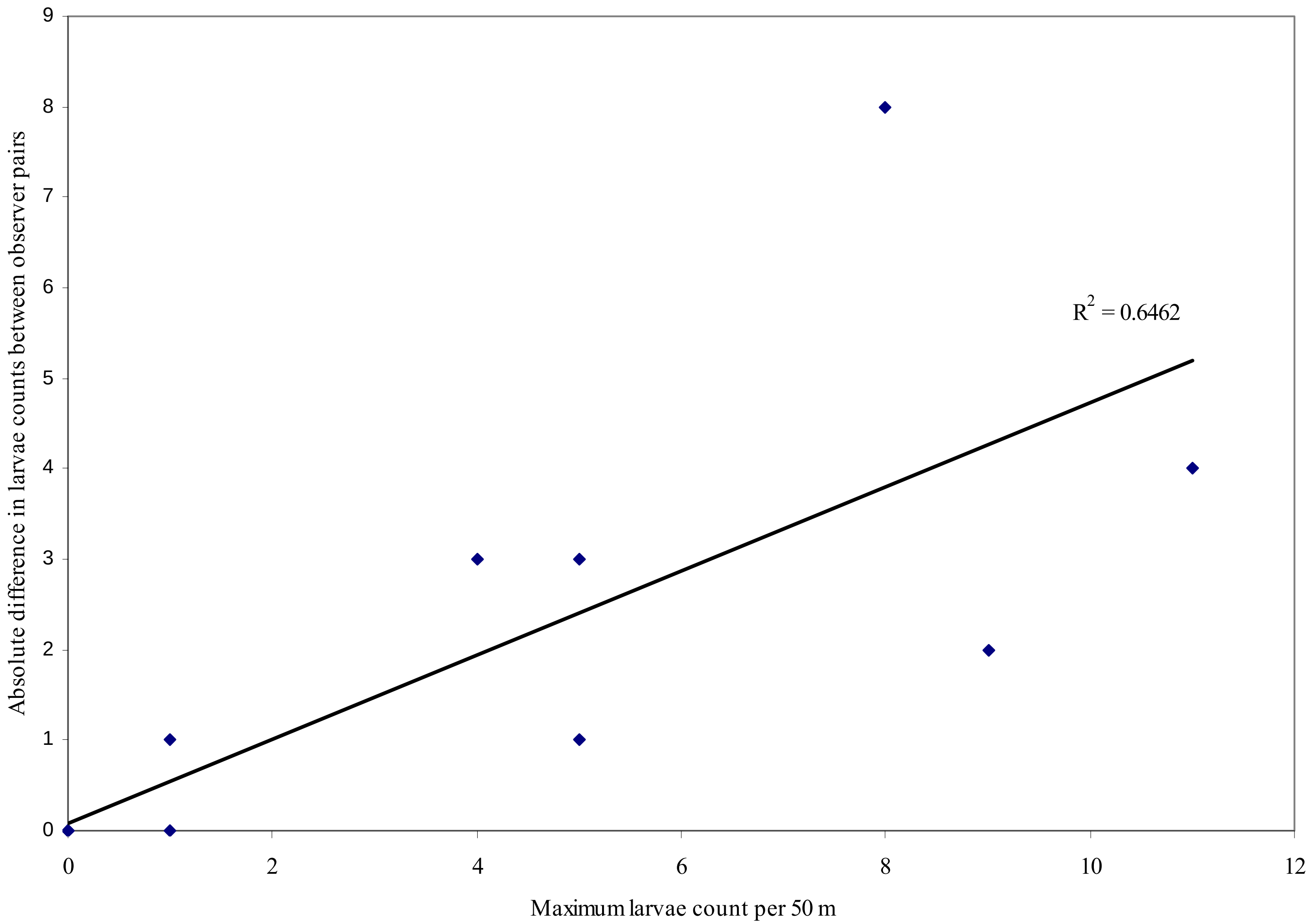


Figure 48. Data from observer variability surveys showing difference in larval counts between observers increases with count size.

APPENDIX 1

GPS COORDINATES AND SURVEY SCHEDULE OF SURVEY BLOCKS AND SITES

		START[1]		END[1]			
BLOCK[2]	SITE	lat[3]	long[4]	lat[3]	long[4]	Drainage	Sampling year
1	A	33.23771	-117.39482	33.23768	-117.39211	Santa Margarita	Year 2 (2004)
1	B	33.23768	-117.39211	33.23743	-117.38944	Santa Margarita	Perm[5] (all years)
1	C	33.23743	-117.38944	33.23719	-117.38674	Santa Margarita	Year 5 (2007)
1	D	33.23719	-117.38674	33.23867	-117.38513	Santa Margarita	Year 4 (2006)
1	E	33.23867	-117.38513	33.24037	-117.38365	Santa Margarita	Year 3 (2005)
1	F	33.24037	-117.38365	33.24221	-117.3826	Santa Margarita	Year 1 (2003)
2	A	33.24221	-117.3826	33.24421	-117.38156	Santa Margarita	Year 1 (2003)
2	B	33.24421	-117.38156	33.2463	-117.38089	Santa Margarita	Year 5 (2007)
2	C	33.2463	-117.38089	33.24843	-117.38023	Santa Margarita	Perm (all years)
2	D	33.24843	-117.38023	33.25024	-117.37874	Santa Margarita	Year 3 (2005)
2	E	33.25024	-117.37874	33.25192	-117.37743	Santa Margarita	Year 4 (2006)
2	F	33.25192	-117.37743	33.25375	-117.37656	Santa Margarita	Year 2 (2004)
3	A	33.25375	-117.37656	33.2555	-117.37534	Santa Margarita	Year 2 (2004)
3	B	33.2555	-117.37534	33.25777	-117.37534	Santa Margarita	Year 1 (2003)
3	C	33.25777	-117.37534	33.26002	-117.37622	Santa Margarita	Perm (all years)
3	D	33.26002	-117.37622	33.26209	-117.37531	Santa Margarita	Year 5 (2007)
3	E	33.26209	-117.37531	33.26414	-117.37589	Santa Margarita	Year 3 (2005)
3	F	33.26414	-117.37589	33.26614	-117.37693	Santa Margarita	Year 4 (2006)
4	A	33.26614	-117.37693	33.2683	-117.37744	Santa Margarita	Year 4 (2006)
4	B	33.2683	-117.37744	33.27054	-117.3776	Santa Margarita	Year 3 (2005)
4	C	33.27054	-117.3776	33.27259	-117.37781	Santa Margarita	Year 2 (2004)
4	D	33.27259	-117.37781	33.27482	-117.3775	Santa Margarita	Year 1 (2003)
4	E	33.27482	-117.3775	33.27704	-117.37723	Santa Margarita	Year 5 (2007)
4	F	33.27704	-117.37723	33.27874	-117.37547	Santa Margarita	Perm (all years)
5	A	33.27874	-117.37547	33.28049	-117.37624	Santa Margarita	Year 5 (2007)
5	B	33.28049	-117.37624	33.28269	-117.37645	Santa Margarita	Year 2 (2004)
5	C	33.28269	-117.37645	33.28495	-117.37642	Santa Margarita	Year 1 (2003)
5	D	33.28495	-117.37642	33.28674	-117.37513	Santa Margarita	Year 3 (2005)
5	E	33.28674	-117.37513	33.28861	-117.37393	Santa Margarita	Perm (all years)
5	F	33.28861	-117.37393	33.29053	-117.3727	Santa Margarita	Year 4 (2006)
6	A	33.29053	-117.3727	33.29256	-117.37182	Santa Margarita	Year 4 (2006)
6	B	33.29256	-117.37182	33.29447	-117.37055	Santa Margarita	Year 5 (2007)
6	C	33.29447	-117.37055	33.29643	-117.36944	Santa Margarita	Year 3 (2005)
6	D	33.29643	-117.36944	33.29782	-117.36747	Santa Margarita	Year 2 (2004)
6	E	33.29782	-117.36747	33.29975	-117.36616	Santa Margarita	Perm (all years)
6	F	33.29975	-117.36616	33.30133	-117.36408	Santa Margarita	Year 1 (2003)
7	A	33.30133	-117.36408	33.30238	-117.36172	Santa Margarita	Perm (all years)
7	B	33.30238	-117.36172	33.30371	-117.35957	Santa Margarita	Year 3 (2005)
7	C	33.30371	-117.35957	33.305	-117.35738	Santa Margarita	Year 4 (2006)
7	D	33.305	-117.35738	33.30647	-117.35528	Santa Margarita	Year 1 (2003)
7	E	33.30647	-117.35528	33.30792	-117.3533	Santa Margarita	Year 5 (2007)
7	F	33.30792	-117.3533	33.30923	-117.35134	Santa Margarita	Year 2 (2004)
8	A	33.30923	-117.35134	33.30984	-117.34898	Santa Margarita	Year 5 (2007)
8	B	33.30984	-117.34898	33.31084	-117.34658	Santa Margarita	Year 3 (2005)
8	C	33.31084	-117.34658	33.3115	-117.34402	Santa Margarita	Year 4 (2006)
8	D	33.3115	-117.34402	33.31221	-117.34152	Santa Margarita	Year 1 (2003)
8	E	33.31221	-117.34152	33.31392	-117.33984	Santa Margarita	Year 2 (2004)
8	F	33.31392	-117.33984	33.31609	-117.33922	Santa Margarita	Perm (all years)

9	A	33.31609	-117.33922	33.31806	-117.33788	Santa Margarita	Year 2 (2004)
9	B	33.31806	-117.33788	33.32032	-117.33758	Santa Margarita	Year 1 (2003)
9	C	33.32032	-117.33758	33.32259	-117.3372	Santa Margarita	Year 3 (2005)
9	D	33.32259	-117.3372	33.32478	-117.33656	Santa Margarita	Year 4 (2006)
9	E	33.32478	-117.33656	33.32681	-117.33565	Santa Margarita	Perm (all years)
9	F	33.32681	-117.33565	33.32871	-117.33424	Santa Margarita	Year 5 (2007)
10	A	33.32871	-117.33424	33.33067	-117.3333	Santa Margarita	Year 1 (2003)
10	B	33.33067	-117.3333	33.33284	-117.33255	Santa Margarita	Perm (all years)
10	C	33.33284	-117.33255	33.33494	-117.33205	Santa Margarita	Year 3 (2005)
10	D	33.33494	-117.33205	33.33689	-117.33278	Santa Margarita	Year 2 (2004)
10	E	33.33689	-117.33278	33.33874	-117.33171	Santa Margarita	Year 5 (2007)
10	F	33.33874	-117.33171	33.34098	-117.3317	Santa Margarita	Year 4 (2006)
11	A	33.34098	-117.3317	33.3432	-117.33178	Santa Margarita	Year 1 (2003)
11	B	33.3432	-117.33178	33.34524	-117.33105	Santa Margarita	Year 5 (2007)
11	C	33.34524	-117.33105	33.34727	-117.3301	Santa Margarita	Year 3 (2005)
11	D	33.34727	-117.3301	33.34915	-117.32931	Santa Margarita	Year 2 (2004)
11	E	33.34915	-117.32931	33.35105	-117.32823	Santa Margarita	Perm (all years)
11	F	33.35105	-117.32823	33.35279	-117.32665	Santa Margarita	Year 4 (2006)
12[6]	A	33.35279	-117.32665	33.35503	-117.32652	Santa Margarita	Year 4 (2006)
12[6]	B	33.35503	-117.32652	33.35726	-117.32646	Santa Margarita	Year 1 (2003)
12[6]	C	33.35726	-117.32646	33.35906	-117.32551	Santa Margarita	Perm (all years)
12[6]	D	33.35906	-117.32551	33.36075	-117.32389	Santa Margarita	Year 2 (2004)
12[6]	E	33.36075	-117.32389	33.36193	-117.32193	Santa Margarita	Year 3 (2005)
13	A	33.36193	-117.32193	33.36333	-117.32018	Santa Margarita	Year 1 (2003)
13	B	33.36333	-117.32018	33.36495	-117.31852	Santa Margarita	Year 4 (2006)
13	C	33.36495	-117.31852	33.36684	-117.3173	Santa Margarita	Year 2 (2004)
13	D	33.36684	-117.3173	33.36905	-117.3162	Santa Margarita	Perm (all years)
13	E	33.36905	-117.3162	33.3711	-117.31519	Santa Margarita	Year 5 (2007)
13	F	33.3711	-117.31519	33.37243	-117.31313	Santa Margarita	Year 3 (2005)
14	A	33.37243	-117.31313	33.37288	-117.31051	Santa Margarita	Year 4 (2006)
14	B	33.37288	-117.31051	33.37471	-117.30975	Santa Margarita	Year 3 (2005)
14	C	33.37471	-117.30975	33.37695	-117.30959	Santa Margarita	Year 2 (2004)
14	D	33.37695	-117.30959	33.37891	-117.30882	Santa Margarita	Year 5 (2007)
14	E	33.37891	-117.30882	33.37962	-117.30648	Santa Margarita	Year 1 (2003)
14	F	33.37962	-117.30648	33.38084	-117.30472	Santa Margarita	Perm (all years)
15	A	33.38084	-117.30472	33.38228	-117.30306	Santa Margarita	Year 2 (2004)
15	B	33.38228	-117.30306	33.3844	-117.30247	Santa Margarita	Year 5 (2007)
15	C	33.3844	-117.30247	33.38493	-117.29992	Santa Margarita	Perm (all years)
15	D	33.38493	-117.29992	33.38489	-117.29723	Santa Margarita	Year 1 (2003)
15	E	33.38489	-117.29723	33.38545	-117.29515	Santa Margarita	Year 4 (2006)
15	F	33.38545	-117.29515	33.38715	-117.29647	Santa Margarita	Year 3 (2005)
16	A	33.38715	-117.29647	33.38939	-117.29667	Santa Margarita	Year 2 (2004)
16	B	33.38939	-117.29667	33.39048	-117.29485	Santa Margarita	Year 5 (2007)
16	C	33.39048	-117.29485	33.39226	-117.29333	Santa Margarita	Perm (all years)
16	D	33.39226	-117.29333	33.39403	-117.29186	Santa Margarita	Year 4 (2006)
16	E	33.39403	-117.29186	33.39436	-117.28958	Santa Margarita	Year 3 (2005)
16	F	33.39436	-117.28958	33.39479	-117.2868	Santa Margarita	Year 1 (2003)
17	A	33.39479	-117.2868	33.39543	-117.28441	Santa Margarita	Year 5 (2007)
17	B	33.39543	-117.28441	33.39742	-117.28352	Santa Margarita	Year 1 (2003)
17	C	33.39742	-117.28352	33.39877	-117.28185	Santa Margarita	Year 4 (2006)
17	D	33.39877	-117.28185	33.39712	-117.28038	Santa Margarita	Perm (all years)

17	E	33.39712	-117.28038	33.39489	-117.28014	Santa Margarita	Year 3 (2005)
17	F	33.39489	-117.28014	33.39319	-117.27898	Santa Margarita	Year 2 (2004)
18	A	33.39319	-117.27898	33.39131	-117.28014	Santa Margarita	Year 4 (2006)
18	B	33.39131	-117.28014	33.39023	-117.27863	Santa Margarita	Year 2 (2004)
18	C	33.39023	-117.27863	33.39187	-117.27716	Santa Margarita	Perm (all years)
18	D	33.39187	-117.27716	33.3935	-117.27546	Santa Margarita	Year 5 (2007)
18	E	33.3935	-117.27546	33.39455	-117.27345	Santa Margarita	Year 1 (2003)
18	F	33.39455	-117.27345	33.39406	-117.27114	Santa Margarita	Year 3 (2005)
19	A	33.39406	-117.27114	33.39526	-117.26941	Santa Margarita	Year 4 (2006)
19	B	33.39526	-117.26941	33.39729	-117.26886	Santa Margarita	Year 5 (2007)
19	C	33.39729	-117.26886	33.39884	-117.26754	Santa Margarita	Year 2 (2004)
19	D	33.39884	-117.26754	33.39721	-117.26594	Santa Margarita	Perm (all years)
19	E	33.39721	-117.26594	33.39553	-117.26459	Santa Margarita	Year 1 (2003)
19	F	33.39553	-117.26459	33.39595	-117.26231	Santa Margarita	Year 3 (2005)
20[6]	A	33.39595	-117.26231	33.39808	-117.26261	Santa Margarita	Year 3 (2005)
20[6]	B	33.39808	-117.26261	33.40008	-117.26352	Santa Margarita	Perm (all years)
20[6]	C	33.40008	-117.26352	33.40123	-117.26146	Santa Margarita	Year 1 (2003)
20[6]	D	33.40123	-117.26146	33.40174	-117.25889	Santa Margarita	Year 2 (2004)
20[6]	E	33.40174	-117.25889	33.40251	-117.25642	Santa Margarita	Year 5 (2007)
12[6]	F	33.36193	-117.32301	33.36413	-117.32296	Santa Margarita	Year 5 (2007)
21	A	33.36413	-117.32296	33.36622	-117.32354	Santa Margarita	Year 1 (2003)
21	B	33.36622	-117.32354	33.36846	-117.32354	Santa Margarita	Perm (all years)
21	C	33.36846	-117.32354	33.37009	-117.32212	Santa Margarita	Year 4 (2006)
21	D	33.37009	-117.32212	33.37176	-117.32066	Santa Margarita	Year 3 (2005)
21	E	33.37176	-117.32066	33.37378	-117.32137	Santa Margarita	Year 2 (2004)
21	F	33.37378	-117.32137	33.37511	-117.32349	Santa Margarita	Year 5 (2007)
22	A	33.37511	-117.32349	33.37722	-117.32422	Santa Margarita	Year 1 (2003)
22	B	33.37722	-117.32422	33.37909	-117.32313	Santa Margarita	Year 3 (2005)
22	C	33.37909	-117.32313	33.38086	-117.32187	Santa Margarita	Year 5 (2007)
22	D	33.38086	-117.32187	33.38275	-117.32059	Santa Margarita	Year 4 (2006)
22	E	33.38275	-117.32059	33.38487	-117.31981	Santa Margarita	Perm (all years)
22	F	33.38487	-117.31981	33.38683	-117.31883	Santa Margarita	Year 2 (2004)
23	A	33.38683	-117.31883	33.38807	-117.32071	Santa Margarita	Year 5 (2007)
23	B	33.38807	-117.32071	33.38984	-117.32174	Santa Margarita	Year 2 (2004)
23	C	33.38984	-117.32174	33.39191	-117.3208	Santa Margarita	Year 4 (2006)
23	D	33.39191	-117.3208	33.39395	-117.31988	Santa Margarita	Perm (all years)
23	E	33.39395	-117.31988	33.39609	-117.32031	Santa Margarita	Year 1 (2003)
23	F	33.39609	-117.32031	33.39781	-117.322	Santa Margarita	Year 3 (2005)
24	A	33.39781	-117.322	33.39932	-117.32198	Santa Margarita	Year 2 (2004)
24	B	33.39932	-117.32198	33.40112	-117.32093	Santa Margarita	Year 1 (2003)
24	C	33.40112	-117.32093	33.4032	-117.32003	Santa Margarita	Year 4 (2006)
24	D	33.4032	-117.32003	33.405	-117.31873	Santa Margarita	Perm (all years)
24	E	33.405	-117.31873	33.40668	-117.32015	Santa Margarita	Year 3 (2005)
24	F	33.40668	-117.32015	33.40887	-117.32065	Santa Margarita	Year 5 (2007)
25	A	33.40887	-117.32065	33.41091	-117.3215	Santa Margarita	Year 1 (2003)
25	B	33.41091	-117.3215	33.41288	-117.32092	Santa Margarita	Perm (all years)
25	C	33.41288	-117.32092	33.41471	-117.31976	Santa Margarita	Year 3 (2005)
25	D	33.41471	-117.31976	33.4165	-117.32118	Santa Margarita	Year 2 (2004)
26	A	33.38805	-117.32111	33.38717	-117.32336	Santa Margarita	Year 2 (2004)
26	B	33.38717	-117.32336	33.38797	-117.32573	Santa Margarita	Year 5 (2007)
26	C	33.38797	-117.32573	33.38787	-117.32825	Santa Margarita	Year 3 (2005)

26	D	33.38787	-117.32825	33.3874	-117.33041	Santa Margarita	Perm (all years)
26	E	33.3874	-117.33041	33.38787	-117.33289	Santa Margarita	Year 4 (2006)
26	F	33.38787	-117.33289	33.3897	-117.3343	Santa Margarita	Year 1 (2003)
25	E	33.3897	-117.3343	33.3918	-117.33502	Santa Margarita	Year 4 (2006)
25	F	33.3918	-117.33502	33.39394	-117.33566	Santa Margarita	Year 5 (2007)
20[6]	F	33.39394	-117.33566	33.39598	-117.33526	Santa Margarita	Year 4 (2006)
27	A	33.38398	-117.57443	33.38315	-117.57207	San Onofre	Year 3 (2005)
27	B	33.38315	-117.57207	33.38292	-117.5696	San Onofre	Perm (all years)
27	C	33.38292	-117.5696	33.38338	-117.56703	San Onofre	Year 2 (2004)
27	D	33.38338	-117.56703	33.38339	-117.56432	San Onofre	Year 5 (2007)
27	E	33.38339	-117.56432	33.38432	-117.56222	San Onofre	Year 4 (2006)
27	F	33.38432	-117.56222	33.38456	-117.55955	San Onofre	Year 1 (2003)
28	A	33.38456	-117.55955	33.38486	-117.55688	San Onofre	Perm (all years)
28	B	33.38486	-117.55688	33.38588	-117.55472	San Onofre	Year 2 (2004)
28	C	33.38588	-117.55472	33.3878	-117.55391	San Onofre	Year 5 (2007)
29	A	33.3878	-117.55391	33.38788	-117.55152	San Onofre	Year 4 (2006)
29	B	33.38788	-117.55152	33.38701	-117.54903	San Onofre	Year 1 (2003)
29	C	33.38701	-117.54903	33.3876	-117.54652	San Onofre	Year 2 (2004)
29	D	33.3876	-117.54652	33.38813	-117.54409	San Onofre	Perm (all years)
29	E	33.38813	-117.54409	33.3892	-117.54207	San Onofre	Year 5 (2007)
29	F	33.3892	-117.54207	33.39066	-117.54073	San Onofre	Year 3 (2005)
28	E	33.39066	-117.54073	33.39078	-117.53825	San Onofre	Year 1 (2003)
28	F	33.39078	-117.53825	33.39209	-117.53646	San Onofre	Year 3 (2005)
28	G	33.39209	-117.53646	33.39312	-117.53441	San Onofre	Year 4 (2006)
30	A	33.39312	-117.53441	33.39406	-117.5324	San Onofre	Year 3 (2005)
30	B	33.39406	-117.5324	33.39412	-117.52973	San Onofre	Perm (all years)
30	C	33.39412	-117.52973	33.39406	-117.52705	San Onofre	Year 5 (2007)
30	D	33.39406	-117.52705	33.39462	-117.52459	San Onofre	Year 4 (2006)
30	E	33.39462	-117.52459	33.39493	-117.52171	San Onofre	Year 2 (2004)
30	F	33.39493	-117.52171	33.39415	-117.51931	San Onofre	Year 1 (2003)
31	A	33.39415	-117.51931	33.39341	-117.51685	San Onofre	Year 4 (2006)
31	B	33.39341	-117.51685	33.39137	-117.51599	San Onofre	Year 2 (2004)
31	C	33.39137	-117.51599	33.39008	-117.514	San Onofre	Year 3 (2005)
31	D	33.39008	-117.514	33.38919	-117.51165	San Onofre	Year 5 (2007)
31	E	33.38919	-117.51165	33.39005	-117.50945	San Onofre	Year 1 (2003)
31	F	33.39005	-117.50945	33.39139	-117.50766	San Onofre	Perm (all years)
32	A	33.39139	-117.50766	33.39293	-117.50593	San Onofre	Perm (all years)
32	B	33.39293	-117.50593	33.39496	-117.50475	San Onofre	Year 3 (2005)
32	C	33.39496	-117.50475	33.39677	-117.50346	San Onofre	Year 2 (2004)
32	D	33.39677	-117.50346	33.39786	-117.50127	San Onofre	Year 5 (2007)
32	E	33.39786	-117.50127	33.39945	-117.49973	San Onofre	Year 4 (2006)
32	F	33.39945	-117.49973	33.39983	-117.49711	San Onofre	Year 1 (2003)
33	A	33.39983	-117.49711	33.39939	-117.49461	San Onofre	Year 3 (2005)
33	B	33.39939	-117.49461	33.39932	-117.49191	San Onofre	Year 4 (2006)
33	C	33.39932	-117.49191	33.39781	-117.49023	San Onofre	Perm (all years)
33	D	33.39781	-117.49023	33.39677	-117.48799	San Onofre	Year 5 (2007)
33	E	33.39677	-117.48799	33.3966	-117.48529	San Onofre	Year 1 (2003)
33	F	33.3966	-117.48529	33.39573	-117.48306	San Onofre	Year 2 (2004)
34	A	33.39573	-117.48306	33.39602	-117.48042	San Onofre	Year 3 (2005)
34	B	33.39602	-117.48042	33.39583	-117.47778	San Onofre	Year 2 (2004)
34	C	33.39583	-117.47778	33.39637	-117.47519	San Onofre	Perm (all years)

34	D	33.39637	-117.47519	33.39662	-117.47255	San Onofre	Year 5 (2007)
34	E	33.39662	-117.47255	33.39763	-117.47039	San Onofre	Year 4 (2006)
34	F	33.39763	-117.47039	33.39855	-117.4679	San Onofre	Year 1 (2003)
35	A	33.39855	-117.4679	33.40009	-117.4663	San Onofre	Year 1 (2003)
35	B	33.40009	-117.4663	33.40032	-117.46372	San Onofre	Year 5 (2007)
35	C	33.40032	-117.46372	33.40157	-117.46169	San Onofre	Year 3 (2005)
35	D	33.40157	-117.46169	33.40296	-117.45994	San Onofre	Perm (all years)
35	E	33.40296	-117.45994	33.4044	-117.45801	San Onofre	Year 4 (2006)
35	F	33.4044	-117.45801	33.40613	-117.45665	San Onofre	Year 2 (2004)
36[6]	A	33.39013	-117.5085	33.38964	-117.50624	San Onofre	Year 1 (2003)
36[6]	B	33.38964	-117.50624	33.38884	-117.50387	San Onofre	Perm (all years)
36[6]	C	33.38884	-117.50387	33.38752	-117.50332	San Onofre	Year 3 (2005)
36[6]	D	33.38752	-117.50332	33.38557	-117.50418	San Onofre	Year 4 (2006)
36[6]	E	33.38557	-117.50418	33.38524	-117.50188	San Onofre	Year 5 (2007)
37	A	33.39994	-117.49821	33.40109	-117.49628	San Onofre	Year 5 (2007)
37	B	33.40109	-117.49628	33.40241	-117.49424	San Onofre	Year 4 (2006)
37	C	33.40241	-117.49424	33.40406	-117.49254	San Onofre	Perm (all years)
37	D	33.40406	-117.49254	33.40518	-117.49017	San Onofre	Year 1 (2003)
37	E	33.40518	-117.49017	33.40648	-117.48805	San Onofre	Year 2 (2004)
37	F	33.40648	-117.48805	33.40844	-117.48682	San Onofre	Year 3 (2005)
38	A	33.40844	-117.48682	33.40991	-117.48503	San Onofre	Perm (all years)
38	B	33.40991	-117.48503	33.41203	-117.48418	San Onofre	Year 5 (2007)
38	C	33.41203	-117.48418	33.41434	-117.48396	San Onofre	Year 1 (2003)
38	D	33.41434	-117.48396	33.41656	-117.48443	San Onofre	Year 2 (2004)
38	E	33.41656	-117.48443	33.4188	-117.48408	San Onofre	Year 3 (2005)
38	F	33.4188	-117.48408	33.42109	-117.48433	San Onofre	Year 4 (2006)
36[6]	F	33.42109	-117.48433	33.42333	-117.48402	San Onofre	Year 2 (2004)
39	A	33.38998	-117.59134	33.39175	-117.59012	San Mateo	Year 4 (2006)
39	B	33.39175	-117.59012	33.39395	-117.59023	San Mateo	Year 5 (2007)
39	C	33.39395	-117.59023	33.39608	-117.58989	San Mateo	Year 2 (2004)
39	D	33.39608	-117.58989	33.39733	-117.58803	San Mateo	Year 3 (2005)
39	E	33.39733	-117.58803	33.39917	-117.5868	San Mateo	Year 1 (2003)
39	F	33.39917	-117.5868	33.40081	-117.58544	San Mateo	Perm (all years)
40	A	33.40081	-117.58544	33.40249	-117.58403	San Mateo	Year 5 (2007)
40	B	33.40249	-117.58403	33.40417	-117.58255	San Mateo	Year 1 (2003)
40	C	33.40417	-117.58255	33.40602	-117.58133	San Mateo	Year 4 (2006)
40	D	33.40602	-117.58133	33.40797	-117.58022	San Mateo	Year 2 (2004)
40	E	33.40797	-117.58022	33.40965	-117.5789	San Mateo	Perm (all years)
40	F	33.40965	-117.5789	33.41187	-117.57895	San Mateo	Year 3 (2005)
41	A	33.41187	-117.57895	33.41406	-117.57919	San Mateo	Year 5 (2007)
41	B	33.41406	-117.57919	33.41619	-117.5786	San Mateo	Year 1 (2003)
41	C	33.41619	-117.5786	33.41815	-117.57755	San Mateo	Year 3 (2005)
41	D	33.41815	-117.57755	33.41956	-117.57589	San Mateo	Year 2 (2004)
41	E	33.41956	-117.57589	33.41992	-117.57329	San Mateo	Perm (all years)
41	F	33.41992	-117.57329	33.42005	-117.57071	San Mateo	Year 4 (2006)
42	A	33.42005	-117.57071	33.41957	-117.56816	San Mateo	Perm (all years)
42	B	33.41957	-117.56816	33.41865	-117.56605	San Mateo	Year 5 (2007)
42	C	33.41865	-117.56605	33.41824	-117.56345	San Mateo	Year 2 (2004)
42	D	33.41824	-117.56345	33.41752	-117.56096	San Mateo	Year 3 (2005)
42	E	33.41752	-117.56096	33.41747	-117.5583	San Mateo	Year 1 (2003)
42	F	33.41747	-117.5583	33.41751	-117.5557	San Mateo	Year 4 (2006)

43	A	33.41751	-117.5557	33.41757	-117.55305	San Mateo	Year 2 (2004)
43	B	33.41757	-117.55305	33.4185	-117.55088	San Mateo	Year 4 (2006)
43	C	33.4185	-117.55088	33.41913	-117.54844	San Mateo	Year 3 (2005)
43	D	33.41913	-117.54844	33.41947	-117.54585	San Mateo	Perm (all years)
43	E	33.41947	-117.54585	33.41955	-117.54315	San Mateo	Year 5 (2007)
43	F	33.41955	-117.54315	33.41948	-117.54049	San Mateo	Year 1 (2003)
44	A	33.41948	-117.54049	33.41952	-117.53781	San Mateo	Perm (all years)
44	B	33.41952	-117.53781	33.41972	-117.53512	San Mateo	Year 4 (2006)
44	C	33.41972	-117.53512	33.41999	-117.53244	San Mateo	Year 3 (2005)
44	D	33.41999	-117.53244	33.42165	-117.53101	San Mateo	Year 5 (2007)
44	E	33.42165	-117.53101	33.42327	-117.5292	San Mateo	Year 2 (2004)
44	F	33.42327	-117.5292	33.42488	-117.52748	San Mateo	Year 1 (2003)
45	A	33.42488	-117.52748	33.42668	-117.52632	San Mateo	Perm (all years)
45	B	33.42668	-117.52632	33.42864	-117.52522	San Mateo	Year 3 (2005)
45	C	33.42864	-117.52522	33.43031	-117.52385	San Mateo	Year 5 (2007)
45	D	33.43031	-117.52385	33.43187	-117.52246	San Mateo	Year 4 (2006)
45	E	33.43187	-117.52246	33.43326	-117.5208	San Mateo	Year 2 (2004)
45	F	33.43326	-117.5208	33.4348	-117.51883	San Mateo	Year 1 (2003)
46	A	33.4348	-117.51883	33.43645	-117.51742	San Mateo	Year 4 (2006)
46	B	33.43645	-117.51742	33.43775	-117.51538	San Mateo	Year 1 (2003)
46	C	33.43775	-117.51538	33.43915	-117.51398	San Mateo	Year 2 (2004)
46	D	33.43915	-117.51398	33.44131	-117.51362	San Mateo	Year 3 (2005)
46	E	33.44131	-117.51362	33.44312	-117.51217	San Mateo	Year 5 (2007)
46	F	33.44312	-117.51217	33.44464	-117.5099	San Mateo	Perm (all years)
47	A	33.44464	-117.5099	33.44575	-117.50768	San Mateo	Year 5 (2007)
47	B	33.44575	-117.50768	33.44654	-117.5053	San Mateo	Year 1 (2003)
47	C	33.44654	-117.5053	33.44869	-117.50459	San Mateo	Year 2 (2004)
47	D	33.44869	-117.50459	33.45053	-117.50363	San Mateo	Perm (all years)
47	E	33.45053	-117.50363	33.45233	-117.50237	San Mateo	Year 4 (2006)
47	F	33.45233	-117.50237	33.45395	-117.50065	San Mateo	Year 3 (2005)
48	A	33.45395	-117.50065	33.45582	-117.49918	San Mateo	Year 1 (2003)
48	B	33.45582	-117.49918	33.45765	-117.49781	San Mateo	Year 5 (2007)
48	C	33.45765	-117.49781	33.45877	-117.49586	San Mateo	Perm (all years)
48	D	33.45877	-117.49586	33.46025	-117.49409	San Mateo	Year 4 (2006)
48	E	33.46025	-117.49409	33.46079	-117.49158	San Mateo	Year 3 (2005)
48	F	33.46079	-117.49158	33.46168	-117.48912	San Mateo	Year 2 (2004)
49	A	33.46168	-117.48912	33.46304	-117.48735	San Mateo	Year 4 (2006)
49	B	33.46304	-117.48735	33.46457	-117.48549	San Mateo	Year 5 (2007)
49	C	33.46457	-117.48549	33.46554	-117.48313	San Mateo	Year 3 (2005)
49	D	33.46554	-117.48313	33.46725	-117.48155	San Mateo	Year 2 (2004)
49	E	33.46725	-117.48155	33.46846	-117.47964	San Mateo	Year 1 (2003)
49	F	33.46846	-117.47964	33.46936	-117.47755	San Mateo	Perm (all years)
50[6]	A	33.46936	-117.47755	33.47024	-117.47506	San Mateo	Perm (all years)
50[6]	B	33.47024	-117.47506	33.47031	-117.47243	San Mateo	Year 3 (2005)
50[6]	C	33.47031	-117.47243	33.4708	-117.46983	San Mateo	Year 2 (2004)
51	A	33.42019	-117.5703	33.422	-117.56919	San Mateo	Perm (all years)
51	B	33.422	-117.56919	33.42425	-117.56931	San Mateo	Year 3 (2005)
51	C	33.42425	-117.56931	33.4263	-117.56989	San Mateo	Year 4 (2006)
51	D	33.4263	-117.56989	33.42822	-117.56919	San Mateo	Year 2 (2004)
51	E	33.42822	-117.56919	33.43021	-117.5682	San Mateo	Year 1 (2003)
51	F	33.43021	-117.5682	33.43226	-117.56896	San Mateo	Year 5 (2007)

52	A	33.43226	-117.56896	33.43408	-117.57034	San Mateo	Year 2 (2004)
52	B	33.43408	-117.57034	33.4362	-117.56985	San Mateo	Year 1 (2003)
52	C	33.4362	-117.56985	33.4379	-117.57022	San Mateo	Year 4 (2006)
52	D	33.4379	-117.57022	33.43988	-117.57118	San Mateo	Year 5 (2007)
52	E	33.43988	-117.57118	33.44156	-117.56958	San Mateo	Perm (all years)
52	F	33.44156	-117.56958	33.44342	-117.57053	San Mateo	Year 3 (2005)
53	A	33.44342	-117.57053	33.44558	-117.57011	San Mateo	Year 5 (2007)
53	B	33.44558	-117.57011	33.44752	-117.56965	San Mateo	Perm (all years)
53	C	33.44752	-117.56965	33.44952	-117.57059	San Mateo	Year 1 (2003)
53	D	33.44952	-117.57059	33.45135	-117.56938	San Mateo	Year 3 (2005)
53	E	33.45228	-117.56931	33.45134	-117.5673	San Mateo	Year 4 (2006)
53	F	33.45134	-117.5673	33.4514	-117.56455	San Mateo	Year 2 (2004)
54	A	33.4514	-117.56455	33.45164	-117.56185	San Mateo	Year 1 (2003)
54	B	33.45164	-117.56185	33.45163	-117.55909	San Mateo	Year 2 (2004)
54	C	33.45163	-117.55909	33.45189	-117.55638	San Mateo	Perm (all years)
54	D	33.45189	-117.55638	33.45225	-117.55377	San Mateo	Year 5 (2007)
54	E	33.45225	-117.55377	33.45239	-117.55108	San Mateo	Year 4 (2006)
54	F	33.45239	-117.55108	33.45244	-117.54856	San Mateo	Year 3 (2005)
55	A	33.45244	-117.54856	33.45254	-117.54607	San Mateo	Year 4 (2006)
55	B	33.45254	-117.54607	33.45346	-117.54366	San Mateo	Perm (all years)
55	C	33.45346	-117.54366	33.45438	-117.54122	San Mateo	Year 2 (2004)
55	D	33.45438	-117.54122	33.45524	-117.53877	San Mateo	Year 3 (2005)
55	E	33.45524	-117.53877	33.45659	-117.53684	San Mateo	Year 1 (2003)
55	F	33.45659	-117.53684	33.45794	-117.53495	San Mateo	Year 5 (2007)
56	A	33.45794	-117.53495	33.45929	-117.53283	San Mateo	Perm (all years)
56	B	33.45929	-117.53283	33.46013	-117.53034	San Mateo	Year 3 (2005)
56	C	33.46013	-117.53034	33.46126	-117.5281	San Mateo	Year 1 (2003)
56	D	33.46126	-117.5281	33.46156	-117.52549	San Mateo	Year 5 (2007)
56	E	33.46156	-117.52549	33.46193	-117.52294	San Mateo	Year 4 (2006)
56	F	33.46193	-117.52294	33.463	-117.52078	San Mateo	Year 2 (2004)
57	A	33.463	-117.52078	33.46389	-117.5184	San Mateo	Year 4 (2006)
57	B	33.46389	-117.5184	33.46557	-117.51696	San Mateo	Year 2 (2004)
57	C	33.46557	-117.51696	33.46692	-117.51512	San Mateo	Year 5 (2007)
57	D	33.46692	-117.51512	33.46798	-117.51336	San Mateo	Year 1 (2003)
57	E	33.46798	-117.51336	33.46979	-117.51195	San Mateo	Year 3 (2005)
57	F	33.46979	-117.51195	33.47085	-117.50971	San Mateo	Perm (all years)
58	A	33.47085	-117.50971	33.4721	-117.50762	San Mateo	Year 1 (2003)
58	B	33.4721	-117.50762	33.47349	-117.50593	San Mateo	Year 2 (2004)
58	C	33.47349	-117.50593	33.47436	-117.50357	San Mateo	Year 3 (2005)
58	D	33.47436	-117.50357	33.47493	-117.50098	San Mateo	Year 5 (2007)
58	E	33.47493	-117.50098	33.47592	-117.49866	San Mateo	Year 4 (2006)
58	F	33.47592	-117.49866	33.47695	-117.49665	San Mateo	Perm (all years)
59	A	33.47695	-117.49665	33.47824	-117.49487	San Mateo	Year 3 (2005)
59	B	33.47824	-117.49487	33.4795	-117.4927	San Mateo	Year 5 (2007)
59	C	33.4795	-117.4927	33.48123	-117.491	San Mateo	Year 4 (2006)
59	D	33.48123	-117.491	33.4826	-117.48902	San Mateo	Year 2 (2004)
59	E	33.4826	-117.48902	33.48478	-117.4887	San Mateo	Year 1 (2003)
59	F	33.48478	-117.4887	33.48621	-117.4868	San Mateo	Perm (all years)
60	A	33.48621	-117.4868	33.48818	-117.48572	San Mateo	Year 4 (2006)
60	B	33.48818	-117.48572	33.49001	-117.48428	San Mateo	Perm (all years)
60	C	33.49001	-117.48428	33.49206	-117.48316	San Mateo	Year 2 (2004)

60	D	33.49206	-117.48316	33.49427	-117.48281	San Mateo	Year 1 (2003)
60	E	33.49427	-117.48281	33.49648	-117.4829	San Mateo	Year 3 (2005)
60	F	33.49648	-117.4829	33.49841	-117.4826	San Mateo	Year 5 (2007)
50[6]	D	33.49841	-117.4826	33.38398	-117.57443	San Mateo	Year 1 (2003)

[1] Datum NAD83
[2] Yellow shaded areas represent intensive blocks
[3] Latitude
[4] Longitude
[5] Permanent
[6] Some Blocks/Sites appear to be out of order. Since not all waterways of the defined potential breeding habitat were perfectly divisible into a whole number of 1.5 km blocks, some blocks were broken up. These blocks may have one or more sites that are located at the upper end of creeks within the same watershed.

APPENDIX 2

PRESENCE SURVEY FIELD PROTOCOL

MCBCP ARROYO TOAD PRESENCE SURVEY FIELD PROTOCOL

INTRO/SUMMARY

- Two field biologists will conduct all surveys. One person will record all information in his/her palm pilot (containing digital data forms).
- (For recorder) At start of surveys, record additional observer, beginning site and weather information in the Control form 2.0.
- Conduct surveys for individual 250m site lengths of watersheds. Enter the block# (1-55) into the Site form of the palm pilot. Enter the site# (A-F) into the subsite form. Each site will have a latitude/longitude that will automatically come up in the palm pilot. You can either manually input or download the GPS coordinates for each reach into your GPS unit.
- After entering the coordinates into your GPS unit, hit the "GO TO" button for the beginning lat/long for the reach. Since the coordinates were figured using a topographical mapping program (TOPO), you may need to adjust your position slightly so that you are in the middle of the main channel.
- Hit the "GO TO" button on your GPS unit for the end coordinate of the reach. Walk slowly upstream (either in the middle of the stream or on the side depending upon ease of movement. If walking in the stream, be very careful not to create waves or riffles that could affect still pools). You will search for arroyo toad egg strings and tadpoles. Upon observing an egg string or tadpole, you will record presence and enter specific data on the animals and in an animal sub-form. You will also collect data for the pool that the eggs/tadpoles are located. After walking the entire site (reaching the end point), you will record characteristics for the entire 250m reach such as average width, % with water, and invasive plants and animals. If there are no eggs/tadpoles observed after walking the entire 250m, you will return to the best looking pool, search for arroyo toad eggs/tadpoles for another 15 minutes(unless there is no water in the reach). If none are found, record physical information on the best looking pool
- For each new 250m reach (block/site), enter the data into separate site and subsite forms.
- At end of survey, record END time and weather information.

----

1) Information to record at the start of the survey…

CONTROL FORM 3.0

Date: Automatic

Survey Type: Stream Survey
Project: AMP-AT Sampling CPEND (P-098)

Weather:

Weather Condition: Enter weather condition
Start air temperature: Record temperature in shade
Start Wind: Beauford scale
% Cloud Cover: *estimate*
Moon Phase: *Leave blank- will be entered from moon chart*

Notes: *enter other observer's initials here*

2) Information to record at start of each 250m site (reach)

SITE 3.0

Predefined Site: Enter block # *(CPEND1-55)*

SUBSITE 3.0

Predefined SubSite: Enter site # (A-F)
Subsite Start time: *Enter start time*
Start lat/long/elev: Automatic
End lat/long/elev: Automatic
Drainage: Automatic
Moon_Visible: Y/N
Slope: Leave blank

WATER QUALITY SUBFORM*:*

Star Water Temp: *Enter temp. (if water present at beginning of reach)*

3) Information to record within the reach upon encountering BUCA egg strings or tadpoles…

SUBFORMS (WITHIN SUBSITE)

SPECIES/ ANIMAL 3.0: At the first sighting ONLY of arroyo toad tadpoles and egg strings:

TYPE: FROG
SPECIES: BUCA

Age category:
- egg mass
- first year larvae: for tadpoles
- Second year larvae: for tadpoles with visible hind legs

Notes: For tadpoles: please enter estimated length here in cm
Recap/Toe-clip/ pit-tag number: Leave blank
Air temp: Enter temp.
Water temp: Enter temp. of pool containing tadpoles/eggs

SPECIES SPECIFIC/ ATSSF FORM
Substrate: (Of pool) pick one (sandy bottom, silt, cobble, detritus, algal mass)
Excessive sand or silt covering egg mass? Check box if YES
% Cover: Over pool (any vegetation) estimate %
Water depth (cm): Measure
Water clear? Check box if YES (Set penny in bottom of pool)
- Y= can see penny clearly in bottom of pool
- N= cannot see penny or outline not clear)

Water velocity (m/s): TBD (Still to be determined)
Total Count: Intensive surveys only: estimate # of individuals of each age category in reach
Deformities: Metamorph surveys only: estimate # of individuals in reach.
AT Notes: Optional (For egg strings, may want to note whether they are out in open or wrapped around vegetation, etc.

4) Information to record within the reach upon encountering other aquatic species (especially non-native) and non-native plants.

SUBFORMS (WITHIN SUBSITE)

a) SPECIES/ ANIMAL 3.0: Enter any Invasive and/or native vertebrates observed: (invasive fish, RACA, XELE, beavers...). Take vouchers or photographs for unknowns.

b) SPECIES/ PLANT 1.0: *Enter in any non-native plants observed (ex. tamarix, arundo, fennel, watercress, non-native grass, other) with a size class for each species (a few plants, scattered small patches, large contiguous stands)*

5) Information to record at end of 250m reach

SUBSITE 3.0

Water: Check box if YES (Anywhere within the 250m reach)
Wet length of survey site: Pull down menu *(0%, 1-30%, 31-60%, 61-99%, 100%?)*
Average width (m): Estimated width of watershed:
If clear- bank to bank
If not clear- width of riparian habitat defined by willows and/or mulefat
Total No. of AT breeding pools > 2ft: # (pools defined as areas of *still water)*
Plant Community(in watershed/not upland): Enter top 2 to 3 dominant plant types (greater than 25% total plant cover) and then description of vegetation

forest: closed trees
woodland: open trees
savanna: sparse trees with intervening grassland
chaparral: closed evergreen shrubs
scrub: open to sparse shrubs
grassland: grass/herbs
Examples (Mulefat, willow savanna- open mulefat and willow with grassland below/ Arundo forest-closed arundo/ Mulefat scrub- open mulefat)

Slope/Stream Slope/Moon Visible: Leave blank
 # pools >2ft: Pools- areas of still water within or outside main stream flow-only obvious ones
 # pools <2ft: same as above
> 10m of sandy substrate present? Check box if YES
> 10m of adjacent sandy terraces? Check box if YES
> 10m of channel braiding? Check box if YES
Overall Site Quality: (Poor, marginal, good, high)
Look at 3 characteristics above:

0/3-poor
1/3-marginal
2/3-good
3/3- excellent

Presence of AT egg masses? Y/N (For first observation only- fill in animal subform *below)*
Presence of AT tadpoles? Y/N (For first observation only- fill in animal subform *below)*
Disturbance and threats: *Enter notes of obvious recent disturbance such as any recent vehicle disturbance, excessive turbidity, trash, etc. (don't worry about threats*)

WATER QUALITY SUBFORM***:***

End Water Temp: *Enter temp. (if water present at end of reach)*

6) If no tadpoles or eggs seen after end of reach, return to best looking pool and search for 15 more minutes. If no arroyo toad tadpoles or egg masses are observed, fill in ATSSF information for best looking pool…

SPECIES/ ANIMAL 3.0

Species: *enter "POOL"*
Fill in air and water temperatures and all ATSSF (Project specific fields as in step 3)

7) Repeat steps 2&3 of protocol for each 250m survey reach.

8) Information to record at end of days' surveys:

CONTROL FORM 3.0

WEATHER:

End air temperature: Record temperature in shade
End Wind Speed: Beauford scale

End time: Automatic
Notes: any notes

APPENDIX 3

INTENSIVE SURVEY FIELD PROTOCOL

MCBCP ARROYO TOAD INTENSIVE DAY/EVENING SURVEY FIELD PROTOCOL

INTRO/QUICK SUMMARY

Day-Time Portion

- One person will record all information in his/her palm pilot. At start of surveys, record additional observer, beginning site and weather information in the Control form 2.0.
- Surveys are conducted for 6 consecutive individual 250m segments of watersheds (Total of 1.5km). Enter the block# (1-55) into the Site form of the palm pilot. Enter the site# (A-F) into the subsite form. Each site will have a lat/long that will automatically come up in your palm pilot. You can either manually input or download the GPS coordinates for each reach into your GPS unit.
- After entering the coordinates into your GPS unit, hit the "GO TO" button for the beginning lat/long for the reach. Since the coordinates were figured using a topographical mapping program (TOPO), you may need to adjust your position slightly so that you are in the middle of the main channel.
- Hit the "GO TO" button on your GPS unit for the end coordinate of the reach. Walk slowly upstream (either in the middle of the stream or on the side depending upon ease of movement. If walking in the stream, be very careful not to create waves or riffles that could affect still pools). You will search for arroyo toad egg strings and tadpoles. Upon observing an egg string or tadpole, you will record presence and enter specific data on the animals and in an animal sub-form (for first egg string and tadpole ONLY). You will also collect data for the pool that the eggs/tadpoles are located. You will also count #egg masses, #tadpoles, and # of metamorphs you observe throughout the 250m site length. After walking the entire site (reaching the end point), you will record characteristics for the entire 250m reach such as average width, % with water, and invasive plants and animals. If there are no eggs/tadpoles observed after walking the entire 250m, you will return to the best looking pool, search for arroyo toad eggs/tadpoles for another 15 minutes. If none are found, record physical information on the best looking pool (unless there is no water in the reach).
- For each new 250m reach (block/site), enter the data into separate subsite forms.
- At end of survey, record END time and weather information.

Night-time Portion:

Here, you will wait for 30 minutes after sunset and walk back down the same 6-250m sites. You will enter the site and weather information as before, but no habitat information. Your main purpose is to count the number of adult arroyo toads in each 250m site length by slowly walking (zigzagging if needed to cover the width of the main channel) the entire length with a strong flashlight/ Koehler Wheat lamp. If possible, scan each toad (without touching or harassing) with a pit-tag reader. Any recaptures will need to be recorded individually. There may be toads present with tags from Dan Holland. Any recaptures will provide needed longevity information.

SPECIFIC PALM PILOT FORM FIELDS REQUIRED FOR DAY AND NIGHT SURVEYS FOLLOW:

Note: Please take some photos of tadpoles and toads and habitat when possible.

DAYTIME

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1) *Information to record at the start of the survey*

CONTROL FORM 3.0

Date: Automatic
Survey Type: Stream Survey
Project: AMP-AT Sampling CPEND (P-098)

Weather:

Weather Condition: Enter weather condition
Start air temperature: Record temperature in shade
Start Wind: Beauford scale
% Cloud Cover: estimate
Moon Phase: Leave blank- will be entered from moon chart

Notes: enter other observer's initials here

2) *Information to record at start of each 250m site (reach)*

SITE 3.0

Predefined Site: Enter block # *(CPEND1-55)*

SUBSITE 3.0

Predefined SubSite: Enter site # (A-F)
Subsite Start time: Enter start time
Start lat/long/elev: Automatic
End lat/long/elev: Automatic
Drainage: Automatic
Moon_Visible: *Y/N*
Slope*: Leave blank*

WATER QUALITY SUBFORM*:*

Star Water Temp*:* Enter temp. (if water present at beginning of reach)

3) *Information to record within the reach upon encountering BUCA egg strings or tadpoles. Will have a maximum of 4 animal records ; 1 for each age class (egg masses, "1st Yr larvae, 2nd Yr Larvae, Metamorphs).*

SUBFORMS (WITHIN SUBSITE)

SPECIES/ ANIMAL 3.0: At the first sighting ONLY of arroyo toad tadpoles and egg strings:

TYPE: FROG
SPECIES: BUCA

Age category: *Enter in age class*

egg mass
first year larvae: for tadpoles
Second year larvae: for tadpoles with visible hind legs
Metamorph: for newly metamorphed toads (4 legs with/without tail <3 cm)

Notes: *For tadpoles: please enter estimated length here in cm*
Recap/Toe-clip/ pit-tag number: *Leave blank*
Air temp*:* Enter temp.
Water temp: Enter temp. of pool containing tadpoles/eggs

SPECIES SPECIFIC/ ATSSF FORM
Substrate: (Of pool) *pick one (sandy bottom, silt, cobble, detritus, algal mass)*
Excessive sand or silt covering egg mass? *Check box if YES*
% Cover: Over pool (any vegetation*) estimate %*
Water depth (cm): *Measure*
Water clear? *Check box if YES (Set penny in bottom of pool)*
Y= can see penny clearly in bottom of pool
N= cannot see penny or outline not clear)
Water velocity (m/s): Put small stick in pool, time 10 seconds, measure distance traveled in meters (1m=100cm), divide by 10.
Total Count: Estimate # of individuals of each age category in reach (tally of total site length)
Deformities: Metamorph surveys only: estimate # of individuals in reach.
AT Notes: If Cover is due to algae, please note here. Optional (For egg strings, may want to note whether they are out in open or wrapped around vegetation, etc.

4) Information to record within the reach upon encountering other aquatic species (especially non-native) and non-native plants.

SUBFORMS (WITHIN SUBSITE)

a) SPECIES/ ANIMAL 3.0: Enter any Invasive and/or native vertebrates observed: (invasive fish, RACA, XELE, beavers...). Take vouchers or photographs for unknowns.

b) SPECIES/ PLANT 1.0: Enter in any non-native plants observed (ex. tamarix, arundo, fennel, watercress, non-native grass, other) with a size class for each species (a few plants, scattered small patches, large contiguous stands)

5) Information to record at end of 250m reach

SUBSITE 3.0

Water: Check box if YES (Anywhere within the 250m reach*)*
Wet length of survey site: Pull down menu *(0%, 1-30%, 31-60%, 61-99%, 100%?)*
Average width (m): Estimated width of watershed*:*
If clear- bank to bank
If not clear- width of riparian habitat defined by willows and/o**r** mulefat
*Total No. of AT breeding pools > 2ft: # (*pools defined as areas of *still water)*
Plant Community(in watershed/not upland): Enter top 2 to 3 dominant plant types (greater than 25% total plant cover) and then description of vegetation
forest: closed trees
woodland: open trees
savanna: sparse trees with intervening grassland
chaparral: closed evergreen shrubs
scrub: open to sparse shrubs
grassland: grass/herbs

Examples (Mulefat, willow savanna- open mulefat and willow with grassland below/ Arundo forest-closed arundo/ Mulefat scrub- open mulefat)

Slope/Stream Slope/Moon Visible: Leave blank

pools >2ft: *Pools- areas of still water within or outside main stream flow-only obvious ones*

pools <2ft: *same as above*

> 10m of sandy substrate present? Check box if YES

> 10m of adjacent sandy terraces? Check box if YES

> 10m of channel braiding? Check box if YES

Overall Site Quality: *(*Poor, marginal, good, high*)*

Look at 3 characteristics above:

0/3-poor

1/3-marginal

2/3-good

3/3- excellent

Presence of AT egg masses? Y/N (For first observation only- fill in animal subform *below)*

*Presence of AT tadpoles? Y/N (*For first observation only- fill in animal subform *below)*

Disturbance and threats*: Enter notes of obvious recent disturbance such as any recent vehicle disturbance, excessive turbidity, trash, etc. (don't worry about threats)*

WATER QUALITY SUBFORM***:***

End Water Temp*:* Enter temp. (if water present at end of reach)

6) If no tadpoles or eggs seen after end of reach, return to best looking pool and search for 15 more minutes. If no arroyo toad tadpoles or egg masses are observed, fill in ATSSF information for best looking pool…

SPECIES/ ANIMAL 3.0

Species: enter "POOL"

Fill in air and water temperatures and all ATSSF (Project specific fields as in step 3)

7) Repeat steps 2-6 of protocol for each 250m survey reach.

8) Information to record at end of days' surveys:

CONTROL FORM 3.0

WEATHER:

End air temperature: Record temperature in shade

End Wind Speed: Beauford scale

End time: Automatic

Notes: any notes

NIGHT SURVEY

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1) Information to record at the start of the survey (Sunset)

CONTROL FORM 3.0

Date: Automatic
Survey Type: Stream Survey
Project: AMP-AT Sampling CPEND (P-098)
Weather:

Weather Condition: Enter weather condition
Start air temperature: Record temperature in shade (At sunset)
Start Wind: Beauford scale
% Cloud Cover: estimate
Moon Phase: Leave blank- will be entered from moon chart

Notes: enter other observer's initials here and "Night Survey"

2) Information to record at start of each 250m site (reach)(30 minutes after sunset)

SITE 3.0

Predefined Site: Enter block # *(CPEND1-55)*

SUBSITE 3.0

Predefined SubSite: Enter site # (A-F)
Subsite Start time: Enter start time
Start lat/long/elev: Automatic
End lat/long/elev: Automatic
Drainage: Automatic
Moon_Visible: Y/N
Slope: *Leave blank*
IN Notes: *Enter air temp at beginning of each 250m reach*

3) Information to record within the reach upon encountering Arroyo toads.

SUBFORMS (WITHIN SUBSITE)

SPECIES/ ANIMAL 3.0:

NOTE: ALL TOADS CAN BE ENTERED IN A SINGLE ANIMAL FORM UNLESS PIT-TAGGED. IF PIT-TAGGED, ENTER IN ANIMAL INDIVIDUALLY AND TAKE SPECIFIC GPS COORDINATE (Need to press "Show all" key to enter lat/long)
TYPE: FROG
SPECIES: BUCA

Age category: Adult
Recap/Toe-clip/ pit-tag number: Enter PIT TAG Number if Pit-tagged
Air temp: ***Enter temp. at first observation within 250m reach***
Water temp: ***Enter temp only if at least one toad found in water***

Click on "SHOW ALL"

# of Adults*: *Record # observed

4) Information to record within the reach upon encountering other aquatic species (especially non-native).

SUBFORMS (WITHIN SUBSITE)

a) SPECIES/ ANIMAL 3.0: Enter any Invasive or native aquatic vertebrates observed: (invasive fish, RACA, XELE, beavers...) along with number observed. Take vouchers or photographs for unknowns.

5) Information to record at end of 250m reach

SUBSITE 3.0

WATER QUALITY SUBFORM*:*

End Water Temp: Enter temp. (if water present at end of reach)

6) Repeat steps 2-5 of protocol for each 250m survey reach.

7) Information to record at end of nights' surveys:

CONTROL FORM 3.0

WEATHER:

End air temperature: Record temperature in shade
End Wind Speed: Beauford scale

End time: Automatic
Notes: any notes

APPENDIX 4

OBSERVER VARIABILITY SURVEY FIELD PROTOCOL

MCBCP ARROYO TOAD OBSERVER VARIABILITY SURVEY FIELD PROTOCOL

- Two people will walk a 250m reach separately. This will be a separate reach than the AT surveys assigned for that day. You can choose any 250 m reach next to or in between the assigned survey sites, so long as it has water.
- Each person will walk the reach and look for egg masses, tadpoles, & metamorphs. Upon finding these, create and animal form, take a GPS grab, and record estimated number and some pool characteristics.
- Note: When tadpoles are spread out in the stream (vs. isolated pools), take a GPS grab and estimate the total number within 10 meter segments (i.e 5 meters on each side).
- You can use the same palm pilot (one person going up + one going back) or your own.

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1) Information to record at the start of the survey

CONTROL FORM 3.0

Date: Automatic
Survey Type: Stream Survey
Project: AMP-AT Sampling CPEND (P-098)
Notes: *enter other observer's initials here*

SITE 3.0

Site Name: Enter "Detect Survey"

SUBSITE 3.0

SubSite Name: Enter your Name
Subsite Start time: *Enter start time*
Start lat/long/elev: Do GPS Grab

2) Information to record within the reach upon encountering BUCA egg strings or tadpoles and/or metamorphs.

SUBFORMS (WITHIN SUBSITE)

SPECIES/ ANIMAL 3.0: At the sighting of arroyo toad egg strings, tadpoles, and metamorphs

Press "SHOW ALL"

GPS GRAB: Do grab
TYPE: FROG
SPECIES: BUCA

Age category: Enter in age class

egg mass
first year larvae: for tadpoles
Second year larvae: for tadpoles with visible hind legs
Metamorph: for newly metamorphed toads (4 legs with/without tail <3 cm)

SPECIES SPECIFIC/ ATSSF FORM

Substrate: (Of pool) *pick one (sandy bottom, silt, cobble, detritus, algal mass)*
Excessive sand or silt covering egg mass? *Check box if YES*
% Cover: Over pool (any vegetation) *estimate %*
Water clear? *Check box if YES* (Set penny in bottom of pool)
Y= can see penny clearly in bottom of pool
N= cannot see penny or outline not clear)
Total Count: Estimate # of individuals of each age category in segment/pool
Deformities: Metamorphs only: estimate # of individuals in reach.
AT Notes: If Cover is due to algae, please note here as "Algae cover".

Note: Water depth and velocity are not recorded

5) Information to record at end of 250m reach

SUBSITE 3.0

End lat/long/elev: *Do Grab*
Water: Check box if YES (Anywhere within the 250m reach)
Wet length of survey site: *Pull down menu (0%, 1-30%, 31-60%, 61-99%, 100%?)*

CONTROL FORM 3.0

End time: Automatic
Notes: any notes