Phylogenetic and Population Genetic Analyses of the Western Pond Turtle (*Emys marmorata*), in Southern California

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

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TABLE OF CONTENTS

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ABSTRACT

The western pond turtle, *Emys marmorata*, is the only remaining turtle native to southern California, and is included and/or proposed as a "covered" species in the multi-species conservation plans throughout southern California. Major threats to *E. marmorata* include loss of habitat due to modification and/or development and the introduction of invasive species, including nonnative turtles. Previous work has shown that the greatest genetic variability within the species is in southern California; Ventura south to Baja California (Spinks & Shaffer 2005; Spinks et al. 2010). This previous work had limited sampling in southern California. We attempted to sample all remaining populations of pond turtles in southern California to better resolve how this genetic variability is distributed in the region, so that management units can be defined. We utilize mtDNA sequence data for these new samples, in addition to sampling a panel of 96 single nucleotide polymorphisms or SNP loci, which are distributed across the turtle genome. In our sampling for tissue collection we found similar numbers of native and nonnative turtles in the wild. We observed the same large genetic differences found in the previous studies of the turtles between northern and southern populations. We also detected evidence of pond turtles being moved into the area from the north, as released or escaped pets. The SNP loci data had enough resolution to identify "natural" breaks in the species (where populations became genetically distinct from adjacent populations), so that management units for conservation could be developed. In assessing genetic bottlenecks, we determined that only the most remote and undisturbed sites appear to genetically retain high diversity and a full compliment of haplotypes.

INTRODUCTION

The western pond turtle, *Emys marmorata*, is the only remaining turtle native to California, *Kinosternon sonoriense* having been formerly observed in extreme southeastern California, and is included and/or proposed as a "covered" species in the multi-species conservation plans throughout southern California. This species is a CDFW Species of Special Concern (Jennings & Hayes 1994). Major threats to *E. marmorata* include loss of habitat due to modification and/or development and the introduction of invasive species, including nonnative turtles (Bury & Germano 2008). Mitigation efforts for populations being lost have often included translocating turtles from development sites, in the hope of establishing new populations or augmenting already protected populations. Despite the fact that such management actions are already in practice, their effectiveness, as well as some basic turtle population information, such as defining population units and understanding threats and implications for recipient populations, is still unknown. Translocation activities could pose a threat if turtles from genetically isolated lineages are mixed, potentially leading to loss of genetic diversity and adaptive potential within the species. A recent phylogenetic analysis of *E. marmorata* throughout its species range (based on mtDNA and nuDNA) suggests that individuals from South Coast Ecoregion, including the Ventura/Santa Clara River systems in Ventura County to the south to Baja California, form a well-supported clade (Spinks & Shaffer 2005, Spinks et al. 2010). Within this clade, a genetic break between Baja California and southern California was also highly supported. Finally, two distinct mitochondrial lineages (Southern California and Santa Barbara) overlap in the Santa Clara River watershed in Ventura County, suggesting a secondary-contact zone between previously allopatric lineages. Based on their analysis, these authors concluded that southern California is a rich source of cryptic genetic variation.

We assessed population genetic structure of western pond turtles in Southern California (Ventura-Kern County south to the Mexican Border) to be able to delineate management units for conservation using multiple markers: mtDNA sequences and single nucleotide polymorphisms (SNPs). These two markers are complimentary. Differentiation among mtDNA sequences reveals genetic divergence in the maternal lineages of a species, and often reveals information about the evolutionary and biogeographic history of a species. SNPs are polymorphic sites throughout the nuclear genome which are biparentally inherited (Morin et al. 2004). These are useful for population genetics assessments and are characteristics which allow for high resolution genotyping of individuals for delineating populations on the basis of genetic similarity (individuals do not need to be assigned to population units a priori), to make inferences about dispersal over the last several generations, and to determine levels of genetic diversity contained within populations.

Turtles within the study area were sequenced and genotyped: 1) to determine whether there is significant genetic structure among populations, 2) to assign individuals to population units, 3) to assess levels of genetic diversity found within remaining turtle populations, and 4) to estimate recent gene flow among population units. This information can be used to create recommendations for development of refugial populations, for augmentation or relocation of existing populations that are consistent with natural patterns of genetic diversity across the landscape, to assess which populations may be particularly threatened by habitat change and loss or invasive species, and to identify populations which are genetically unique.

Study Area

Previous genetics work (Spinks & Shaffer 2005, Spinks et al. 2010) included sampling of eight populations from Ventura, Los Angeles, San Bernardino, Orange, Riverside, and San Diego counties. These populations incorporated some of the main occupied watersheds across these counties, but left many gaps that are necessary to understand for the development of management units. Brattstrom and Messer (1988) and Jennings and Hayes (1994) both state that there are less than 10 "viable" populations south of the Santa Clara River, indicating an urgency for this sampling. Our study focused on these six counties with the goal of filling in these gaps and sampling all possible turtle populations we could access. We also had the goal of better determining the range limits (boundaries) of the three major clades previously identified in southern California based on the sequence data (Santa Barbara clade, San Joaquin Valley clade, Southern clade), with higher resolution markers.

METHODS

Sample Collection

Tissues were collected from throughout southern California by the USGS and various cooperators (Fisher et al. 2004, Madden-Smith et al. 2005, Schuster et al. 2006, Brown & Fisher 2008, Western Riverside County MSHCP 2008, Dagit & Albers 2009, Western Riverside County MSHCP 2009, Schuster & Fisher 2010, Brown et al. 2012, CDFW, United Water, etc.). USGS San Diego Field Station has been surveying, trapping, and monitoring *E. marmorata* in southern California for almost a decade using standardized protocols (Figure 1; USGS 2006a, b, c). Turtles were captured either with traps, nets, or by hand. Nonnative turtles were also collected during these surveys (n=864), and these were removed from these sites and either became museum voucher specimens or became part of the California Turtle and Tortoise Society adoption program (Figure 2). Tissue samples were acquired during surveys using non-lethal sampling methods (e.g., tail clips) and following previously established protocols. A small tail tip from the turtle was surgically removed and the samples were stored in 95% ETOH until return to the lab where they were then frozen. All turtles captured and released were PIT tagged so that recaptures could be identified over time (Buhlmann & Tuberville 1998). In total, in excess of 514 sites (survey and trap) across 3,545 individual survey events, were studied for turtles. This resulted in 816 pond turtle captures, including recaptures.

We acquired a total of over 600 pond turtle tissue samples from the majority of watersheds that *E. marmorata* still occupies in southern California and these were augmented with 110 samples that were previously collected by Dan Holland and stored by Dr. Shaffer (Table 1, Appendix I-II, Figure 3). T hus we utilize 470 of our samples in the analysis for a sample size of 580 turtles, including the Dr. Shaffer samples. The additional 130 USGS samples that were not run were from additional individuals from these same sites and were above the sample sizes we needed for the analyses we were conducting. Our focus in this contract (2010-2011) was to supplement the previous sampling with tissues from 1) Ventura County: Santa Clara watershed, 2) Riverside-Orange counties: Santa Ana and Santa Margarita watersheds, and 3) San Bernardino County: Mojave watershed. This was in large part to fill in large sampling gaps to spatially refine the distinct clade boundaries as well as to resample historic populations to look for bottleneck effects (i.e., Cockleburr Creek and Santa Margarita River). Sampling of natural populations of turtles in the Mojave watershed is of particular interest because the turtles which were sampled in Spinks and Shaffer (2005) appear to have been transplanted from San Diego County and are likely to be genetically divergent from natural populations in Victorville and Afton Canyon. Ideally, we would have preferred to sample 10-20 individuals from each location to obtain a good representation of the genetic makeup of each site; however in some cases, there were very few individuals remaining at locations or watersheds, so fewer samples were collected (i.e., San Juan Creek). Some sites (i.e., Brea Canyon, Los Angeles County) where we knew there were large turtle populations from consultants reports we were denied our request for access for sampling by the private property owner/manager.

Genotyping of Samples

We used previously published primers and methods to obtain DNA sequences (Spinks & Shaffer 2005, Spinks et al. 2010). This resulted in 705 base pairs of ND4 being generated for a subset of the samples collected. SNP development was done in Brad Shaffer's lab at UC Davis, funded by a separate DFW grant which looked at populations of pond turtles across their entire range. Our study focused only on southern California populations. SNPs are a relatively new genetic tool, but they appear very powerful at resolving patterns within even small sample sizes for populations (Morin et al. 2009). In total, 96 SNPs were selected based on a panel of eight turtles from across the species' range.

Phylogenetic and Population Genetic Analyses

mtDNA sequences were used to estimate a neighbor-joining (NJ) gene tree in the program PAUP. While other phylogenetic tree building methods (Bayesian, Maximum Likelihood, Maximum Parsimony) may be better at assessing the statistical support for clade relationships, we were trying to determine clade boundaries instead, so we utilized the NJ tree simply to assess concordance between genetic groupings obtained with mtDNA sequence data when we compared their boundaries to those supported by SNP markers.

SNP Analyses
Prior to analyzing SNP loci, resulting genotype data were assessed for consistency and missing data. Inconsistencies may be due to null alleles and amplification difficulties at certain loci, or poor quality and small amounts of extracted genomic DNA. We compared genotypes across all 96 loci for a panel of 17 individuals that were genotyped more than once to assess consistency in genotype calls. While most individuals genotyped consistently across loci, there were three individuals for which genotypes were not consistent across multiple runs. In each of these cases, the percentage of missing data also exceeded 15%. Therefore we assessed the percentage of missing data for all individuals and loci in our dataset. Twelve individuals and one locus with greater than 10% missing data were removed from further analysis, resulting in a final dataset that included 580 individuals and 95 loci (470 of our samples in addition to the 110 stored samples from Shaffer's lab).

Genetic Assignment
We used STRUCTURE 2.3.2 (Pritchard et al. 2000) to analyze the SNP data for inferring population structure and to assign individuals to different genetic clusters. This is a non-spatial algorithm that is routinely used for identifying the number of distinct genetic entities in genetic datasets. Under the STRUCTURE estimation method the number of clusters (*K*) that putatively best explains the dataset is inferred from the posterior probability distribution of the data given the number of clusters, $P(X|K)$. We tested for all values from K = 1 to K = 10 with 200,000 iterations of the Markov chain Monte Carlo (MCMC) algorithm following a burn-in of the model using 100,000 iterations with three independent runs at each *K* value to check for the consistency of the Markov chain runs. Structure runs were performed using the correlated alleles model with admixture (which assumes that individuals have composite genomes resulting from mixed ancestry) and without a location prior (allowing individuals to be assigned based on genotype and not location). The number of clusters, *K* was then roughly inferred by visual inspection of the $\ln P(D|K)$ curves, where the $\ln P(D|K)$ curve plateaus (Figure 8). We also evaluated the results of analyses that considered a range of *K* around this plateau (K = 3, 4, 5 and 6), because different patterns and information can emerge from the data by exploring different *K* values.

Population Genetics
For 59 collection locations (or populations) where two or more individuals were sampled (Table 2), we analyzed allele frequencies and population genetic structure using the program Genalex (Peakall & Smouse 2006). We calculated allele frequencies and tested for deviations from Hardy Weinberg equilibrium for each locus in each population. Diversity indices [number of alleles, expected (He) and observed heterozygosity (Ho)] were averaged across 95 loci for each population. To assess genetic structure across populations, we examined how genetic variance was partitioned hierarchically among watersheds, populations within watersheds, among, and within individuals in an AMOVA (analysis of molecular variance) framework. We also calculated F_{ST} among all population pairs and compared this to the geographic distance among sites using a Mantel Test in the program IBDWS (Jensen et al. 2005). We tested for signatures of recent and historical bottlenecks in the program BOTTLENECK (Cornuet & Luikart 1996). We used the heterozygote excess test with an infinite alleles mutation model to test for signatures of bottlenecks in the recent past (ca. < 4 Ne generations, where Ne = the effective population size). With a large population decline, rare alleles should be lost more quickly than common ones leading to an excess of observed heterozygotes relative to that expected under equilibrium conditions. The Wilcox signed-rank test was used to evaluate any significant deviation from 50:50 heterozygote deficiency/excess. One caveat to this analysis is that if there is an

ascertainment bias in the selected SNP loci (e.g., if loci were selected because they have high heterozygosity), these may generate false bottleneck signatures (Morin et al. 2004).

RESULTS

Current Distribution and Status

Pond turtles were found in most watersheds we needed for sample collection, which had been identified as gaps in previous sampling efforts, although we were not able to obtain any new material from the Mojave watershed. We trapped both downstream of Victorville where they have been confirmed in the past, and at Afton Canyon (Lovich & Meyer 2002). They probably persist still at the Victorville site, but when we sampled it was late (October-Nov.) 2010 and their activity might have dropped for the year. When we went back in 2011 the pools were scoured out by high flows over the winter so there was no place to trap, and the entire reach was shallow over sand. At Afton Canyon, we trapped in 2011, as did Brad Shaffer (UC Davis, now UCLA), and neither of us detected pond turtles. The last verified record from that site was by Bobby Espinoza (CSU Northridge) in 2006, and they may be absent now, and we had discussions with other resource staff and scientists about turtles here and cannot confirm any more recent records.

Unfortunately, apparently only small populations appear to persist in certain watersheds (i.e., San Juan Creek, San Luis Rey River). Most, if not all watersheds, are invaded by nonnative turtles (Figure 12, Table 5), and these appear to be a threat to the long term viability of pond turtles (Spinks et al. 2003). Details by watershed are given below in the discussion along with the summary results of the genetics.

mtDNA Sequence Data

We recovered the same structure as had been found in the previous two papers (Figure 5; Spinks & Shaffer 2005, Spinks et al. 2010). Our sequences all fell into these previously identified clades (and haplotypes), although we determined more finely where the boundaries between the clades are in southern California, and discovered a few more haplotypes within the Southern clade. We did also find that several “wild” turtles in southern California were represented by extralimital haplotypes. These included animals found with San Joaquin, Northern (Sierra), and the Santa Barbara haplotypes as introduced individuals, indicating there is a lot of movement of pond turtles, probably from intentionally released pets (Table 3, Figure 6,7).

The only Mojave River sample in our study is the Camp Cady Wildlife Area (DFW) sample previously collected by Dan Holland (Holland 1991). These still link with haplotypes (2 different ones) from San Mateo Creek, San Diego County, and a few other turtles from Camp Pendleton sites. They lacked unique haplotypes as might be expected from their remote location. It appears these turtles are introduced from northern San Diego to the artificial ponds along the Mojave River. Unfortunately we still lack any “natural” Mojave River pond turtle samples.

Our samples from the Ventura River (Matilija Creek and San Antonio Creek) and Calleguas Creek both contain Santa Barbara mtDNA haplotypes. The Ventura River sites only had this (Santa Barbara) haplotype present, whereas Santa Paula Creek (Santa Clara River) previously was identified as a site with both the Santa Barbara and Southern haplotypes present. We found that Calleguas Creek also had both Santa Barbara and Southern haplotypes present, except in the Conejo Creek headwater site of Rancho Sierra Vista Pond, which only contained a Southern clade haplotype. This boundary between these two clades is now better defined, with other populations in the Santa Monica Mountains east of Calleguas Creek containing only Southern Clade haplotypes.

The Santa Clara River watershed was found to contain three major clades of pond turtles, the Santa Barbara clade in the lower watershed, the Southern clade in the middle watershed, and the San Joaquin/southern Sierran clade "*marmorata*" in the headwaters of the upper watershed.

Gorman Pond and Lake Elizabeth, both on the San Andreas faultline in Los Angeles County, contain mtDNA haplotypes for the San Joaquin/southern Sierran populations "*marmorata*". The San Francisquito Canyon turtles also have this haplotype, and they are in the upper Santa Clara Watershed as well. We do not have mtDNA for the Aliso Canyon (Los Angeles County) turtle which is additionally in the upper Santa Clara River watershed, but it might share this pattern also. This disjunction is very interesting as Piru Creek (near Agua Blanca Creek), and Piru Creek (Frenchman Flats Campground) are downstream of Gorman Pond, and west of these other sites, yet contain the Southern haplotype only.

Within the Southern clade, new haplotypes were found that were apparently restricted to specific sites. One of these appears restricted to sites in Topanga Canyon, another appears restricted to San Diego Creek (Orange County), and a third to Chileno Canyon (West Fork San Gabriel River). We also found a new haplotype that was widespread across many populations from Ventura to San Diego Counties, including some sites that were very remote (i.e., Trancas Canyon, Pacoima Creek, Long Canyon-Santa Margarita River, West Fork San Luis Rey River, Pine Valley). This haplotype, though widespread, was missed by chance in the previous work.

The unique Baja haplotypes of the Southern clade were not found in southern San Diego County with the additional sampling we did, and are still restricted to Baja California.

Structure Results from the SNP dataset

Visual inspection of the $\ln P(D|K)$ curves from STRUCTURE analyses under the 'correlated allele frequencies' model suggested between 4-7 clusters as an approximate number for K (Figure 8), and a sharp plateau in the curve was observed at K= 4.

K=3 is the cleanest break between populations in how individuals are assigned. This separates the San Joaquin/Sierra samples (including Gorman Pond and Lake Elizabeth) from the coastal and southern populations. This also discriminates the Baja samples from the other populations. This and all of the other K values show that the Baja populations grade into southern San Diego populations, with turnover completing in the upper San Diego River watershed.

K=4 shows the same pattern as the *K*=3 with the addition of separation now along the Santa Ana River into northern and southern populations (Figure 9). *K*=5 adds to this discrimination of high elevation northern (Los Angeles County) populations (ie Piru, Pacoima, Big Tujunga, and San Gabriel) from the lower elevation ones (ie Santa Monica Mountains, Ventura). *K*=6 further separates the southern group between the San Luis Rey River and the Santa Margarita River. The other patterns are the same (Figure 10). Samples from two different sides of Mt. Palomar are strikingly different at this resolution. Some of the management recommendations from these higher *K* values are discussed below.

Population Genetics

Most loci did not deviate from Hardy-Weinberg equilibrium (HWE) in most populations. Of 1536 polymorphic locus*population samples, 129 (8%) deviated significantly from HWE at p • 0.05. Of these, none deviated from HWE in the majority of sampled populations (range 1-8), and so all loci were retained for further analysis.

We detected significant genetic structure among populations and watersheds across the study region. At the population level, 40% of genetic variance was partitioned among populations, with FST of 0.403 (p • 0.001). When populations were grouped by watershed, 28% of the genetic variance was partitioned among watersheds (FRT = 0.284, p • 0.001) and 12% partitioned among populations (FSR = 0.166, p • 0.001), suggesting that turtles are more genetically similar within watersheds than among them (Table 4). Only 3% of the genetic variation was partitioned among individuals within populations, suggesting that most populations lack variability within them, and between population variability is more important for genetic structure. Finally, isolation by distance analysis showed a strong correlation between genetic distance and geographic distance among populations (Mantel Test r = 0.6441, p • 0.001, Figure 11).

Within populations, the percentage of polymorphic loci and heterozygosity varied among populations considerably (Table 2). The percentage of polymorphic loci ranged from 5% in the southernmost Baja population (Arroyo del Rancho Portrero) to 62% at Alice Keck Park, a population of known mixed origin. Expected heterozygosity (He) ranged from 0.016 in Arroyo del Rancho Portrero to 0.176 in Elizabeth Lake, Santa Clara River Watershed. There was no clear pattern of shifts in genetic variation with latitude or elevation. Instead, differences in genetic diversity likely reflect local conditions and population history, such as local habitat conditions that support different population sizes, previous reductions in population size, or populations of mixed ancestry. Signatures of recent genetic bottlenecks were detected in 16 of the 59 populations sampled. Notably, all but one population sampled in the Santa Clara River watershed appear to be have gone through a decline in population size in the past, as reflected in a reduced genetic variability across loci, and this was seen as well in all four of the sampled populations in southern San Diego County (San Diego River, Sweetwater, and Tijuana watersheds). Even though we can see that there is a signature in the genetic data of a population crash; it does not mean that currently the population size is reduced, only that there was a reduction in the past.

DISCUSSION

The use of the various genetic markers gave this study a unique ability to resolve different levels of the evolutionary and biogeographic history in the pond turtles in southern California. These markers also enabled the discovery that turtles were being moved around through intentional and unintentional purposes that might erode over time the patterns of natural genetic structure. We were able to delimit more clearly the introgression of Santa Barbara mtDNA haplotypes with the Southern ones, and delimit the San Joaquin haplotype southern boundaries. It is clear from this work that there are multiple management units that can be defined in southern California for structuring recovery and conservation actions. These are discussed below as is our current knowledge of population status within these groupings, so that priorities for conservation or management can be developed.

Management Units

These will be discussed from north to south. This is our best assessment at utilizing all of the genetic (mtDNA and SNP) data to think about natural breaks in the populations. For SNP's the *K*=3 most likely represents differences at or near a "species level" within the taxa (Spinks et al. in review), and these "species" should be maintained as separate units in management. As we go through the higher *K* levels (4-6) we continue to find additional breaks, and these help identify historic or natural breaks in the species that could be maintained to manage for the historic genetic patterns that occurred across southern California. We present these below to indicate that if possible and desired a conservative approach can be utilized to manage for units that are at some level uniquely defined.

- Ventura River – These populations have only the Santa Barbara mtDNA haplotypes present. For SNPs (*K*=6) they cluster with Sisquoc/Santa Ynez/Jalama Creek, and not like the Lower Santa Clara River (primarily more dominate red color as seen in figure 10).
- Lower Santa Clara River/Calleguas Creek - These populations contain an admixture of Santa Barbara and Southern mtDNA haplotypes. They probably represent a recent "reconnection" these divergent populations. We know that much of the Santa Clara watershed was a seaway during recent high sea level events, and this could have been the barrier that allowed for divergence of these haplotypes. When sea level dropped and the river became re-established, this "reconnection" of populations could have taken place. For SNPs (*K*=6) they show a similar pattern of admixture, primarily light purple with some red (Figure 10). Currently there doesn't seem to be any barriers along the lower ends of these watersheds that are a barrier for dispersal. This pattern of biogeography, with a break in this region, is seen in several other species, including horned lizards, ring-neck snakes, and alligator lizards (Feldman & Spicer 2006, Leache et al. 2009).
- Topanga Canyon – These populations only contain Southern clade haplotypes, including a haplotype apparently restricted to the canyon, so they differ from the above unit in that way, as that unit has mixed haplotypes. For SNPs they have a similar admixture pattern as above, with both red and light purple (Figure 10). For Malibu and Trancas we have small samples so it's not clear if they should be lumped here or separated into their own units.
- Gorman Pond – This population is basically not different from populations sampled along the Kern River, although there is a slight signature of southern turtles present in the SNPs

(*K*=3-6). It's the only population without a bottleneck signature, and is apparently very large (Dave Germano pers. comm.). Apparently there are no pond turtle populations within the Tejon Ranch (Mike White, pers. comm.), so Gorman pond might be a good one for harvesting turtles for translocation to the ranch for recovery actions in the future or for purchase as mitigation for the Tehachapi Renewable Transmission Project as it is currently privately owned.

- Lake Elizabeth/San Francisquito Canyon – These two seem very similar, and with the very few turtles ever seen in San Francisquito Canyon over the last decade (n=3), it is probable that the turtles in the canyon may have come from the lake over time. Both sites have Sierra-San Joaquin Clade mtDNA, but show as a unique mixed population with the SNPs (*K*=3-6). We were unable to get turtle samples from Castaic Lake or upstream in the canyon to determine if they represent the same genetic patterns or not. This was due to lack of access but this population should be samples and revisited as its placement in the watershed may be important to better understanding these patterns. Lake Elizabeth probably represents the largest population of pond turtles in Santa Clara/Mojave Rivers Ranger District of the Angeles National Forest. The population is adjacent to a major road where we detected road kill turtles, and exotic turtles were present at this site. Due to its unique genetic signature and potential large size, it would benefit from management actions to ensure its long term viability. These actions would include signage, against leaving pet turtles (red-ear sliders) and fencing to ensure the pond turtles do not go on the adjacent high volume road. Possibly other pond turtle populations exist in the lakes and ponds along the rift zone, but this is the best protected one currently. Historically turtles occurred in Amargosa Creek downstream of Leona Valley (R. Fisher, pers. obs.) but it is not clear if they still occupy that habitat. These turtles in Amargosa Creek are the only verified desert slope population of this species besides the Mojave River population.
- Piru/Pacoima/Big Tujunga/San Gabriel River – These populations, although quite distant from each other, share genetic patterns. All of these populations are above significant dams, and they share Southern mtDNA haplotypes, and strikingly similar SNP signatures (*K*=6), indicating no admixture. They are all almost solid light purple on Figure 10. It could be they represent historic headwater populations that have remained isolated while the low elevation dynamics of flooding and historic sea level change has, created the admixture seen in lower Santa Clara and Topanga.
- Fullerton Arboretum/Bernard Biological Field Station/Camp Cady/Lower Santa Ana River – These populations all seem to be mixtures of mtDNAs from several places, and SNPs (*K*=4-6) that are admixtures. These are modified habitats, with turtles of uncertain origins. Management for these should not be a priority.
- Ladd Canyon/Aliso Creek(Orange County; pop 41) – These two sites, although different watersheds, seem to have the same SNP (*K*=4-6) signature, and the upper end of Aliso Creek comes physically close to Santiago Canyon, which is in the watershed that Ladd Canyon drains into. This seems to be a natural signature and probably a historic genetic pattern for turtles in the mountains in Orange County.
- Cajalco Pools – This appears to be a different signature for SNPs (*K*=6) than other sites in the Santa Ana River, although we have a very small sample from Aliso Canyon (Chino Hills; pop 35) which could share this pattern.
- San Diego Creek (Orange County)/San Joaquin Marsh – These turtles seems to have their own signature for SNPs (*K*=6) also and probably should be managed separately from other Orange County turtles. Unfortunately, we were not able to sample turtles from

Bonita Reservoir or Bonita Creek where turtles might now be absent. They probably would represent this same type.

- Shady Canyon Turtle Pond – This site is the Irvine Ranch mitigation pond in upper Shady Canyon. The turtles here are from Bommer Canyon and Sand Canyon Reservoir. They show a unique SNP signature at several (3 and higher) different values for *K*. There is no evidence that there are turtles from other areas mixed in with the native ones, but possibly mixing the two local populations resulted in this signature. Apparently there are many turtles in this population, so it might be a good source of turtles for use in restoration in Orange County, as long as there are no resident pond turtles in any potential sites.
- San Juan/Oso/Trabuco – There appears to be very few turtles left in this watershed, although 15 years ago there were many. Focal surveys should be done to determine if there are enough turtles to even have a reproductive population remaining in this system. This means that we only detected a few scattered individuals across these widely spread tributaries and the concern is that there is no longer breeding or recruitment in this watershed. Since we attempted to obtain a good sample, but only captured a few turtles, it is difficult to determine if they represent a unique unit or should be included with other more northern Orange County turtles. They appear to be genetically distinguishable from the turtles in Camp Pendleton, and further north in Orange County.
- San Mateo/Coastal Camp Pendelton creeks/Santa Margarita River – These watersheds appear to be a natural unit, including the upper headwaters of the Santa Margarita River on Santa Rosa Plateau and Mount Palomar, based on SNPs (*K*=5-6). This is interesting as it is such a large area that the unit covers but there are several large populations of turtles spread throughout this region and possibly still is a lot of gene flow maintaining connectivity over such a large region.
- San Luis Rey/Escondido/Lusardi – These watersheds appear similar for the SNPs (*K*=5-6), even though they cover a large area. The upper San Dieguito populations in Black Canyon/Scholder Creek may be distinct and shouldn't be included with this unit pending further study. For San Luis Rey River, apparently the only population of turtles left is in the west fork above Lake Henshaw. This unit, although covering a large area might not have many turtles left and no large populations. The Lusardi Creek population is almost all males, and we have no estimate of the population in Escondido Creek. Access to Guejito Creek was denied, but this site might be part of this unit genetically and be a large population.
- Upper San Diego River – These turtles, although only a few were sampled, seem to have a unique SNP signature (*K*=3-6). They show some signal of the Baja turtles. It appears that the populations of pond turtles above El Capitan Reservoir were badly impacted by the 2003 and 2007 fires and we were able to only sample a few individuals. Prior to 2003 there were many more turtles in the upper San Diego watershed (Fisher unpub.).
- Sweetwater River – This population, directly below Loveland Reservoir, has a unique SNP signature (*K*=3-6), with about 30% of the pattern of Baja. It is not known if there are turtles or how large the population is above the Reservoir. Current management in the form of exotic species removal at this population has resulted in an observable increase in recruitment (Brown et al. 2012).
- Pine Valley, Tijuana River – This population is showing about 50% of the Baja pattern with the SNPs (*K*=3-6). This is apparently one of the largest populations in San Diego County, but we currently lack a population estimate. Turtles also occur in Hauser Creek

(which flows into Barrett Lake with Pine Valley Creek), but we were unable to sample any for this study to determine if they were genetically the same, but we expect they probably are given their proximity/continuity in the Cottonwood watershed. The next population to the south is Vallecitos, which is also a tributary of the Tijuana River but a separate subwatershed from Pine Valley and Hauser creeks and over 50km away. It is strikingly different with unique mtDNAs and 75% of the SNP (all levels of *K*) signature of the southernmost Baja population.

Data Gaps

Several areas are important watersheds where we know little about turtle populations and/or their genetics. These are regional gaps in knowledge that will help in making decisions for management of the species in southern California. The Mojave River is the most important gap to fill, as turtles could be native to the Mojave Desert and represent very distantly related lineages (Lovich & Meyer 2002). Also, a recent record for San Jacinto Wildlife Area (DFW) in western Riverside County is the first record for the San Jacinto River and would be a good sample to add to the study to fill in this large sampling gap. For San Diego County, additional tributaries of the northern rivers need to be surveyed to determine if there are any large populations outside of the military lands in the north. In the south, determining the status of turtles in the upper San Diego watershed and getting population estimates for Pine Valley are priorities, as these two are probably the most robust populations remaining in central San Diego County. Also surveying and sampling Brea Canyon, Guejito Creek, and several other sites where access was denied would be important to get baseline for turtles from these sites. Overall the priority sites to still sample number about 10 across all of the watersheds, and these were in general not sampled due to lack of access, or failure to detect turtles while conducting the surveys.

RECOMMENDATIONS

Human mediated movement of pond turtles around southern California is more of a problem than we knew before. More education and signage about this illegal activity is clearly needed. Also there are significant gaps in knowledge of population size and viability for most populations. Although we can infer effective population sizes for some of these populations based on the sampling we did. Populations in southern Orange County mostly disappeared over a 15 year period while planning for habitat conservation was taking place. There is a general replacement of wetlands in this county by artificial lakes, many or most now occupied by invasive species. Some opportunities for reintroduction exist in Orange County, especially since there is a large population at Shady Canyon to harvest from, but to date there has not been any of these projects begun. Occurrence and genetic patterns within northern San Diego County are poorly known, and future planned work should fill some of these gaps. For example funded surveys planned in 2013 are focused to fill in some of the occurrence gaps in turtle occupancy in northern San Diego County. If turtles are detected then we can try to do genetic analyses on these specimens in the future. Once we have a further assessment of the populations of these units, and population estimates for Pine Valley, and remote areas on the northern slope of Palomar, then development of conservation goals for them should be a priority.

Based on our current knowledge, most of the populations should be managed separately, as they represent unique genetic signatures, and if possible minimally within watershed management should be the priority. Where few individuals still persist, and for sites being lost through habitat modification, informed planning can now take place to identify closest related populations to try to enhance and ensure that long term viability is maintained regionally. Certain watersheds have been found to now lack turtles, such as Otay, but now contain wetlands that are protected, and these watersheds could be a focus to begin creating assurance colonies that represent some of the unique lineages identified in this study.

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Table 1. Populations and sample sizes.

Population Number	Population Name/Description	Watershed	Total Samples
1	Gorman Pond	Santa Clara	10
2	South Fork Kern River	Kern	10
3	Mariposa Pond	Kern	11
4	Bloomfield Ranch, E of Onyx	Kern	10
5	Cedar Creek, SW of Glenville	Kern	8
6	Elizabeth Lake	Santa Clara	5
7	San Francisquito Canyon	Santa Clara	2
8	San Luis Obispo Creek	San Luis Obispo	2
9	Manzana Creek, Sisquoc River	Santa Maria	10
9	Orcutt Creek	Santa Maria	1
10	Jalama Creek	Jalama	9
11	Alice Keck Park	Mission	7
	Rincon Creek	Rincon	1
12	Santa Ynez	Santa Ynez	2
13	Matilija Creek	Ventura	4
	San Antonio Creek	Ventura	2
14	Lower Santa Clara River	Santa Clara	11
15	Santa Paula Creek	Santa Clara	5
16	Sespe Creek	Santa Clara	3
17	Aliso Canyon	Santa Clara	1
18	Piru Creek	Santa Clara	15
19	Frenchmans Flat	Santa Clara	7
20	Calleguas	Calleguas	41
21	Trancas	Trancas	1
22	Malibu Creek Lower	Malibu	3
23	Malibu Creek	Malibu	1
24	Malibu Creek	Malibu	1
25	Waterfall_Zpond	Topanga	28
26	SM Prec	Topanga	7
27	Big Tujunga Creek	Los Angeles	23
28	Pacoima Wash	Los Angeles	9
29	West Fork San Gabriel	San Gabriel	9
30	Fullerton Arboretum	Created Pond	1
31	BBFS Pond	Created Pond	8
32	Gordon Ranch	Santa Ana	1
	Norco Pools	Santa Ana	1
	Santa Ana River	Santa Ana	2
33	Camp Cady	Mojave	7
34	Ladd Canyon	Santa Ana	7
35	Aliso Cyn	Santa Ana	2
36	Cajalco Pools	Santa Ana	6
37	San Diego Creek	San Diego (OC)	7
	San Joaquin Freshwater Marsh	San Diego (OC)	1
38	San Diego Creek	San Diego (OC)	2
39	Shady Canyon MP	San Diego (OC)	13
40	Laguna Hills Lakes	San Diego (OC)	2
	Lake Forest	San Diego (OC)	1
41	Aliso Creek	Aliso (OC)	7
42	Aliso Crk N	Aliso (OC)	5
43	Doheney	San Juan	1
	Mission Viejo	San Juan	1
	Oso Creek	San Juan	1
	San Juan Creek	San Juan	1
44	Lower San Mateo Creek	San Mateo	9
45	Lower San Mateo Creek	San Mateo	4
46	Upper San Mateo Creek	San Mateo	21
47	Upper San Mateo Creek	San Mateo	20
48	Los Alamos Canyon	San Mateo	1
49	Las Flores Creek	Las Flores (CPEND)	9
50	Aliso Lagoon	Aliso (CPEND)	1
51	Cockleburr Pond New	Cockleburr	12
52	Cockleburr Pond Old	Cockleburr	8
53	Santa Margarita River L2	Santa Margarita	5
54	Santa Margarita River L1	Santa Margarita	6
55	Santa Margarita River	Santa Margarita	2
56	Santa Margarita ER	Santa Margarita	13
57	Alturas Creek	Santa Margarita	1
	Group 13 Lake	Santa Margarita	1
58	Murrieta Creek	Santa Margarita	12
59	Cole Creek	Santa Margarita	2
60	Warm Springs Creek	Santa Margarita	3
61	Tucalota Creek	Santa Margarita	1
62	Long Canyon	Santa Margarita	1
63	Cottonwood Creek	Santa Margarita	6
64	W.F. San Luis Rey	San Luis	5
65	Escondido Creek	Escondido	2
66	Lusardi Creek	San Dieguito	13
67	Upper Santa Ysabel Creek	San Dieguito	4
68	Los Penasquitos County Park	Los Penasquitos	2
69	San Diego River	San Diego	7
70	Sycuan Peak Ecological Reserve	Sweetwater	26
71	Tijuana River	Tijuana	15
72	Vallecitos	Tijuana	7
73	Arroyo del Rancho Potrero	Santo Domingo	25
	Total Samples (All Sites):		580

Table 2. Summary of results. Mean Sample Size (N), % Polymorphic Loci, Mean No. Alleles (Na), Mean Observed Heterozygosity (Ho), and Mean Expected Heterozygosity (He) across 95 loci. Bottleneck test results: Wilcoxen Signed Rank Test 1-sided P-values for heterozygote excess as as signature of recent bottlenecks.

Watershed*	Population Name	N	% Polymorphic loci	Na	Ho	He	Bottleneck P-value**
Kern River	Bloomfield	9.937	33.68%	1.337	0.080	0.077	0.839
	South Fork	9.968	29.47%	1.295	0.083	0.080	0.407
	Mariposa	8.000	28.42%	1.284	0.078	0.081	0.430
Southern Sierra	Cedar	7.958	48.42%	1.484	0.084	0.133	0.713
Mojave	Camp Cady	7.000	11.58%	1.116	0.045	0.038	0.260
Santa Maria	Manzana	9.979	53.68%	1.537	0.102	0.137	0.506
South Coast	Jalama	9.000	33.68%	1.337	0.103	0.106	**0.027**
	Alice Keck	6.916	62.11%	1.621	0.172	0.156	0.923
Santa Clara	Gorman	9.958	43.16%	1.432	0.134	0.127	0.074
	Elizabeth	4.989	49.47%	1.495	0.194	0.176	**0.006**
	Frenchmans	6.968	17.89%	1.179	0.073	0.064	**0.006**
	Piru	14.958	26.32%	1.263	0.069	0.078	**0.028**
	Santa Paula	4.979	22.11%	1.221	0.103	0.086	**0.002**
	Lower Santa Clara	10.947	32.63%	1.326	0.109	0.102	**0.009**
Ventura	Matilija	3.989	23.16%	1.232	0.089	0.084	0.053
	San Antonio	2.000	16.84%	1.168	0.100	0.067	0.884
Calleguas	Upper Calleguas	26.947	44.21%	1.442	0.099	0.091	0.617
	RSV	10.958	29.47%	1.295	0.099	0.084	0.175
Los Angeles	Pacoima	8.916	27.37%	1.274	0.081	0.074	0.490
	BigTujunga	21.905	40.00%	1.400	0.067	0.069	0.913
San Gabriel	West Fork	3.958	12.63%	1.126	0.047	0.038	0.661
	Chileno	4.989	18.95%	1.189	0.080	0.063	0.351
Santa Monica	Smprec	7.000	29.47%	1.295	0.116	0.088	0.187
	Zpond	27.905	25.26%	1.253	0.076	0.072	**0.012**
	Malibu	4.905	31.58%	1.316	0.105	0.096	0.742
Santa Ana	BBFS pond	7.989	51.58%	1.516	0.094	0.134	**0.016**
	Norco	2.000	11.58%	1.116	0.063	0.047	0.618
	Aliso	1.989	13.68%	1.137	0.079	0.057	0.500
	Cajalco	5.979	23.16%	1.232	0.105	0.085	**0.008**
	Ladd	6.979	13.68%	1.137	0.051	0.045	0.137
	San Diego Creek	9.916	47.37%	1.474	0.120	0.108	0.844
	Laguna	2.989	15.79%	1.158	0.096	0.062	0.094
	Shady Canyon	12.947	43.16%	1.432	0.119	0.107	0.454
Laguna	Aliso Creek N	5.000	16.84%	1.168	0.084	0.065	**0.003**
	Aliso Creek	6.979	16.84%	1.168	0.065	0.057	0.096
San Mateo	SanMateo_1	10.968	23.16%	1.232	0.075	0.063	0.262
	SanMateo_2	5.979	20.00%	1.200	0.066	0.065	0.221
	SanMateo_6	8.916	20.00%	1.200	0.068	0.057	0.245
San Onofre	Los Flores	8.979	26.32%	1.263	0.090	0.076	0.150
	Cockleburr	12.874	31.58%	1.316	0.077	0.072	0.774
Santa Margarita	Murrieta	3.979	18.95%	1.189	0.080	0.064	0.433
	Murrieta Creek	12.000	35.79%	1.358	0.082	0.079	0.916
	S. Marg. Ecol. Res. 1	5.979	25.26%	1.253	0.090	0.077	0.384
	S. Marg. Ecol. Res. 2	1.989	20.00%	1.200	0.116	0.079	0.952
	S. Marg. Ecol. Res. 3	2.989	16.84%	1.168	0.074	0.071	**0.017**
	SantaMargarita Mid River	4.000	22.11%	1.221	0.095	0.075	0.305
	SantaMargarita Lower 1	6.000	24.21%	1.242	0.093	0.081	0.095
	SantaMargarita Lower 2	5.000	18.95%	1.189	0.069	0.065	0.185
	Aguanga	7.000	21.05%	1.211	0.084	0.073	**0.032**
San Luis Rey	West Fork San Luis Rey	5.000	21.05%	1.211	0.067	0.072	0.156
San Dieguito	Santa Ysabel	4.000	21.05%	1.211	0.087	0.079	**0.009**
	Lusardi	12.968	27.37%	1.274	0.085	0.079	0.052
Penasquitos	LPCP	1.989	14.74%	1.147	0.084	0.061	0.572
San Diego	SanDiego River	4.000	24.21%	1.242	0.100	0.095	**0.003**
Sweetwater	Sycuan	25.937	35.79%	1.358	0.139	0.129	**0.000**
Tijuana	Upper Pine	3.989	25.26%	1.253	0.137	0.102	**0.001**
	Pine	9.958	38.95%	1.389	0.135	0.125	**0.009**
?	Vallecitos	6.947	15.79%	1.158	0.041	0.050	0.195
?	Arroyo del Rancho Potrero	24.537	5.26%	1.042	0.019	0.016	0.078

*Watersheds included in AMOVA are bolded.

** Populations where significant test results suggest a recent population bottleneck are bolded.

Table 3. Translocated turtles. Probable "escaped or intentionally released" pet pond turtles from out of the region, but found in southern California.

San Joaquin Valley					
SLC65983	Orange	14	SAN GABRIEL RIVER	Anaheim	Cal State Fullerton Arboretum
09KLB4P27	Orange				Prehistoric Pets
DRC10124	San Diego	54	SANTA MARGARITA RIVER	Lower SMR	
Northern (Sierra)					
MSC1095	Los Angeles	20	SANTA ANA RIVER	Middle Santa Ana River	Bernard Biological Field Station
SLC6731	Orange	20	SANTA ANA RIVER	Lower Santa Ana River	Santa Ana River
TM81113	San Diego	13	SAN DIEGUITO	Santa Ysabel	Santa Ysabel Creek
Santa Barbara					
MSC1091	Los Angeles	20	SANTA ANA RIVER	Middle Santa Ana River	Bernard Biological Field Station
X314676162	Orange	20	SAN DIEGO CREEK	Lower Santa Ana River	San Diego Creek (adjacent to San Joaquin Marsh)
KLB102223	San Diego	46	SAN MATEO CREEK	Lower San Mateo Creek	

Table 4. Analysis of Molecular Variance. Analysis of Molecular Variance Results partitioned by collection sites within watersheds and associated F-statistics. Watersheds with only one collection location within them were excluded from this analysis. Significance was assessed with 1000 permutations across the full dataset.

Source	df	SS	MS	Est. Var.	%
Among Regions	15	1988.086	132.539	2.155	28%
Among Pops	34	601.850	17.701	0.903	12%
Among Indiv	362	1718.220	4.746	0.218	3%
Within Indiv	412	1776.000	4.311	4.311	57%
Total	823	6084.155		7.587	100%

F-Statistics	Value	P-value
Frt	0.284	0.001
Fsr	0.166	0.001
Fst	0.403	0.001
Fis	0.048	0.004
Fit	0.432	0.001

Table 5. Nonnative aquatic species. Nonnative turtles, centrarchid fishes and *Lithobates catesbeianus* obsevations from 2005 to 2013. For nonnative turtle locations prior to 2005, see Figure 12 or Madden-Smith, et al, 2005.

	Apalone sp.	*Chelydra* sp.	*Chrysemys* sp.	*Graptemys* sp.	*Kinosternon* sp.	*Trachemys* sp.	*Lepomis* sp.	*Micropterus* sp.	*Lithobates catesbeianus*
Agua Hedionda Creek						x	x	x	x
Alder Creek						x			
Aliso Creek						x			
Bautista Creek							x		
Bernard Biological Field Station								x	
Big Tujunga Creek						x	x	x	x
Buena Vista Creek						x	x		x
Cajalco Pools							x		
Cal Poly-Pomona						x			
Cedar Creek									x
Chino Creek							x	x	x
Collier Marsh						x	x		x
Copper Canyon								x	
Deep Creek							x	x	x
Doane Creek									x
Elizabeth Lake						x			
French Creek							x		
Fullerton Arboretum			x	x	x	x	x		x
Guajome Creek						x			
Haines Creek							x	x	
Indian Creek						x	x		
Lake Hemet			x			x	x		
Lake Perris		x				x	x		
Lake Skinner							x	x	
Las Flores Creek						x			
Los Alamos Canyon									x
Los Penasquitos Creek						x	x	x	
Lower Cottonwood Creek							x		
Lower Piru Creek							x		
Lower San Gabriel River						x			
Lower San Luis Rey River	x					x			x
Lower Santa Clara River							x	x	
Lower Santa Ysabel Creek							x		x
Lusardi Creek						x	x	x	x
Machado Lake						x	x		
Matilija Creek							x	x	x
Middle San Luis Rey River						x	x		x
Middle Sweetwater River							x	x	x
Mojave River (Lower)									x
North Fork San Onofre Canyon							x	x	x
Oso Creek						x			
Piedra de Lumbre Canyon							x		x
Pilgrim Creek						x			x
Prado Basin								x	
Rancho Jamul Ecological Reserve									x
Salsipuedes Creek									x
Salt Creek						x			
San Antonio Creek									x
San Diego Creek	x					x	x	x	x
San Diego River						x	x	x	x
San Dieguito Creek									x
San Francisquito Canyon							x		
San Jacinto Wildlife Area		x				x			x
San Marcos Creek						x	x		x
San Mateo Canyon							x		x
San Mateo Creek						x	x		x
San Vicente Creek						x	x		x
Santa Ana River									x
Santa Margarita River	x					x	x	x	x
Santa Maria Creek							x		x
Santa Ynez River									x
Sycamore Canyon							x		
Temecula Creek									x
Temescal Creek (Santa Ysabel)									x
Ventura River									x
Victorville									x
Rio Hondo						x			
San Dieguito River									x
San Jacinto River						x			x
San Luis Rey River							x		x
Santa Ysabel Creek									x
Sweetwater River						x			x

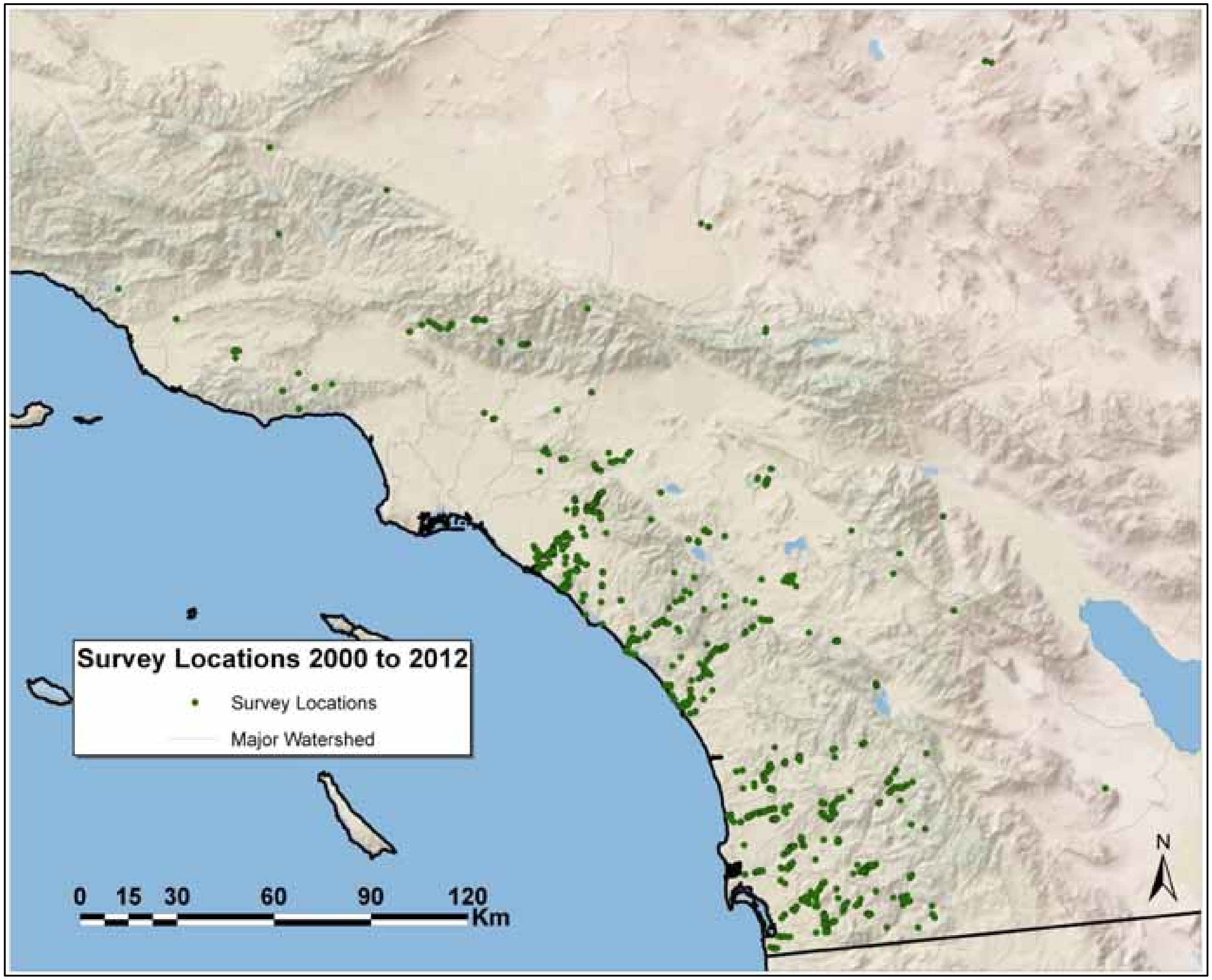


Figure 1. Survey locations for western pond turtles from 2000-2012. Includes both turtle trapping and visual encounter surveys (514 sites; 3,545 individual events). Includes data from CDFG, Western Riverside County MSHCP, United Water District, and RCD of the Santa Monica Mountains.

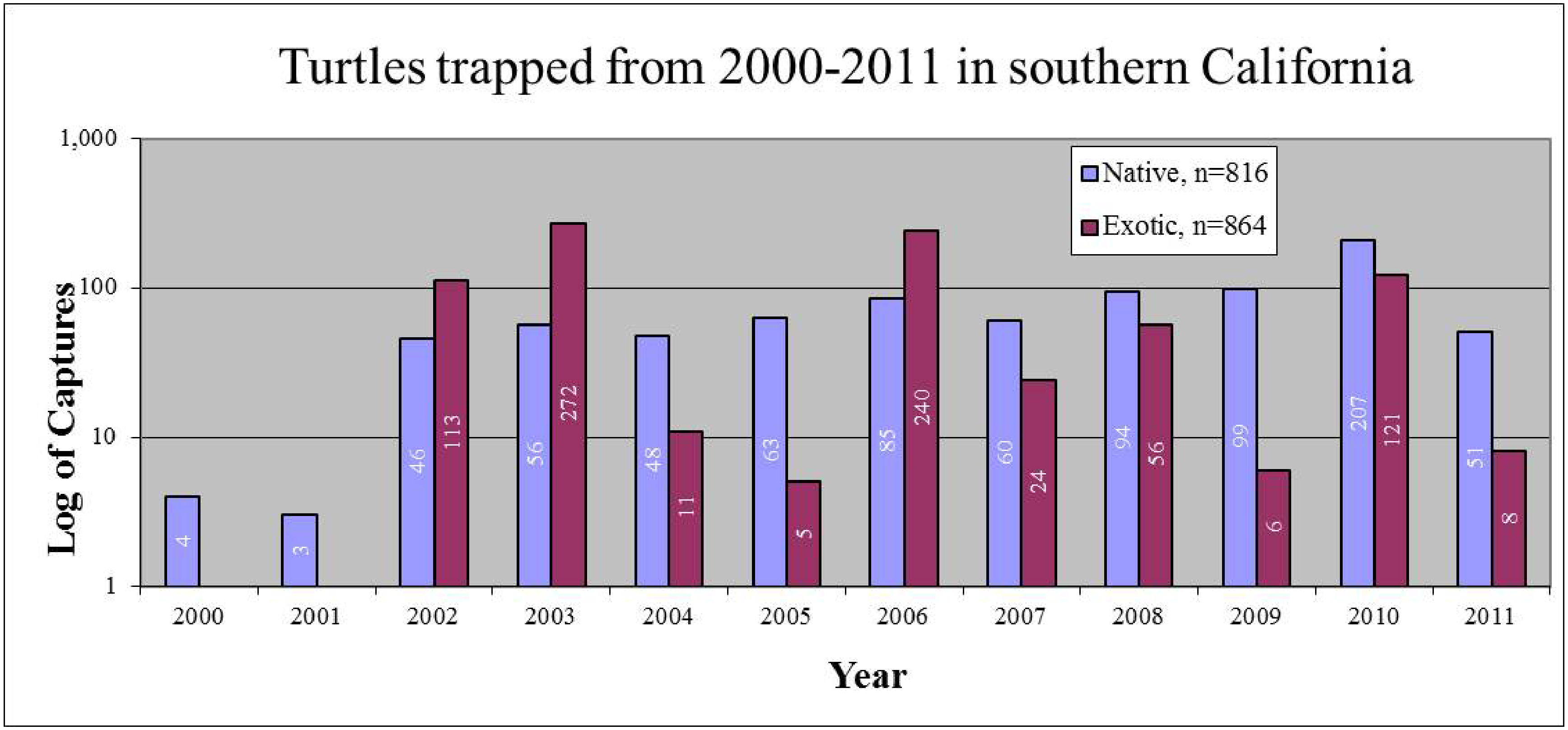


Figure 2. Survey results for western pond turtles from 2000-2011. Includes turtle trapping surveys only. Includes data from USGS and CDFG.

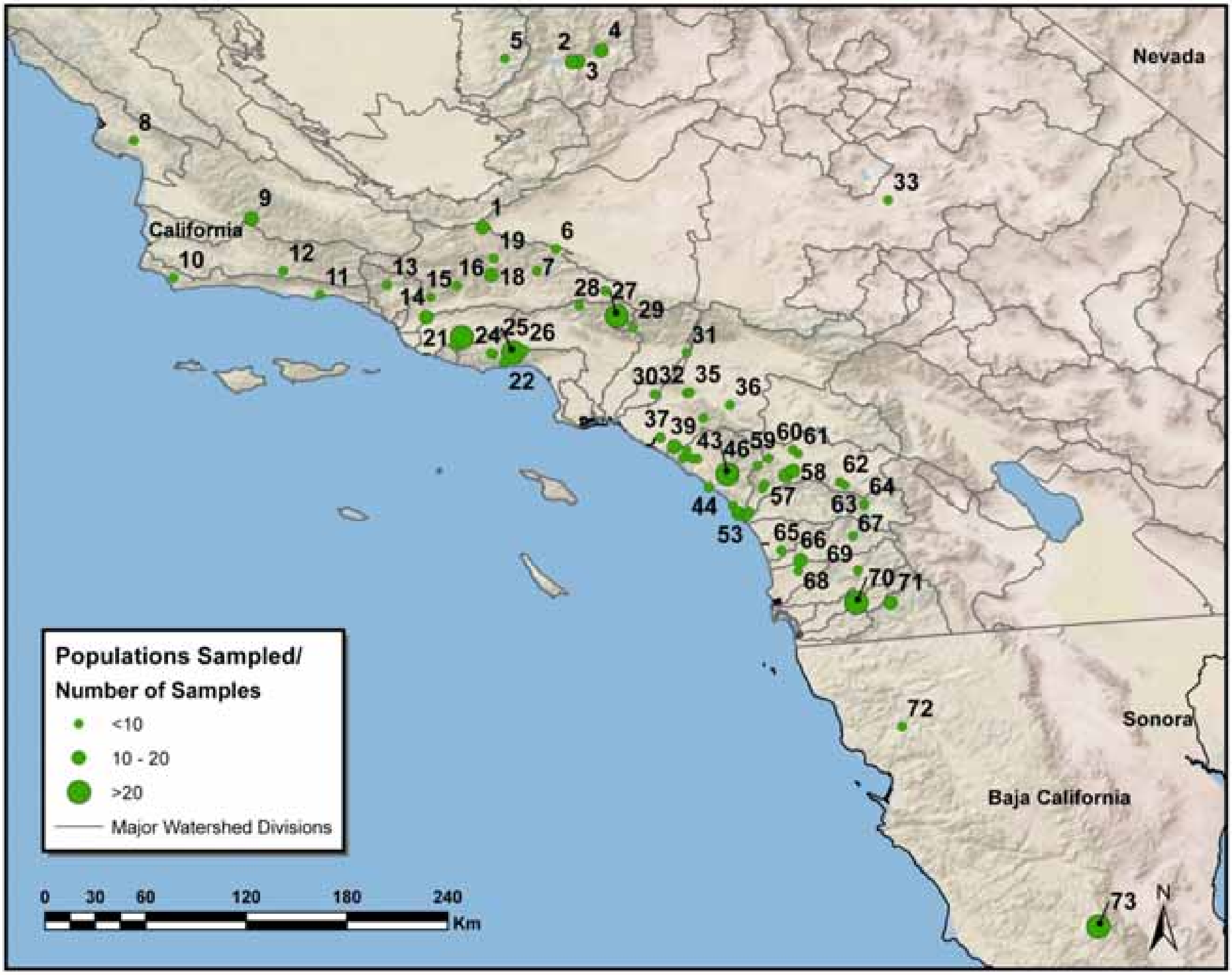


Figure 3. Western pond turtles included in the SNP genetic analysis. This includes turtles previously collected by Dan Holland and available through UC Davis. Population numbers are referred to in the text and in the STRUCTURE results. Size of point relates to sample size for that population. 4 digit HUCs are overlaid, which are the same as the CalWatershed Level 2 subregions.

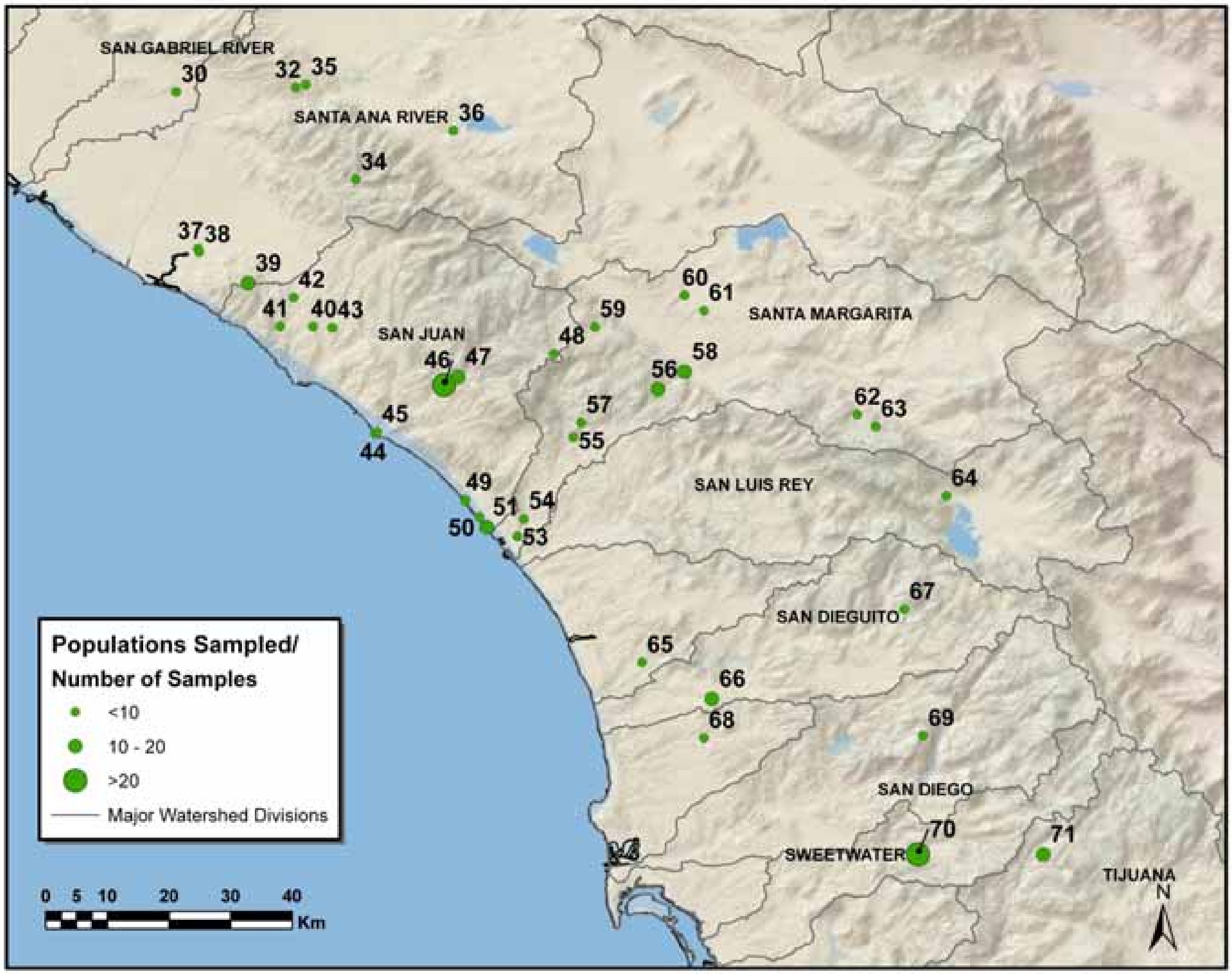


Figure 4. Samples from San Diego and Orange counties. Turtles included in the SNP genetic analysis, close-up of the San Diego and Orange County populations included in this study. Population numbers are referred to in the text and on the STRUCTURE results. Size of point relates to sample size for that population.

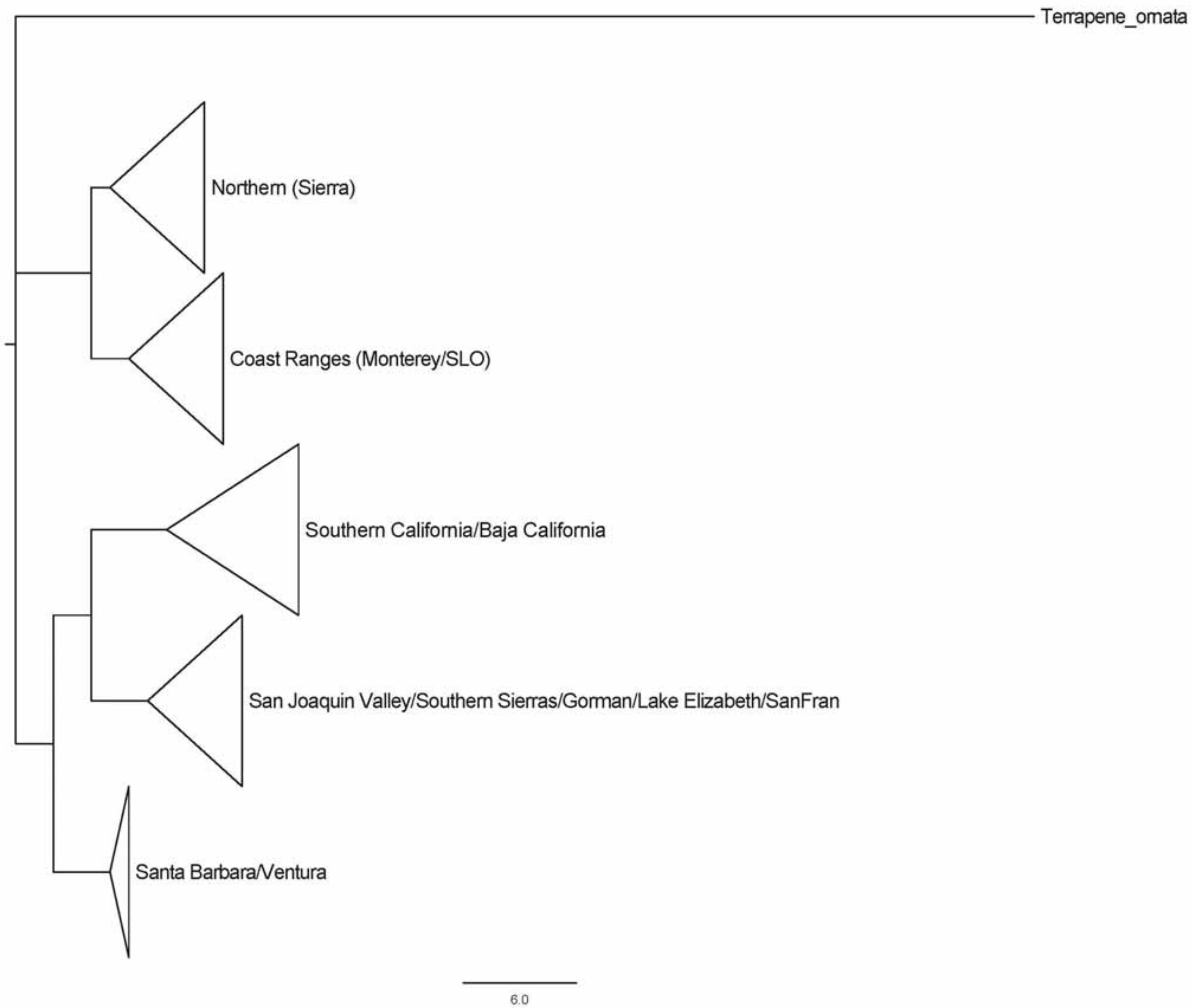


Figure 5. Neighbor Joining tree for western pond turtles. Neighbor Joining tree for pond turtles (mtDNA), including new sequence data for 200+ individuals for southern California. Includes already published data from Spinks and Shaffer (2005) and Spinks et al. (2010). These clade names are used in the text.

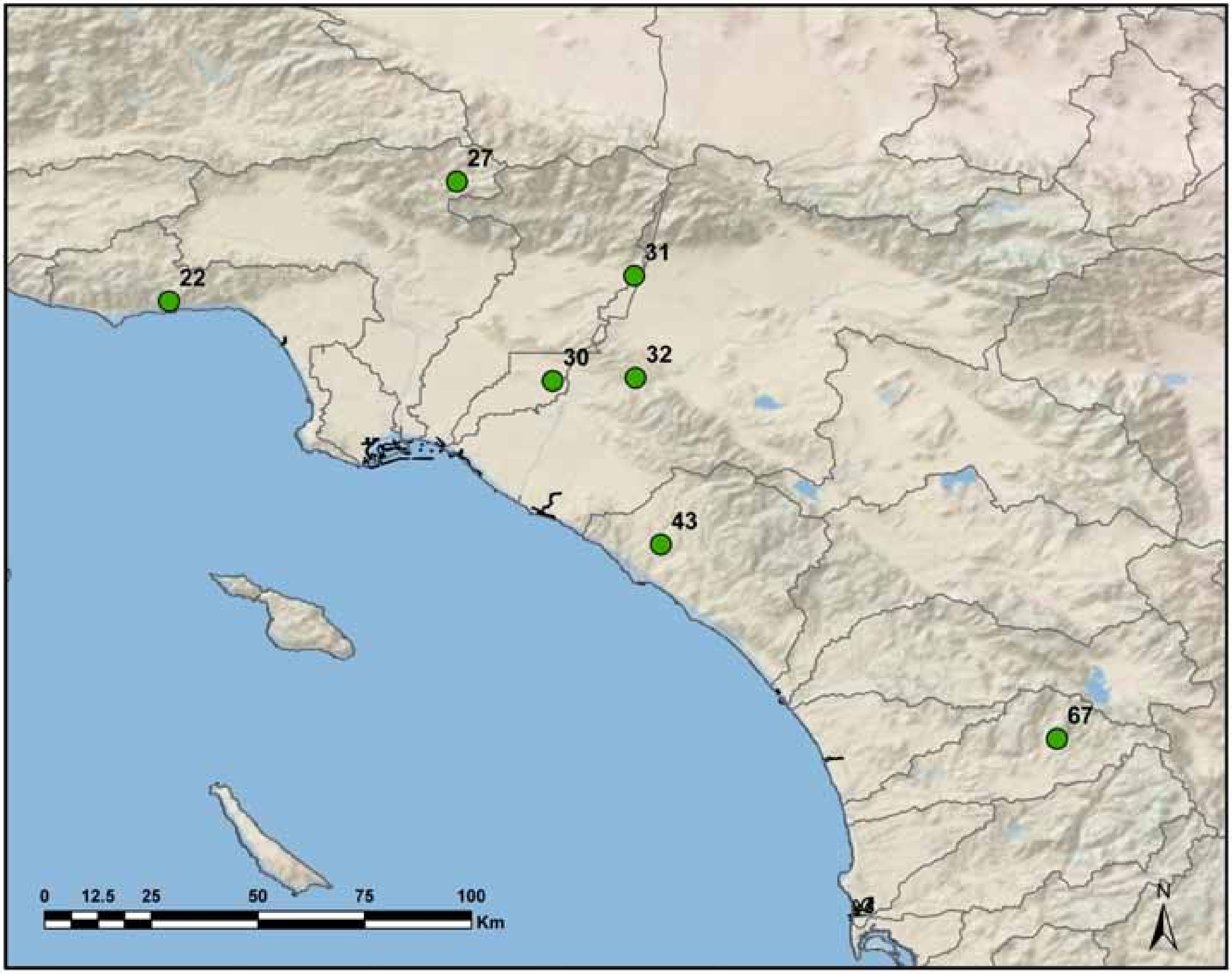


Figure 6. Translocated western pond turtles. Sites where "introduced" pond turtles were identified using the genetic techniques. This is evidence that there is more movement of turtles in southern California by people then is documented.

Figure 7. Western pond turtle condition. Pond turtle (TM8-11-13) captured in 2008 along Santa Ysabel Creek, San Diego County, upstream of San Pasqual Valley and downstream of Boden Canyon, found during post-fire arroyo toad surveys. This turtle was thought to be native, and was pit-tagged and released. We know from the mtDNA results that it is from northern California, probably from the Sierra Nevadas, and was released or escaped as a pet. Fresh chew marks are seen on its shell.

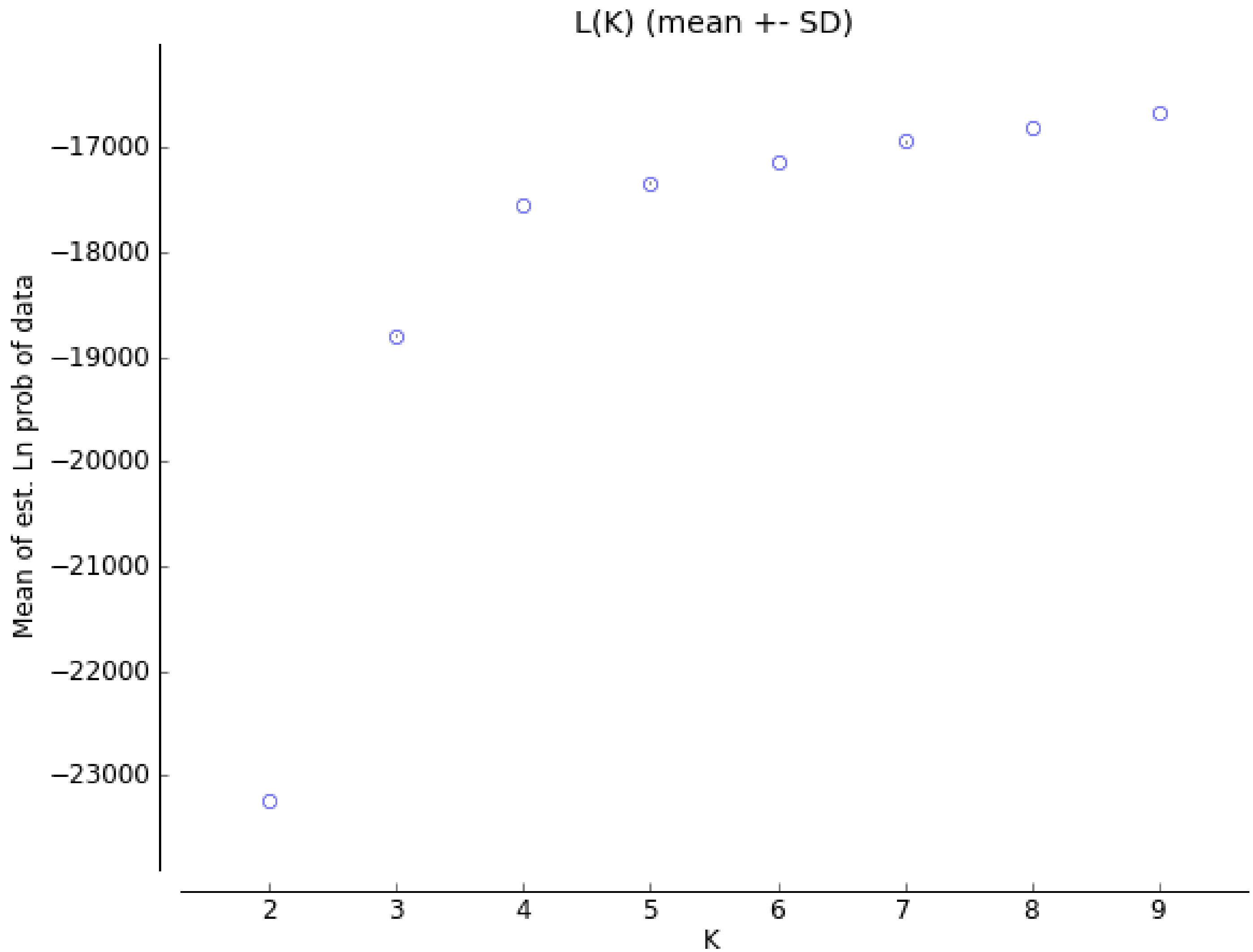


Figure 8. Analysis of SNP variation. Analysis of SNP variation in pond turtles utilizing Structure v2.2.3. Plot of posterior likelihood of the data with increasing number of clusters (*K*), greatest gain is *K*=3, with no distinct plateau (*K*: 4 – 9).

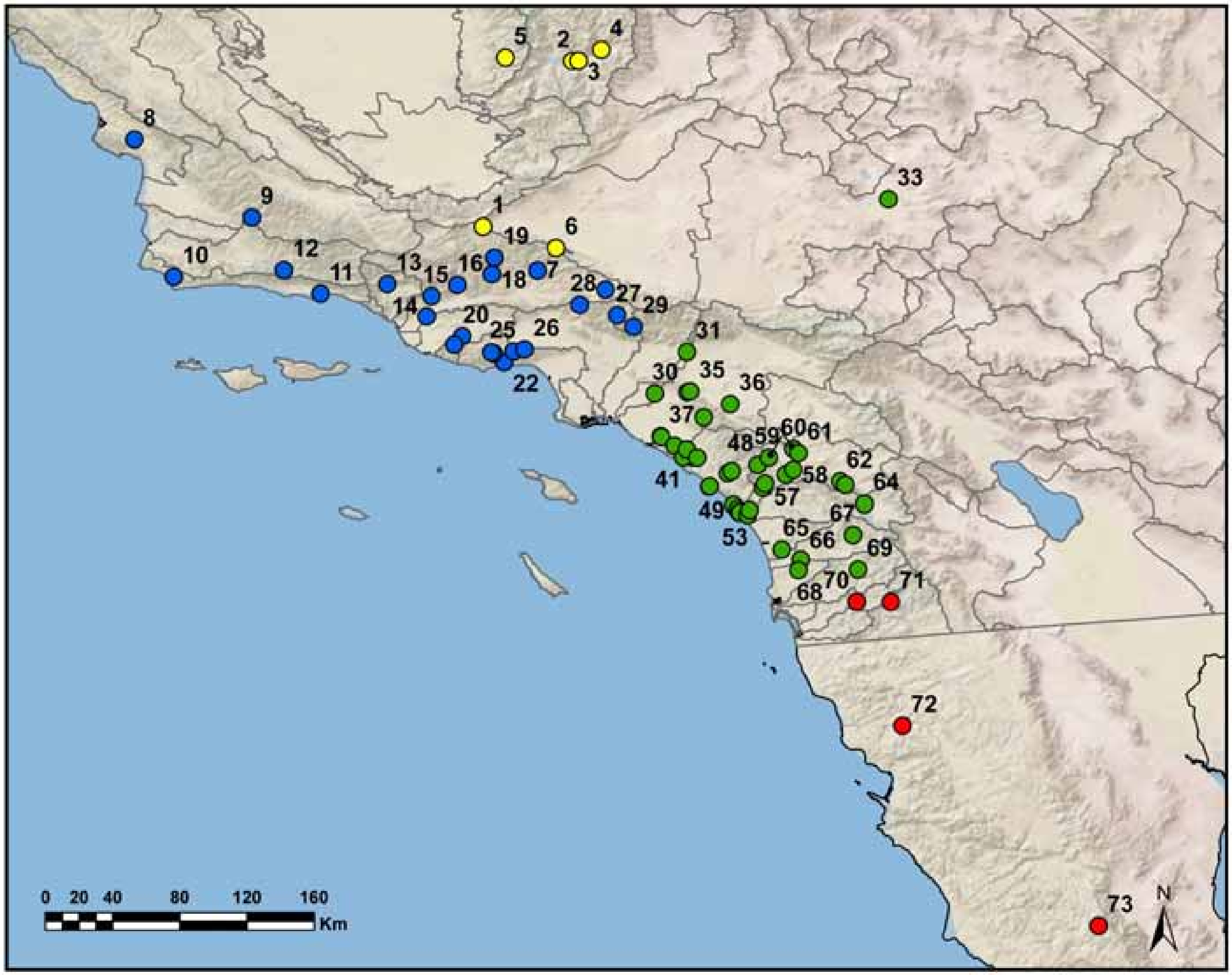


Figure 9. Assignment of SNP variation. Assignment of SNP variation in pond turtles utilizing Structure v2.2.3, and *K*=4. Different color relate to different groupings from the analysis.

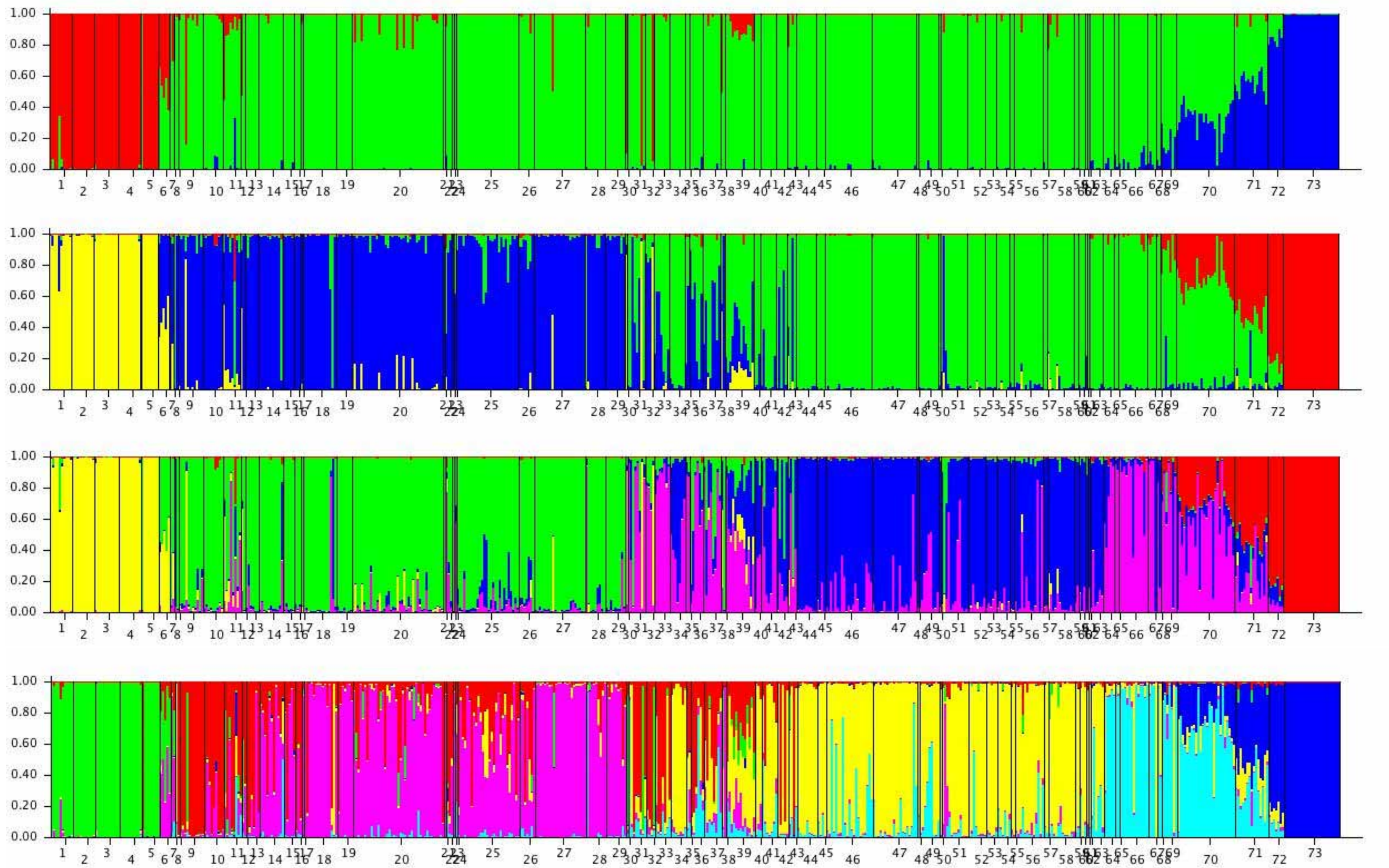


Figure 10. Bar plots of posterior probabilities of individuals. Bar plots of posterior probabilities of individuals generated using Structure v2.2.3. Plots are ordered for cluster membership, from top, *K*=3, *K*=4, *K*=5, and *K*=6. 580 individual turtles are represented on each plot. Population numbers relate to Table 1 and are ordered from north to south (left to right).

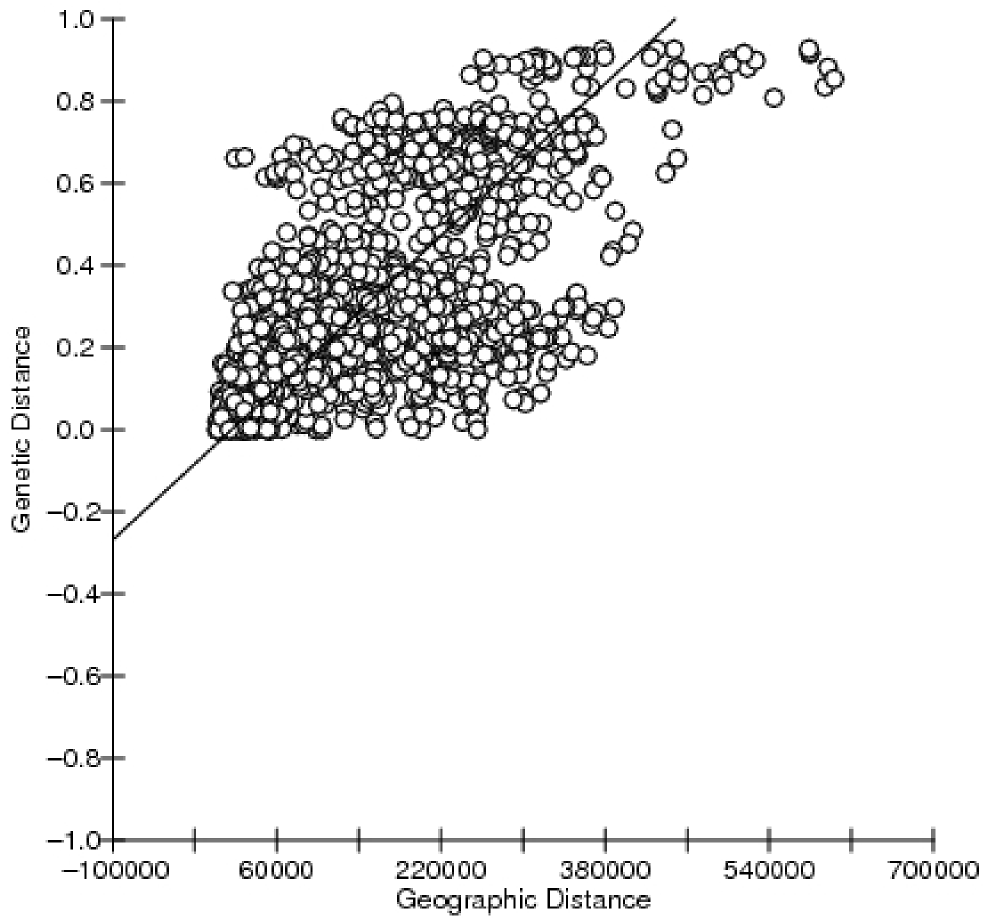


Figure 11. Pairwise Fst Values for all populations. Pairwise Fst Values for all populations plotted against the geographic distance between populations illustrating a pattern of isolation by distance within between the populations of this species that were sampled.

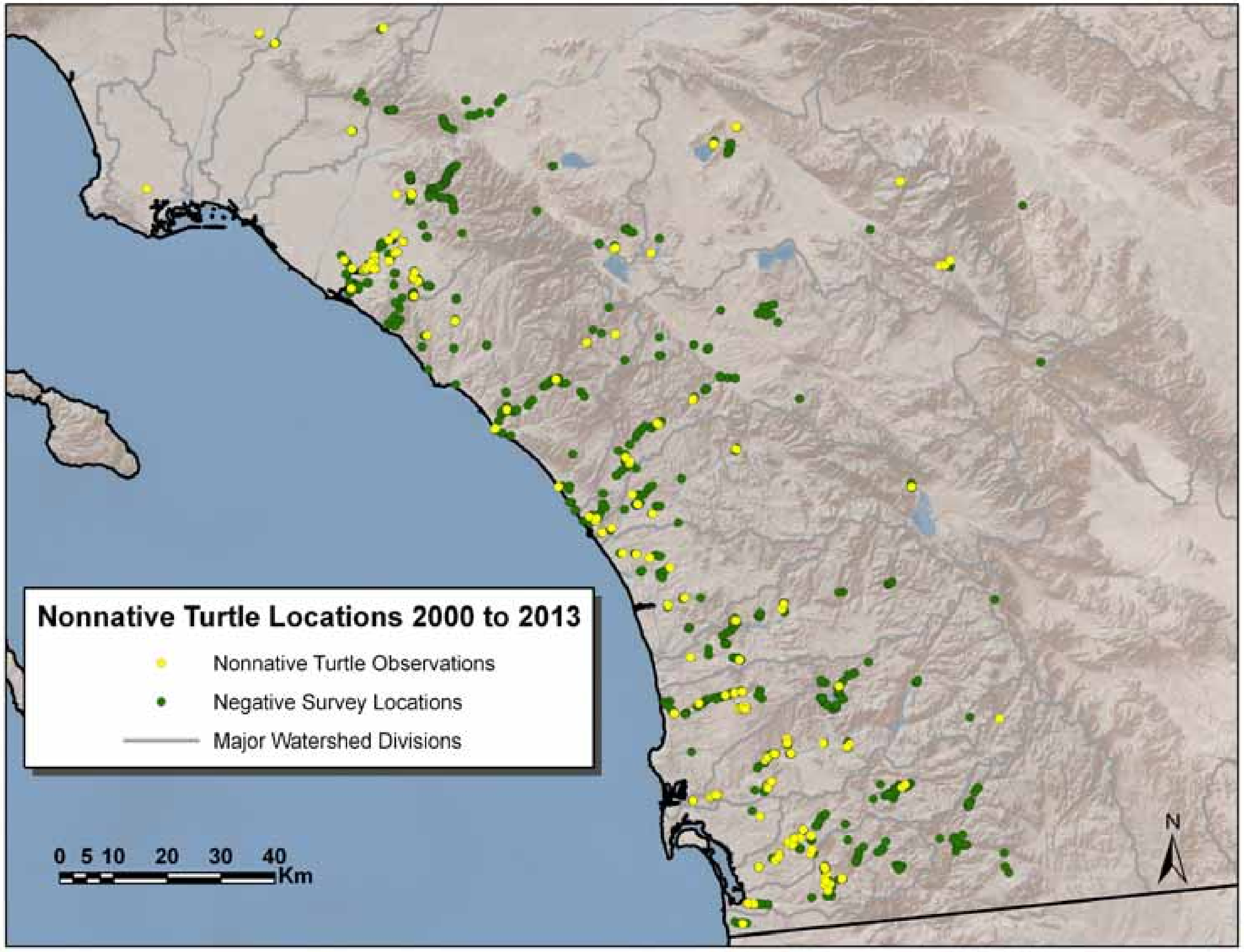


Figure 12. Nonnative Turtle Observations 2000 to 2013. Observations of nonnative turtles from stream surveys from 2000 to 2013 and include turtles from the genera *Apalone*, *Chelydra*, *Chrysemys*, *Graptemys*, *Kinosternon*, and *Trachemys*.

Appendix I: Individual samples utilized in study.

Sample ID	County	Watershed	Site Name	Latitude	Longitude	Year	Pop
CB102410	Los Angeles	Santa Clara	Gorman Pond	34.782653	-118.805462	2010	1
CB102411	Los Angeles	Santa Clara	Gorman Pond	34.782772	-118.805508	2010	1
CB102412	Los Angeles	Santa Clara	Gorman Pond	34.782952	-118.805592	2010	1
CB102413	Los Angeles	Santa Clara	Gorman Pond	34.782668	-118.805488	2010	1
CB102414	Los Angeles	Santa Clara	Gorman Pond	34.782493	-118.805365	2010	1
CB10245	Los Angeles	Santa Clara	Gorman Pond	34.782790	-118.805525	2010	1
CB10246	Los Angeles	Santa Clara	Gorman Pond	34.782827	-118.805545	2010	1
CB10247	Los Angeles	Santa Clara	Gorman Pond	34.782768	-118.805498	2010	1
CB10248	Los Angeles	Santa Clara	Gorman Pond	34.782642	-118.805485	2010	1
CB10249	Los Angeles	Santa Clara	Gorman Pond	34.782892	-118.805402	2010	1
HBS116072	Kern	Kern	South Fork Kern River	35.672100	-118.327600	c1990	2
HBS116073	Kern	Kern	South Fork Kern River	35.672100	-118.327600	c1990	2
HBS116074	Kern	Kern	South Fork Kern River	35.672100	-118.327600	c1990	2
HBS116076	Kern	Kern	South Fork Kern River	35.672100	-118.327600	c1990	2
HBS116077	Kern	Kern	South Fork Kern River	35.672100	-118.327600	c1990	2
HBS116078	Kern	Kern	South Fork Kern River	35.672100	-118.327600	c1990	2
HBS116079	Kern	Kern	South Fork Kern River	35.672100	-118.327600	c1990	2
HBS116080	Kern	Kern	South Fork Kern River	35.672100	-118.327600	c1990	2
HBS116084	Kern	Kern	South Fork Kern River	35.672100	-118.327600	c1990	2
HBS39728	Kern	Kern	South Fork Kern River	35.672100	-118.327600	c1990	2
HBS115450	Kern	Kern	Mariposa Pond	35.690300	-118.238600	c1990	3
HBS115451	Kern	Kern	Mariposa Pond	35.690300	-118.238600	c1990	3
HBS39855	Kern	Kern	Mariposa Pond	35.690300	-118.238600	c1990	3
HBS114783	Kern	Kern	Mariposa Pond, TNC Kern River Preserve	35.666658	-118.312047	c1990	3
HBS115456	Kern	Kern	Mariposa Pond, TNC Kern River Preserve	35.666658	-118.312047	c1990	3
HBS115458	Kern	Kern	Mariposa Pond, TNC Kern River Preserve	35.666658	-118.312047	c1990	3
HBS115461	Kern	Kern	Mariposa Pond, TNC Kern River Preserve	35.666658	-118.312047	c1990	3
HBS115463	Kern	Kern	Mariposa Pond, TNC Kern River Preserve	35.666658	-118.312047	c1990	3
HBS115464	Kern	Kern	Mariposa Pond, TNC Kern River Preserve	35.666658	-118.312047	c1990	3
HBS115465	Kern	Kern	Mariposa Pond, TNC Kern River Preserve	35.666658	-118.312047	c1990	3
HBS39738	Kern	Kern	Mariposa Pond, Weldon	35.668419	-118.328569	c1990	3
HBS114143	Kern	Kern	Bloomfield Ranch, E of Onyx	35.732500	-118.171400	c1990	4
HBS114147	Kern	Kern	Bloomfield Ranch, E of Onyx	35.732500	-118.171400	c1990	4
HBS114151	Kern	Kern	Bloomfield Ranch, E of Onyx	35.732500	-118.171400	c1990	4

HBS114152	Kern	Kern	Bloomfield Ranch, E of Onyx	35.732500	-118.171400	c1990	4
HBS114153	Kern	Kern	Bloomfield Ranch, E of Onyx	35.732500	-118.171400	c1990	4
HBS114154	Kern	Kern	Bloomfield Ranch, E of Onyx	35.732500	-118.171400	c1990	4
HBS114155	Kern	Kern	Bloomfield Ranch, E of Onyx	35.732500	-118.171400	c1990	4
HBS114158	Kern	Kern	Bloomfield Ranch, E of Onyx	35.732500	-118.171400	c1990	4
HBS39839	Kern	Kern	Bloomfield Ranch, E of Onyx	35.732500	-118.171400	c1990	4
HBS39878	Kern	Kern	Bloomfield Ranch, E of Onyx	35.732500	-118.171400	c1990	4
HBS114304	Kern	Kern	Cedar Creek, SW of Glenville	35.689800	-118.686600	c1990	5
HBS114329	Kern	Kern	Cedar Creek, SW of Glenville	35.689800	-118.686600	c1990	5
HBS114338	Kern	Kern	Cedar Creek, SW of Glenville	35.689800	-118.686600	c1990	5
HBS114344	Kern	Kern	Cedar Creek, SW of Glenville	35.689800	-118.686600	c1990	5
HBS114345	Kern	Kern	Cedar Creek, SW of Glenville	35.689800	-118.686600	c1990	5
HBS114346	Kern	Kern	Cedar Creek, SW of Glenville	35.689800	-118.686600	c1990	5
HBS118703	Kern	Kern	Cedar Creek, SW of Glenville	35.689800	-118.686600	c1990	5
HBS39768	Kern	Kern	Cedar Creek, SW of Glenville	35.689800	-118.686600	c1990	5
CB102417	Los Angeles	Santa Clara	Elizabeth Lake	34.668910	-118.413087	2010	6
CB102418	Los Angeles	Santa Clara	Elizabeth Lake	34.668063	-118.415557	2010	6
CB102420	Los Angeles	Santa Clara	Elizabeth Lake	34.668595	-118.412272	2010	6
CB102421	Los Angeles	Santa Clara	Elizabeth Lake	34.668595	-118.412272	2010	6
CB10243	Los Angeles	Santa Clara	Elizabeth Lake	34.668432	-118.416070	2010	6
ARB9210	Los Angeles	Santa Clara	San Francisquito Canyon	34.548590	-118.511400	2009	7
SLC8159	Los Angeles	Santa Clara	San Francisquito Canyon	34.545833	-118.516133	2008	7
X416	San Luis Obispo	San Luis Obispo	San Luis Obispo Creek	35.251031	-120.676199	c1990	8
X416VTRescue	San Luis Obispo	San Luis Obispo	San Luis Obispo Creek	35.251031	-120.676199	c1990	8
HBS115415	Santa Barbara	Santa Maria	Manzana Creek, Sisquoc River	34.823800	-119.997100	c1990	9
HBS115418	Santa Barbara	Santa Maria	Manzana Creek, Sisquoc River	34.823800	-119.997100	c1990	9
HBS115419	Santa Barbara	Santa Maria	Manzana Creek, Sisquoc River	34.823800	-119.997100	c1990	9
HBS115420	Santa Barbara	Santa Maria	Manzana Creek, Sisquoc River	34.823800	-119.997100	c1990	9
HBS115421	Santa Barbara	Santa Maria	Manzana Creek, Sisquoc River	34.823800	-119.997100	c1990	9
HBS115422	Santa Barbara	Santa Maria	Manzana Creek, Sisquoc River	34.823800	-119.997100	c1990	9
HBS115446	Santa Barbara	Santa Maria	Manzana Creek, Sisquoc River	34.823800	-119.997100	c1990	9
HBS118747	Santa Barbara	Santa Maria	Manzana Creek, Sisquoc River	34.823800	-119.997100	c1990	9
HBS39856	Santa Barbara	Santa Maria	Manzana Creek, Sisquoc River	34.823800	-119.997100	c1990	9
HBS39864	Santa Barbara	Santa Maria	Manzana Creek, Sisquoc River	34.823800	-119.997100	c1990	9
JM30	Santa Barbara	Santa Maria	Orcutt Creek	34.911160	-120.534410	2010	9
HBS115237	Santa Barbara	Jalama	Jalama Creek	34.513426	-120.453833	c1990	10
HBS115238	Santa Barbara	Jalama	Jalama Creek	34.513426	-120.453833	c1990	10
HBS115239	Santa Barbara	Jalama	Jalama Creek	34.513426	-120.453833	c1990	10
HBS115240	Santa Barbara	Jalama	Jalama Creek	34.513426	-120.453833	c1990	10
HBS115241	Santa Barbara	Jalama	Jalama Creek	34.513426	-120.453833	c1990	10
HBS115242	Santa Barbara	Jalama	Jalama Creek	34.512294	-120.502049	c1990	10

HBS118736	Santa Barbara	Jalama	Jalama Creek	34.513426	-120.453833	c1990	10
HBS118737	Santa Barbara	Jalama	Jalama Creek	34.513426	-120.453833	c1990	10
HBS118738	Santa Barbara	Jalama	Jalama Creek	34.512294	-120.502049	c1990	10
TDCM01007VTRescue	Santa Barbara	Mission	Alice Keck Park	34.429050	-119.706017	2009	11
X1036	Santa Barbara	Mission	Alice Keck Park	34.429050	-119.706017	2009	11
X1037VTRescue	Santa Barbara	Mission	Alice Keck Park	34.429050	-119.706017	2009	11
X1038VTRescue	Santa Barbara	Mission	Alice Keck Park	34.429050	-119.706017	2009	11
X1039VTRescue	Santa Barbara	Mission	Alice Keck Park	34.429050	-119.706017	2009	11
X1040VTRescue	Santa Barbara	Mission	Alice Keck Park	34.429050	-119.706017	2009	11
X1VTRescue	Santa Barbara	Mission	Alice Keck Park	34.429050	-119.706017	2009	11
RINCON	Santa Barbara	Rincon	Rincon Creek	34.373567	-119.477667	c1990	11
HBS116057	Ventura	Santa Ynez	Santa Ynez	34.549700	-119.874200	c1990	12
HBS39841	Ventura	Santa Ynez	Santa Ynez	34.549700	-119.874200	c1990	12
CB10210_dup1	Ventura	Ventura	Matilija Creek	34.500770	-119.344637	2010	13
CB1024	Ventura	Ventura	Matilija Creek	34.500870	-119.344463	2010	13
CB1028	Ventura	Ventura	Matilija Creek	34.500865	-119.344552	2010	13
DRC1081	Ventura	Ventura	Matilija Creek	34.500760	-119.343898	2010	13
DRC1053	Ventura	Ventura	San Antonio Creek	34.421532	-119.266722	2010	13
DRC1054	Ventura	Ventura	San Antonio Creek	34.421570	-119.266612	2010	13
CB11241	Ventura	Santa Clara	Lower Santa Clara River	34.299460	-119.108990	2011	14
CB112410	Ventura	Santa Clara	Lower Santa Clara River	34.299690	-119.109260	2011	14
CB11242	Ventura	Santa Clara	Lower Santa Clara River	34.299460	-119.108990	2011	14
CB11243	Ventura	Santa Clara	Lower Santa Clara River	34.299460	-119.108990	2011	14
CB11244	Ventura	Santa Clara	Lower Santa Clara River	34.299460	-119.108990	2011	14
CB11245	Ventura	Santa Clara	Lower Santa Clara River	34.299000	-119.108400	2011	14
CB11246	Ventura	Santa Clara	Lower Santa Clara River	34.299460	-119.108990	2011	14
CB11247	Ventura	Santa Clara	Lower Santa Clara River	34.299690	-119.109260	2011	14
CB11248	Ventura	Santa Clara	Lower Santa Clara River	34.299690	-119.109260	2011	14
CB11249	Ventura	Santa Clara	Lower Santa Clara River	34.299690	-119.109260	2011	14
Hansen	Ventura	Santa Clara	Lower Santa Clara River	34.310800	-119.096333	c2010	14
HBS116028	Ventura	Santa Clara	Santa Paula Creek	34.408900	-119.082500	c1990	15
HBS116029	Ventura	Santa Clara	Santa Paula Creek	34.408900	-119.082500	c1990	15
HBS116030	Ventura	Santa Clara	Santa Paula Creek	34.408900	-119.082500	c1990	15
HBS39837	Ventura	Santa Clara	Santa Paula Creek	34.408900	-119.082500	c1990	15
HBS39843	Ventura	Santa Clara	Santa Paula Creek	34.408900	-119.082500	c1990	15
HBS119118	Ventura	Santa Clara	Sepse Creek	34.470180	-118.943658	c1990	16
HBS119122	Ventura	Santa Clara	Sepse Creek	34.470180	-118.943658	c1990	16
HBS119132	Ventura	Santa Clara	Sepse Creek	34.470180	-118.943658	c1990	16
KLB10174	Los Angeles	Santa Clara	Aliso Canyon	34.444420	-118.149250	2010	17
09KLB4P41	Ventura	Santa Clara	Piru Creek	34.541390	-118.770880	2009	18
HBS115754	Ventura	Santa Clara	Piru Creek	34.526977	-118.756961	c1990	18

HBS115755	Ventura	Santa Clara	Piru Creek	34.526977	-118.756961	c1990	18
HBS115756	Ventura	Santa Clara	Piru Creek	34.526977	-118.756961	c1990	18
HBS115757	Ventura	Santa Clara	Piru Creek	34.526977	-118.756961	c1990	18
HBS115758	Ventura	Santa Clara	Piru Creek	34.526977	-118.756961	c1990	18
HBS115759	Ventura	Santa Clara	Piru Creek	34.526977	-118.756961	c1990	18
HBS118772	Ventura	Santa Clara	Piru Creek	34.526977	-118.756961	c1990	18
HBS118774	Ventura	Santa Clara	Piru Creek	34.526977	-118.756961	c1990	18
HBS121128	Ventura	Santa Clara	Piru Creek	34.526977	-118.756961	c1990	18
HBS121129	Ventura	Santa Clara	Piru Creek	34.526977	-118.756961	c1990	18
HBS121130	Ventura	Santa Clara	Piru Creek	34.526977	-118.756961	c1990	18
HBS121131	Ventura	Santa Clara	Piru Creek	34.526977	-118.756961	c1990	18
HBS121132	Ventura	Santa Clara	Piru Creek	34.526977	-118.756961	c1990	18
HBS39849	Ventura	Santa Clara	Piru Creek	34.526977	-118.756961	c1990	18
HBS115760	Los Angeles	Santa Clara	Frenchmans Flat	34.616151	-118.745137	c1990	19
HBS115761	Los Angeles	Santa Clara	Frenchmans Flat	34.616151	-118.745137	c1990	19
HBS115762	Los Angeles	Santa Clara	Frenchmans Flat	34.616151	-118.745137	c1990	19
HBS115763	Los Angeles	Santa Clara	Frenchmans Flat	34.616151	-118.745137	c1990	19
HBS115764	Los Angeles	Santa Clara	Frenchmans Flat	34.616151	-118.745137	c1990	19
HBS115765	Los Angeles	Santa Clara	Frenchmans Flat	34.616151	-118.745137	c1990	19
HBS115766	Los Angeles	Santa Clara	Frenchmans Flat	34.616151	-118.745137	c1990	19
09KLB4P154	Ventura	Calleguas	RC Playfield	34.192320	-118.909760	2009	20
09KLB4P160	Ventura	Calleguas	RC Playfield	34.192320	-118.909760	2009	20
09KLB4P161	Ventura	Calleguas	RC Playfield	34.192320	-118.909760	2009	20
09KLB4P11_dup1	Ventura	Calleguas	RSV	34.149047	-118.960406	2009	20
09KLB4P12	Ventura	Calleguas	RSV	34.149047	-118.960406	2009	20
09KLB4P13	Ventura	Calleguas	RSV	34.149047	-118.960406	2009	20
09KLB4P14	Ventura	Calleguas	RSV	34.149047	-118.960406	2009	20
09KLB4P15	Ventura	Calleguas	RSV	34.149047	-118.960406	2009	20
09KLB4P16	Ventura	Calleguas	RSV	34.149047	-118.960406	2009	20
09KLB4P17	Ventura	Calleguas	RSV	34.149047	-118.960406	2009	20
09KLB4P18	Ventura	Calleguas	RSV	34.149047	-118.960406	2009	20
09KLB4P19	Ventura	Calleguas	RSV	34.149047	-118.960406	2009	20
09KLB4P20	Ventura	Calleguas	RSV	34.149047	-118.960406	2009	20
09KLB4P24	Ventura	Calleguas	RSV	34.149047	-118.960406	2009	20
09KLB4P105	Ventura	Calleguas	Upper Calleguas	34.210660	-118.916090	2009	20
09KLB4P114	Ventura	Calleguas	Upper Calleguas	34.214360	-118.913730	2009	20
09KLB4P115	Ventura	Calleguas	Upper Calleguas	34.214360	-118.913730	2009	20
09KLB4P122	Ventura	Calleguas	Upper Calleguas	34.214360	-118.913730	2009	20
09KLB4P123	Ventura	Calleguas	Upper Calleguas	34.214360	-118.913730	2009	20
09KLB4P124	Ventura	Calleguas	Upper Calleguas	34.214360	-118.913730	2009	20
09KLB4P125	Ventura	Calleguas	Upper Calleguas	34.214360	-118.913730	2009	20

09KLB4P126	Ventura	Calleguas	Upper Calleguas	34.214360	-118.913730	2009	20
09KLB4P128	Ventura	Calleguas	Upper Calleguas	34.214490	-118.910680	2009	20
09KLB4P129	Ventura	Calleguas	Upper Calleguas	34.213030	-118.902380	2009	20
09KLB4P130	Ventura	Calleguas	Upper Calleguas	34.210660	-118.916090	2009	20
09KLB4P132	Ventura	Calleguas	Upper Calleguas	34.210660	-118.887840	2009	20
09KLB4P133	Ventura	Calleguas	Upper Calleguas	34.210660	-118.887840	2009	20
09KLB4P134	Ventura	Calleguas	Upper Calleguas	34.210660	-118.887840	2009	20
09KLB4P135	Ventura	Calleguas	Upper Calleguas	34.210660	-118.887840	2009	20
09KLB4P136	Ventura	Calleguas	Upper Calleguas	34.210660	-118.887840	2009	20
09KLB4P137	Ventura	Calleguas	Upper Calleguas	34.210660	-118.887840	2009	20
09KLB4P138	Ventura	Calleguas	Upper Calleguas	34.210660	-118.887840	2009	20
09KLB4P141	Ventura	Calleguas	Upper Calleguas	34.210660	-118.887840	2009	20
09KLB4P144	Ventura	Calleguas	Upper Calleguas	34.210660	-118.887840	2009	20
09KLB4P145	Ventura	Calleguas	Upper Calleguas	34.210660	-118.887840	2009	20
09KLB4P147	Ventura	Calleguas	Upper Calleguas	34.210660	-118.887840	2009	20
09KLB4P148	Ventura	Calleguas	Upper Calleguas	34.212670	-118.897870	2009	20
09KLB4P149	Ventura	Calleguas	Upper Calleguas	34.212670	-118.897870	2009	20
09KLB4P150	Ventura	Calleguas	Upper Calleguas	34.213230	-118.909520	2009	20
09KLB4P151	Ventura	Calleguas	Upper Calleguas	34.214490	-118.910680	2009	20
90KLB4P110	Ventura	Calleguas	Upper Calleguas	34.210660	-118.916090	2009	20
09KLB4P10	Ventura	Trancas	Trancas	34.149047	-118.960406	2009	21
09KLB4P100	Los Angeles	Malibu	Malibu Creek Lower	34.058970	-118.692400	2009	22
09KLB4P97	Los Angeles	Malibu	Malibu Creek Lower	34.053100	-118.693040	2009	22
09KLB4P98	Los Angeles	Malibu	Malibu Creek Lower	34.053100	-118.693040	2009	22
09KLB4P103	Los Angeles	Malibu	Malibu Creek	34.102730	-118.749460	2009	23
09KLB4P104	Los Angeles	Malibu	Malibu Creek	34.107310	-118.761360	2009	24
09KLB4P44	Los Angeles	Topanga	Waterfall_Zpond	34.112550	-118.641560	2009	25
09KLB4P46	Los Angeles	Topanga	Waterfall_Zpond	34.112550	-118.641560	2009	25
09KLB4P55	Los Angeles	Topanga	Waterfall_Zpond	34.112670	-118.641650	2009	25
09KLB4P57	Los Angeles	Topanga	Waterfall_Zpond	34.112670	-118.641650	2009	25
09KLB4P65	Los Angeles	Topanga	Waterfall_Zpond	34.112670	-118.641650	2009	25
09KLB4P67	Los Angeles	Topanga	Waterfall_Zpond	34.112670	-118.641650	2009	25
09KLB4P68	Los Angeles	Topanga	Waterfall_Zpond	34.112670	-118.641650	2009	25
09KLB4P69	Los Angeles	Topanga	Waterfall_Zpond	34.112670	-118.641650	2009	25
09KLB4P71	Los Angeles	Topanga	Waterfall_Zpond	34.112942	-118.640769	2009	25
09KLB4P72	Los Angeles	Topanga	Waterfall_Zpond	34.112942	-118.640769	2009	25
09KLB4P73	Los Angeles	Topanga	Waterfall_Zpond	34.112942	-118.640769	2009	25
09KLB4P74	Los Angeles	Topanga	Waterfall_Zpond	34.112942	-118.640769	2009	25
09KLB4P92	Los Angeles	Topanga	Waterfall_Zpond	34.111983	-118.642578	2009	25
09KLB4P93	Los Angeles	Topanga	Waterfall_Zpond	34.111983	-118.642578	2009	25
09KLB4P94	Los Angeles	Topanga	Waterfall_Zpond	34.111983	-118.642578	2009	25

09KLB4P95	Los Angeles	Topanga	Waterfall_Zpond	34.111983	-118.642578	2009	25
09KLB4P96	Los Angeles	Topanga	Waterfall_Zpond	34.111983	-118.642578	2009	25
JM10a_rep213ngul	Los Angeles	Topanga	Waterfall_Zpond	34.112942	-118.640769	2009	25
JM11	Los Angeles	Topanga	Waterfall_Zpond	34.112670	-118.641650	2009	25
JM12a_rep226ngul	Los Angeles	Topanga	Waterfall_Zpond	34.112670	-118.641650	2009	25
JM13	Los Angeles	Topanga	Waterfall_Zpond	34.112670	-118.641650	2009	25
JM14	Los Angeles	Topanga	Waterfall_Zpond	34.112670	-118.641650	2009	25
JM3	Los Angeles	Topanga	Waterfall_Zpond	34.112550	-118.641560	2009	25
JM4	Los Angeles	Topanga	Waterfall_Zpond	34.112550	-118.641560	2009	25
JM5	Los Angeles	Topanga	Waterfall_Zpond	34.112550	-118.641560	2009	25
JM7	Los Angeles	Topanga	Waterfall_Zpond	34.112942	-118.640769	2009	25
JM8a_rep217ngul	Los Angeles	Topanga	Waterfall_Zpond	34.112942	-118.640769	2009	25
JM9	Los Angeles	Topanga	Waterfall_Zpond	34.112942	-118.640769	2009	25
09KLB4P162	Los Angeles	Topanga	SM Prec	34.123406	-118.583536	2009	26
09KLB4P163	Los Angeles	Topanga	SM Prec	34.123406	-118.583536	2009	26
09KLB4P87	Los Angeles	Topanga	SM Prec	34.123406	-118.583536	2009	26
09KLB4P88	Los Angeles	Topanga	SM Prec	34.123406	-118.583536	2009	26
09KLB4P89	Los Angeles	Topanga	SM Prec	34.123406	-118.583536	2009	26
09KLB4P90	Los Angeles	Topanga	SM Prec	34.123406	-118.583536	2009	26
09KLB4P91	Los Angeles	Topanga	SM Prec	34.123406	-118.583536	2009	26
BTuj11	Los Angeles	Los Angeles	Big Tujunga Creek	34.307678	-118.076988	2009	27
BTuj13	Los Angeles	Los Angeles	Big Tujunga Creek	34.310970	-118.114440	2009	27
BTuj14	Los Angeles	Los Angeles	Big Tujunga Creek	34.307720	-118.077050	2009	27
BTuj141	Los Angeles	Los Angeles	Big Tujunga Creek	34.307595	-118.074863	2009	27
BTuj16	Los Angeles	Los Angeles	Big Tujunga Creek	34.306898	-118.074168	2009	27
BTuj18	Los Angeles	Los Angeles	Big Tujunga Creek	34.306898	-118.074168	2009	27
BTuj19	Los Angeles	Los Angeles	Big Tujunga Creek	34.310643	-118.094775	2009	27
BTuj24	Los Angeles	Los Angeles	Big Tujunga Creek	34.307715	-118.076040	2009	27
BTuj28	Los Angeles	Los Angeles	Big Tujunga Creek	34.307835	-118.075990	2009	27
BTuj29	Los Angeles	Los Angeles	Big Tujunga Creek	34.307595	-118.074863	2009	27
BTuj30	Los Angeles	Los Angeles	Big Tujunga Creek	34.307595	-118.074863	2009	27
BTuj33	Los Angeles	Los Angeles	Big Tujunga Creek	34.307477	-118.074757	2009	27
BTuj34	Los Angeles	Los Angeles	Big Tujunga Creek	34.307477	-118.074757	2009	27
BTuj37	Los Angeles	Los Angeles	Big Tujunga Creek	34.307477	-118.074757	2009	27
BTuj41	Los Angeles	Los Angeles	Big Tujunga Creek	34.307852	-118.076062	2009	27
BTuj42	Los Angeles	Los Angeles	Big Tujunga Creek	34.307852	-118.076062	2009	27
BTuj43	Los Angeles	Los Angeles	Big Tujunga Creek	34.307852	-118.076062	2009	27
BTuj44	Los Angeles	Los Angeles	Big Tujunga Creek	34.307852	-118.076062	2009	27
BTuj45	Los Angeles	Los Angeles	Big Tujunga Creek	34.307852	-118.076062	2009	27
DRC104515	Los Angeles	Los Angeles	Big Tujunga Creek	34.311050	-118.103628	2010	27
SLC910832	Los Angeles	Los Angeles	Big Tujunga Creek	34.307477	-118.074757	2009	27

SLC910838	Los Angeles	Los Angeles	Big Tujunga Creek	34.307835	-118.075990	2009	27
BTuj23	Los Angeles	Los Angeles	Big Tujunga Creek 2	34.297673	-118.240310	2009	27
CB101987	Los Angeles	Los Angeles	Pacoima Wash	34.362548	-118.288803	2010	28
CB101988	Los Angeles	Los Angeles	Pacoima Wash	34.363087	-118.288160	2010	28
LG99110	Los Angeles	Los Angeles	Pacoima Wash	34.363390	-118.287070	2009	28
LG99111	Los Angeles	Los Angeles	Pacoima Wash	34.363390	-118.287070	2009	28
LG9913	Los Angeles	Los Angeles	Pacoima Wash	34.363370	-118.287060	2009	28
LG9914	Los Angeles	Los Angeles	Pacoima Wash	34.363390	-118.287060	2009	28
LG9915	Los Angeles	Los Angeles	Pacoima Wash	34.363390	-118.287070	2009	28
LG9917	Los Angeles	Los Angeles	Pacoima Wash	34.363390	-118.287070	2009	28
LG9918	Los Angeles	Los Angeles	Pacoima Wash	34.363390	-118.287070	2009	28
ARB10261	Los Angeles	San Gabriel	Chileno Cyn_WFSG	34.242900	-117.950540	2010	29
ARB10262	Los Angeles	San Gabriel	Chileno Cyn_WFSG	34.242650	-117.950200	2010	29
FG110411	Los Angeles	San Gabriel	Chileno Cyn_WFSG	34.241362	-117.951300	2010	29
FG11047	Los Angeles	San Gabriel	Chileno Cyn_WFSG	34.242680	-117.950125	2010	29
FG11048	Los Angeles	San Gabriel	Chileno Cyn_WFSG	34.242277	-117.949992	2010	29
HBS116217	Los Angeles	San Gabriel	West Fork San Gabriel	34.248770	-118.059415	c1990	29
HBS116218	Los Angeles	San Gabriel	West Fork San Gabriel	34.248770	-118.059415	c1990	29
HBS116219	Los Angeles	San Gabriel	West Fork San Gabriel	34.248770	-118.059415	c1990	29
HBS119202	Los Angeles	San Gabriel	West Fork San Gabriel	34.248770	-118.059415	c1990	29
SLC65983	Orange	FAKE	Fullerton Arboretum	33.887233	-117.884283	2006	30
HBS114099	Los Angeles	FAKE	BBFS Pond	34.109020	-117.712551	c1990	31
HBS114100	Los Angeles	FAKE	BBFS Pond	34.109020	-117.712551	c1990	31
MSC1091	Los Angeles	FAKE	BBFS Pond	34.108970	-117.712310	2010	31
MSC1092	Los Angeles	FAKE	BBFS Pond	34.109192	-117.712172	2010	31
MSC1093	Los Angeles	FAKE	BBFS Pond	34.109137	-117.712495	2010	31
MSC1094	Los Angeles	FAKE	BBFS Pond	34.109190	-117.712568	2010	31
MSC1095	Los Angeles	FAKE	BBFS Pond	34.109353	-117.712388	2010	31
MSC1096	Los Angeles	FAKE	BBFS Pond	34.109137	-117.712495	2010	31
HBS114231	San Bernardino	Santa Ana	Gordon Ranch	33.975004	-117.746288	c1990	32
09KLB4P203	Riverside	Santa Ana	Norco Pools	33.944300	-117.581472	2009	32
SLC6731	Orange	Santa Ana	Santa Ana River	33.734520	-117.906610	2006	32
CB11251	Riverside	Santa Ana	Santa Ana River (Riv)	33.920000	-117.605190	2011	32
HBS118683	San Bernardino	Mojave	Camp Cady	34.930400	-116.631400	c1990	33
HBS118684	San Bernardino	Mojave	Camp Cady	34.930400	-116.631400	c1990	33
HBS118685	San Bernardino	Mojave	Camp Cady	34.930400	-116.631400	c1990	33
HBS118686	San Bernardino	Mojave	Camp Cady	34.930400	-116.631400	c1990	33
HBS39725	San Bernardino	Mojave	Camp Cady	34.930400	-116.631400	c1990	33
HBS39726	San Bernardino	Mojave	Camp Cady	34.930400	-116.631400	c1990	33
HBS39727	San Bernardino	Mojave	Camp Cady	34.930400	-116.631400	c1990	33
LG8471	Orange	Santa Ana	Ladd Canyon	33.759200	-117.622130	2008	34

LG84710	Orange	Santa Ana	Ladd Canyon	33.759120	-117.620260	2008	34
LG84711	Orange	Santa Ana	Ladd Canyon	33.757880	-117.626030	2008	34
LG8472	Orange	Santa Ana	Ladd Canyon	33.759220	-117.622120	2008	34
LG8473	Orange	Santa Ana	Ladd Canyon	33.759190	-117.622100	2008	34
LG8474	Orange	Santa Ana	Ladd Canyon	33.759180	-117.622100	2008	34
LG8479	Orange	Santa Ana	Ladd Canyon	33.759180	-117.620260	2008	34
CB10229	San Bernardino	Santa Ana	Aliso Cyn	33.901673	-117.698755	2010	35
CDFG279	San Bernardino	Santa Ana	Aliso Cyn	33.894140	-117.691150	2007	35
CDFG187	Riverside	Santa Ana	Cajalco Pools	33.830460	-117.479770	2008	36
CDFG18775	Riverside	Santa Ana	Cajalco Pools	33.830460	-117.479770	2008	36
X20100512A	Riverside	Santa Ana	Cajalco Pools	33.830270	-117.479610	2010	36
X20100518A	Riverside	Santa Ana	Cajalco Pools	33.830290	-117.480100	2010	36
X20100518B	Riverside	Santa Ana	Cajalco Pools	33.830290	-117.480100	2010	36
X20100518C	Riverside	Santa Ana	Cajalco Pools	33.830190	-117.479470	2010	36
SLC655100	Orange	San Diego (OC)	San Diego Creek	33.659950	-117.852100	2006	37
SLC655107	Orange	San Diego (OC)	San Diego Creek	33.657100	-117.853400	2006	37
SLC655108	Orange	San Diego (OC)	San Diego Creek	33.657100	-117.853400	2006	37
SLC655131	Orange	San Diego (OC)	San Diego Creek	33.659833	-117.853883	2006	37
SLC655133	Orange	San Diego (OC)	San Diego Creek	33.659833	-117.853883	2006	37
SLC65586	Orange	San Diego (OC)	San Diego Creek	33.653700	-117.849350	2006	37
SLC66412	Orange	San Diego (OC)	San Diego Creek	33.657867	-117.851133	2006	37
X3148464624	Orange	San Diego (OC)	San Joaquin Freshwater Marsh	33.657200	-117.853600	2003	37
X3146550969	Orange	San Diego (OC)	San Diego Creek	33.653467	-117.848650	2003	38
X314676162_dup2	Orange	San Diego (OC)	San Diego Creek	33.651850	-117.852900	2003	38
X105	Orange	San Diego (OC)	Shady Canyon MP	33.606970	-117.779590	2005	39
X17	Orange	San Diego (OC)	Shady Canyon MP	33.606970	-117.779590	2005	39
X25	Orange	San Diego (OC)	Shady Canyon MP	33.606970	-117.779590	2005	39
X26	Orange	San Diego (OC)	Shady Canyon MP	33.606970	-117.779590	2005	39
X31	Orange	San Diego (OC)	Shady Canyon MP	33.606970	-117.779590	2005	39
X3210401411	Orange	San Diego (OC)	Shady Canyon MP	33.606970	-117.779590	2005	39
X36	Orange	San Diego (OC)	Shady Canyon MP	33.606970	-117.779590	2005	39
X38	Orange	San Diego (OC)	Shady Canyon MP	33.606970	-117.779590	2005	39
X42	Orange	San Diego (OC)	Shady Canyon MP	33.606970	-117.779590	2005	39
X51	Orange	San Diego (OC)	Shady Canyon MP	33.606970	-117.779590	2005	39
X52	Orange	San Diego (OC)	Shady Canyon MP	33.606970	-117.779590	2005	39
X56	Orange	San Diego (OC)	Shady Canyon MP	33.606970	-117.779590	2005	39
X59	Orange	San Diego (OC)	Shady Canyon MP	33.606970	-117.779590	2005	39
X26905	Orange	San Diego (OC)	Laguna Hills Lakes	33.621792	-117.730225	c1990	40
X26906	Orange	San Diego (OC)	Laguna Hills Lakes	33.621792	-117.730225	c1990	40
X26904	San Diego	San Diego (OC)	San Mateo Creek 6	33.387270	-117.593220	c1990	40
MSC10111	Orange	Aliso (OC)	Aliso Creek	33.543580	-117.728180	2010	41

MSC101110	Orange	Aliso (OC)	Aliso Creek	33.543660	-117.732800	2010	41
MSC101111	Orange	Aliso (OC)	Aliso Creek	33.543580	-117.728180	2010	41
MSC101112	Orange	Aliso (OC)	Aliso Creek	33.543580	-117.739080	2010	41
MSC101115	Orange	Aliso (OC)	Aliso Creek	33.543790	-117.732640	2010	41
MSC101116	Orange	Aliso (OC)	Aliso Creek	33.543840	-117.733190	2010	41
MSC10116	Orange	Aliso (OC)	Aliso Creek	33.543790	-117.732640	2010	41
X26898	Orange	Aliso (OC)	Aliso Crk N	33.591072	-117.711679	1997	42
X26900	Orange	Aliso (OC)	Aliso Crk N	33.585080	-117.712959	1997	42
X26901	Orange	Aliso (OC)	Aliso Crk N	33.585080	-117.712959	1997	42
X26902	Orange	Aliso (OC)	Aliso Crk N	33.585080	-117.712959	1997	42
X26903	Orange	Aliso (OC)	Aliso Crk N	33.585080	-117.712959	1997	42
10KLB4P31	Orange	San Juan	Doheney	33.461999	-117.671518	2009	43
10KLB4P30	Orange	San Juan	Mission Viejo	33.607537	-117.671518	2009	43
MSC10114	Orange	San Juan	Oso Creek	33.570450	-117.673190	2010	43
MSC10115	Orange	San Juan	San Juan Creek	33.527560	-117.608840	2010	43
ARB1045	San Diego	San Mateo	San Mateo Creek 6	33.387545	-117.592828	2010	44
SLC8381	San Diego	San Mateo	San Mateo Creek 6	33.386780	-117.594100	2008	44
SLC8382_dup1	San Diego	San Mateo	San Mateo Creek 6	33.386780	-117.594100	2008	44
SLC8383	San Diego	San Mateo	San Mateo Creek 6	33.386780	-117.594100	2008	44
SLC8384	San Diego	San Mateo	San Mateo Creek 6	33.386780	-117.594100	2008	44
SLC8411	San Diego	San Mateo	San Mateo Creek 6	33.386800	-117.594050	2008	44
SLC86645	San Diego	San Mateo	San Mateo Creek 6	33.387117	-117.593500	2008	44
SLC86649	San Diego	San Mateo	San Mateo Creek 6	33.387267	-117.593217	2008	44
SLC86684	San Diego	San Mateo	San Mateo Creek 6	33.386850	-117.593667	2008	44
HBS115911	San Diego	San Mateo	San Mateo Creek 6	33.389423	-117.590968	c1990	45
HBS115912	San Diego	San Mateo	San Mateo Creek 6	33.389423	-117.590968	c1990	45
HBS115913	San Diego	San Mateo	San Mateo Creek 6	33.389423	-117.590968	c1990	45
HBS115914	San Diego	San Mateo	San Mateo Creek 6	33.389423	-117.590968	c1990	45
CSB4152	San Diego	San Mateo	San Mateo Creek 1	33.469200	-117.475783	2004	46
KLB102210	San Diego	San Mateo	San Mateo Creek 1	33.470760	-117.471760	2010	46
KLB102213	San Diego	San Mateo	San Mateo Creek 1	33.470560	-117.470740	2010	46
SLC86634	San Diego	San Mateo	San Mateo Creek 1	33.470433	-117.470650	2008	46
SLC86636	San Diego	San Mateo	San Mateo Creek 1	33.470433	-117.470650	2008	46
SLC86654	San Diego	San Mateo	San Mateo Creek 1	33.470433	-117.470650	2008	46
SLC86655	San Diego	San Mateo	San Mateo Creek 1	33.470433	-117.470650	2008	46
SLC86672	San Diego	San Mateo	San Mateo Creek 1	33.470400	-117.470750	2008	46
SLC8668	San Diego	San Mateo	San Mateo Creek 1	33.470433	-117.470650	2008	46
SLC8669	San Diego	San Mateo	San Mateo Creek 1	33.470433	-117.470650	2008	46
WSD1068	San Diego	San Mateo	San Mateo Creek 1	33.470513	-117.470873	2010	46
JM21a_rep216ngul	San Diego	San Mateo	San Mateo Creek 2	33.460820	-117.491620	2010	46
JM26	San Diego	San Mateo	San Mateo Creek 2	33.462670	-117.489750	2010	46

JM27	San Diego	San Mateo	San Mateo Creek 2	33.462600	-117.489820	2010	46
JM29	San Diego	San Mateo	San Mateo Creek 2	33.460820	-117.491620	2010	46
JM32	San Diego	San Mateo	San Mateo Creek 2	33.461500	-117.489900	2010	46
WSD10610	San Diego	San Mateo	San Mateo Creek 2	33.460687	-117.491440	2010	46
JM31	San Diego	San Mateo	San Mateo Creek 3	33.435500	-117.520030	2010	46
WSD1061	San Diego	San Mateo	San Mateo Creek 4	33.418783	-117.553922	2010	46
JM24	San Diego	San Mateo	San Mateo Creek 5	33.412098	-117.579543	2010	46
JM25b_rep331ngul	San Diego	San Mateo	San Mateo Creek 5	33.412105	-117.579468	2010	46
HBS115915	San Diego	San Mateo	San Mateo Creek 1	33.469800	-117.472700	c1990	47
HBS115916	San Diego	San Mateo	San Mateo Creek 1	33.469800	-117.472700	c1990	47
HBS115917	San Diego	San Mateo	San Mateo Creek 1	33.469800	-117.472700	c1990	47
HBS115918	San Diego	San Mateo	San Mateo Creek 1	33.469800	-117.472700	c1990	47
HBS115919	San Diego	San Mateo	San Mateo Creek 1	33.469800	-117.472700	c1990	47
HBS115920	San Diego	San Mateo	San Mateo Creek 1	33.469800	-117.472700	c1990	47
HBS115922	San Diego	San Mateo	San Mateo Creek 1	33.469800	-117.472700	c1990	47
HBS115926	San Diego	San Mateo	San Mateo Creek 1	33.469800	-117.472700	c1990	47
HBS115927	San Diego	San Mateo	San Mateo Creek 1	33.469800	-117.472700	c1990	47
HBS115928	San Diego	San Mateo	San Mateo Creek 1	33.469800	-117.472700	c1990	47
HBS115929	San Diego	San Mateo	San Mateo Creek 1	33.469800	-117.472700	c1990	47
HBS115931	San Diego	San Mateo	San Mateo Creek 1	33.469800	-117.472700	c1990	47
HBS115944	San Diego	San Mateo	San Mateo Creek 1	33.469800	-117.472700	c1990	47
HBS115947	San Diego	San Mateo	San Mateo Creek 1	33.469800	-117.472700	c1990	47
HBS115953	San Diego	San Mateo	San Mateo Creek 1	33.469800	-117.472700	c1990	47
HBS115954	San Diego	San Mateo	San Mateo Creek 1	33.469800	-117.472700	c1990	47
HBS115965	San Diego	San Mateo	San Mateo Creek 1	33.469800	-117.472700	c1990	47
HBS115971	San Diego	San Mateo	San Mateo Creek 1	33.469800	-117.472700	c1990	47
HBS39801	San Diego	San Mateo	San Mateo Creek 1	33.469800	-117.472700	c1990	47
HBS39857	San Diego	San Mateo	San Mateo Creek 1	33.469800	-117.472700	c1990	47
103103006	Riverside	San Mateo	Los Alamos Canyon	33.503900	-117.332680	2007	48
ARB1046	San Diego	Las Flores (CPEND)	Las Flores Creek	33.289818	-117.462060	2010	49
SLC87415	San Diego	Las Flores (CPEND)	Las Flores Creek	33.289767	-117.462550	2008	49
SLC8742	San Diego	Las Flores (CPEND)	Las Flores Creek	33.289767	-117.462550	2008	49
SLC8743	San Diego	Las Flores (CPEND)	Las Flores Creek	33.289700	-117.462183	2008	49
SLC8744	San Diego	Las Flores (CPEND)	Las Flores Creek	33.289700	-117.462183	2008	49
SLS10172	San Diego	Las Flores (CPEND)	Las Flores Creek	33.289885	-117.461893	2010	49
SLS10173	San Diego	Las Flores (CPEND)	Las Flores Creek	33.290215	-117.463540	2010	49
SLS10178	San Diego	Las Flores	Las Flores Creek	33.289885	-117.461893	2010	49

		(CPEND)					
SLS10179	San Diego	Las Flores (CPEND)	Las Flores Creek	33.289933	-117.463297	2010	49
SLC8591	San Diego	Aliso (CPEND)	Aliso Lagoon	33.266267	-117.441567	2008	50
AID3229237449	San Diego	Cockleburr	Cockleburr Pond New	33.250880	-117.431370	2006	51
AID3229238696	San Diego	Cockleburr	Cockleburr Pond New	33.251090	-117.430600	2006	51
SLC7131	San Diego	Cockleburr	Cockleburr Pond New	33.250917	-117.431233	2007	51
SLC8274	San Diego	Cockleburr	Cockleburr Pond New	33.250883	-117.431367	2008	51
SLC8598	San Diego	Cockleburr	Cockleburr Pond New	33.250833	-117.431350	2008	51
SLC96611	San Diego	Cockleburr	Cockleburr Pond New	33.250927	-117.431195	2009	51
SLC96619	San Diego	Cockleburr	Cockleburr Pond New	33.251012	-117.431168	2009	51
SLC96620	San Diego	Cockleburr	Cockleburr Pond New	33.251072	-117.431125	2009	51
SLC9663	San Diego	Cockleburr	Cockleburr Pond New	33.250765	-117.431247	2009	51
SLC96636	San Diego	Cockleburr	Cockleburr Pond New	33.250927	-117.431195	2009	51
SLC96644	San Diego	Cockleburr	Cockleburr Pond New	33.251012	-117.431168	2009	51
WSD10359	San Diego	Cockleburr	Cockleburr Pond New	33.250593	-117.431558	2010	51
HBS114546	San Diego	Cockleburr	Cockleburr Pond Old	33.251500	-117.427600	c1990	52
HBS114567	San Diego	Cockleburr	Cockleburr Pond Old	33.251500	-117.427600	c1990	52
HBS114568	San Diego	Cockleburr	Cockleburr Pond Old	33.251500	-117.427600	c1990	52
HBS114569	San Diego	Cockleburr	Cockleburr Pond Old	33.251500	-117.427600	c1990	52
HBS114572	San Diego	Cockleburr	Cockleburr Pond Old	33.251500	-117.427600	c1990	52
HBS114609	San Diego	Cockleburr	Cockleburr Pond Old	33.251500	-117.427600	c1990	52
HBS118716	San Diego	Cockleburr	Cockleburr Pond Old	33.251500	-117.427600	c1990	52
HBS39798	San Diego	Cockleburr	Cockleburr Pond Old	33.251500	-117.427600	c1990	52
DAW5211	San Diego	Santa Margarita	Santa Margarita River L2	33.236958	-117.387657	2004	53
DRC101210	San Diego	Santa Margarita	Santa Margarita River L2	33.239690	-117.382837	2010	53
JM20	San Diego	Santa Margarita	Santa Margarita River L2	33.237063	-117.388510	2010	53
JM23	San Diego	Santa Margarita	Santa Margarita River L2	33.236958	-117.387657	2010	53
JM28	San Diego	Santa Margarita	Santa Margarita River L2	33.238377	-117.384313	2010	53
DRC101213	San Diego	Santa Margarita	Santa Margarita River L1	33.263675	-117.377063	2010	54
DRC101214	San Diego	Santa Margarita	Santa Margarita River L1	33.263610	-117.376945	2010	54
JM17a_rep219ngul	San Diego	Santa Margarita	Santa Margarita River L1	33.263447	-117.376753	2010	54
JM18	San Diego	Santa Margarita	Santa Margarita River L1	33.263675	-117.377063	2010	54
JM19	San Diego	Santa Margarita	Santa Margarita River L1	33.263610	-117.376945	2010	54
JM22	San Diego	Santa Margarita	Santa Margarita River L1	33.263675	-117.377063	2010	54
SLC83735	San Diego	Santa Margarita	Santa Margarita River	33.378817	-117.308383	2008	55
SLC96830	San Diego	Santa Margarita	Santa Margarita River	33.384760	-117.300758	2009	55
103026330	Riverside	Santa Margarita	Santa Margarita ER 1	33.456730	-117.169870	2006	56
103354090	Riverside	Santa Margarita	Santa Margarita ER 1	33.456580	-117.169570	2006	56
SMER11b_rep259ngul	Riverside	Santa Margarita	Santa Margarita ER 1	33.456730	-117.169870	2006	56
SMER13	San Diego	Santa Margarita	Santa Margarita ER 1	33.456390	-117.169720	2006	56
SMER14	San Diego	Santa Margarita	Santa Margarita ER 1	33.456150	-117.170440	2007	56

SMER7a_rep225ngul	Riverside	Santa Margarita	Santa Margarita ER 1	33.456730	-117.169200	2006	56
SMER7b	Riverside	Santa Margarita	Santa Margarita ER 1	33.456730	-117.169200	2006	56
SMER7b_rep3125ngul	Riverside	Santa Margarita	Santa Margarita ER 1	33.456730	-117.169200	2006	56
103265800	Riverside	Santa Margarita	Santa Margarita ER 2	33.455540	-117.203750	2006	56
103108266	Riverside	Santa Margarita	Santa Margarita ER 3	33.435280	-117.197330	2006	56
103110301	Riverside	Santa Margarita	Santa Margarita ER 3	33.435860	-117.197540	2006	56
103269359	Riverside	Santa Margarita	Santa Margarita ER 3	33.437820	-117.196580	2006	56
103117837	Riverside	Santa Margarita	Santa Margarita ER2	33.455540	-117.203750	2006	56
CB11121	San Diego	Santa Margarita	Alturas Creek	33.374450	-117.257261	2011	57
HBS115085	San Diego	Santa Margarita	Group 13 Lake	33.432113	-117.329091	c1990	57
CB11231	Riverside	Santa Margarita	Murrieta Creek	33.476910	-117.141470	2011	58
CB11232	Riverside	Santa Margarita	Murrieta Creek	33.477120	-117.141540	2011	58
CB11233	Riverside	Santa Margarita	Murrieta Creek	33.475920	-117.141200	2011	58
CB11234	Riverside	Santa Margarita	Murrieta Creek	33.476750	-117.141480	2011	58
CB11235	Riverside	Santa Margarita	Murrieta Creek	33.476750	-117.141480	2011	58
CB11236	Riverside	Santa Margarita	Murrieta Creek	33.474660	-117.140900	2011	58
CB11237	Riverside	Santa Margarita	Murrieta Creek	33.477650	-117.141880	2011	58
CB11238	Riverside	Santa Margarita	Murrieta Creek	33.477650	-117.141880	2011	58
CB11281	Riverside	Santa Margarita	Murrieta Creek	33.480270	-117.144090	2011	58
CB11282	Riverside	Santa Margarita	Murrieta Creek	33.480270	-117.144090	2011	58
CB11283	Riverside	Santa Margarita	Murrieta Creek	33.479170	-117.143190	2011	58
CB11284	Riverside	Santa Margarita	Murrieta Creek	33.478240	-117.142330	2011	58
HBS114645	Riverside	Santa Margarita	Cole Creek	33.543080	-117.273320	c1990	59
HBS114646	Riverside	Santa Margarita	Cole Creek	33.543080	-117.273320	c1990	59
CB11271	Riverside	Santa Margarita	Warm Springs Creek	33.589350	-117.142220	2011	60
CB11272	Riverside	Santa Margarita	Warm Springs Creek	33.589350	-117.142220	2011	60
CB11273	Riverside	Santa Margarita	Warm Springs Creek	33.589350	-117.142220	2011	60
X20100512B	Riverside	Santa Margarita	Tucalota Creek	33.567220	-117.114160	2010	61
RNF7375	San Diego	Santa Margarita	Long Canyon	33.415033	-116.890150	2007	62
X26026	San Diego	Santa Margarita	Cottonwood Creek	33.397500	-116.863160	c1990	63
X26027	San Diego	Santa Margarita	Cottonwood Creek	33.397500	-116.863160	c1990	63
X26028	San Diego	Santa Margarita	Cottonwood Creek	33.397500	-116.863160	c1990	63
X26029	San Diego	Santa Margarita	Cottonwood Creek	33.397500	-116.863160	c1990	63
X26030	San Diego	Santa Margarita	Cottonwood Creek	33.397500	-116.863160	c1990	63
X26031	San Diego	Santa Margarita	Cottonwood Creek	33.397500	-116.863160	c1990	63
DRC104032	San Diego	San Luis	W.F. San Luis Rey	33.297212	-116.760532	2010	64
DRC10406	San Diego	San Luis	W.F. San Luis Rey	33.290622	-116.758643	2010	64
DRC10407	San Diego	San Luis	W.F. San Luis Rey	33.297250	-116.760495	2010	64
DRC10408	San Diego	San Luis	W.F. San Luis Rey	33.297212	-116.760532	2010	64
DRC10409	San Diego	San Luis	W.F. San Luis Rey	33.297212	-116.760532	2010	64
X3145945248	San Diego	Escondido	Escondido Creek	33.053300	-117.204467	2003	65

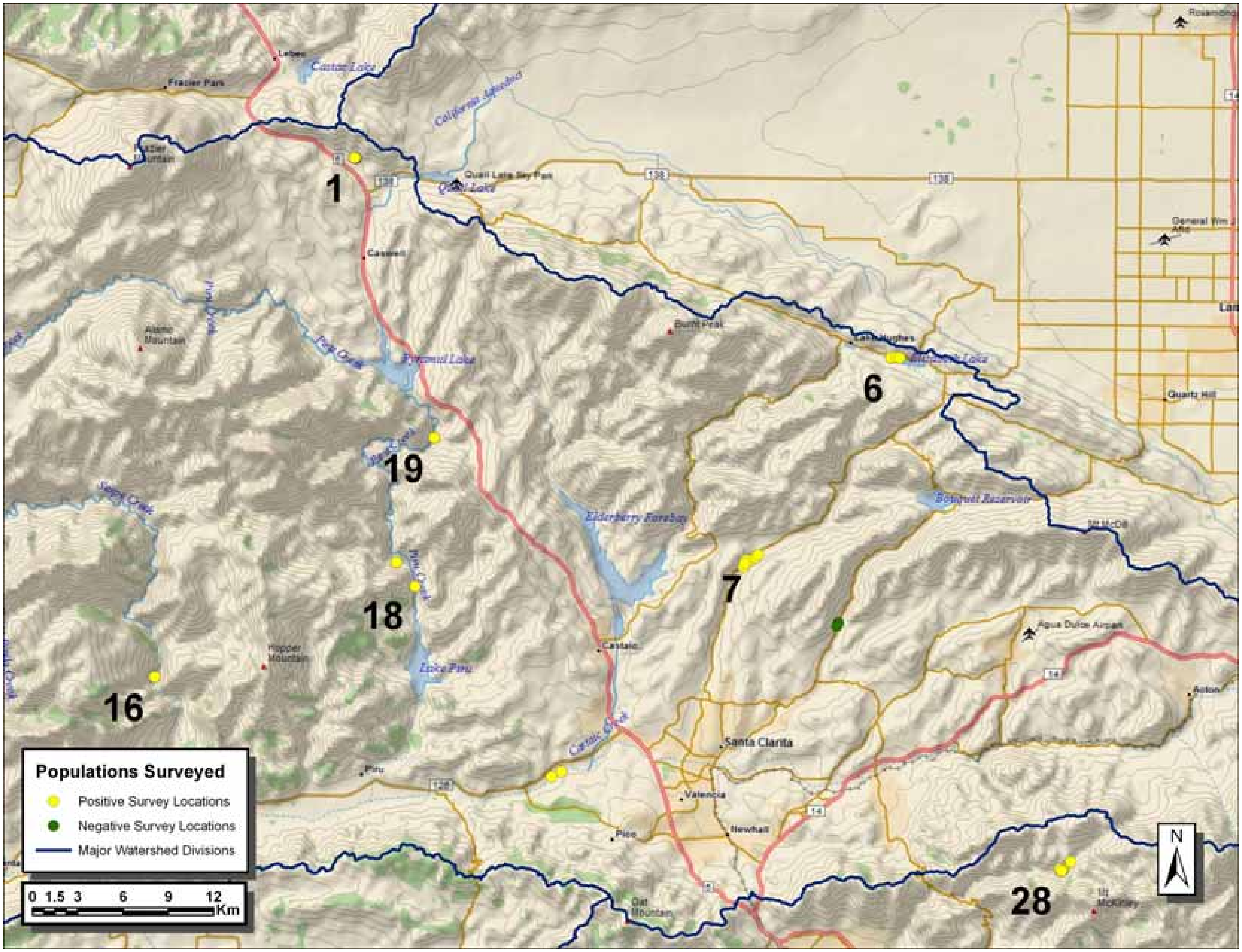
X3145946954	San Diego	Escondido	Escondido Creek	33.054033	-117.203800	2003	65
CB11202	San Diego	San Dieguito	Lusardi Creek	33.000250	-117.103760	2011	66
CB11208	San Diego	San Dieguito	Lusardi Creek	33.000250	-117.103760	2011	66
CBll206	San Diego	San Dieguito	Lusardi Creek	33.000250	-117.103760	2011	66
CBll207	San Diego	San Dieguito	Lusardi Creek	33.000250	-117.103760	2011	66
SLC7431	San Diego	San Dieguito	Lusardi Creek	33.000250	-117.103760	2007	66
X3110292580	San Diego	San Dieguito	Lusardi Creek	32.999850	-117.102083	2002	66
X3110292834	San Diego	San Dieguito	Lusardi Creek	32.999850	-117.102083	2002	66
X3140501080	San Diego	San Dieguito	Lusardi Creek	32.999600	-117.100800	2003	66
X3140504684	San Diego	San Dieguito	Lusardi Creek	32.999733	-117.102300	2003	66
X3140591124	San Diego	San Dieguito	Lusardi Creek	32.999600	-117.100800	2003	66
X3140674778	San Diego	San Dieguito	Lusardi Creek	32.999600	-117.100800	2003	66
X3140763001	San Diego	San Dieguito	Lusardi Creek	32.999733	-117.102300	2003	66
X3140763911	San Diego	San Dieguito	Lusardi Creek	32.999733	-117.102300	2003	66
X1033661887991	San Diego	San Dieguito	Black Canyon	33.130588	-116.799747	2010	67
X1033661887992	San Diego	San Dieguito	Black Canyon	33.131452	-116.800928	2010	67
TM81113	San Diego	San Dieguito	Santa Ysabel Creek	33.090240	-116.897320	2008	67
HBS39813	San Diego	San Dieguito	Scholder Creek	33.173300	-116.787200	c1990	67
BI27167	San Diego	Los Penasquitos	Los Penasquitos County Park	32.939767	-117.130433	2007	68
X3140681812	San Diego	Los Penasquitos	Los Penasquitos County Park	32.946233	-117.097683	2003	68
CB9655	San Diego	San Diego	Cedar Creek	32.995462	-116.711572	2009	69
09CB4E123	San Diego	San Diego	King Creek	32.902255	-116.644077	2009	69
X3144219540	San Diego	San Diego	Lake Murray	32.795383	-117.038033	2003	69
BI281910	San Diego	San Diego	San Diego River	33.022640	-116.718890	2008	69
BI281911	San Diego	San Diego	San Diego River	33.022640	-116.718890	2008	69
CR102513	SanDiego	San Diego	San Diego River	33.020220	-116.719772	2010	69
Santee890a_rep223ngul	San Diego	San Diego	Santee Lakes	32.865900	-117.006950	2003	69
AVID058033030	San Diego	Sweetwater	Sycuan Peak Ecological Reserve	32.772433	-116.798250	2002	70
CB10113	San Diego	Sweetwater	Sycuan Peak Ecological Reserve	32.772550	-116.801650	2010	70
CB1098	San Diego	Sweetwater	Sycuan Peak Ecological Reserve	32.771897	-116.798955	2010	70
CB11136	San Diego	Sweetwater	Sycuan Peak Ecological Reserve	32.772550	-116.801650	2011	70
DRC11424	San Diego	Sweetwater	Sycuan Peak Ecological Reserve	32.772550	-116.801650	2011	70
JM1	San Diego	Sweetwater	Sycuan Peak Ecological Reserve	32.772033	-116.808317	2003	70
JM2	San Diego	Sweetwater	Sycuan Peak Ecological Reserve	32.772367	-116.798617	2003	70
Santee883	San Diego	Sweetwater	Sycuan Peak Ecological Reserve	32.772433	-116.798117	2002	70
SPER058	San Diego	Sweetwater	Sycuan Peak Ecological Reserve	32.772283	-116.800800	2002	70
SPER085	San Diego	Sweetwater	Sycuan Peak Ecological Reserve	32.773533	-116.794483	2003	70
SPER179	San Diego	Sweetwater	Sycuan Peak Ecological Reserve	32.772283	-116.800800	2002	70
SPER227	San Diego	Sweetwater	Sycuan Peak Ecological Reserve	32.774400	-116.806583	2003	70
SPER242	San Diego	Sweetwater	Sycuan Peak Ecological Reserve	32.774400	-116.806583	2003	70
SPER256	San Diego	Sweetwater	Sycuan Peak Ecological Reserve	32.772233	-116.800817	2003	70

SPER333	San Diego	Sweetwater	Sycuan Peak Ecological Reserve	32.772636	-116.802474	c2003	70
SPER342	San Diego	Sweetwater	Sycuan Peak Ecological Reserve	32.774400	-116.806583	2003	70
SPER343	San Diego	Sweetwater	Sycuan Peak Ecological Reserve	32.774400	-116.806583	2003	70
SPER481	San Diego	Sweetwater	Sycuan Peak Ecological Reserve	32.772233	-116.800817	2003	70
SPER497	San Diego	Sweetwater	Sycuan Peak Ecological Reserve	32.773533	-116.794483	2003	70
SPER536	San Diego	Sweetwater	Sycuan Peak Ecological Reserve	32.772033	-116.808317	2003	70
SPER624	San Diego	Sweetwater	Sycuan Peak Ecological Reserve	32.772283	-116.800833	2003	70
SPER626	San Diego	Sweetwater	Sycuan Peak Ecological Reserve	32.772433	-116.798600	2003	70
SPER735	San Diego	Sweetwater	Sycuan Peak Ecological Reserve	32.774400	-116.806583	2003	70
SPER839a_rep217ngul	San Diego	Sweetwater	Sycuan Peak Ecological Reserve	32.772967	-116.806883	2003	70
X3102055300	San Diego	Sweetwater	Sycuan Peak Ecological Reserve	32.772433	-116.798250	2002	70
X5805533	San Diego	Sweetwater	Sycuan Peak Ecological Reserve	32.772300	-116.798767	2002	70
X3113290297	San Diego	Tijuana	Barrett Lake	32.688417	-116.654567	2002	71
CB101515	San Diego	Tijuana	Pine Valley	32.755193	-116.647772	2010	71
CB10201	San Diego	Tijuana	Pine Valley	32.753170	-116.648510	2010	71
CB10202	San Diego	Tijuana	Pine Valley	32.753170	-116.648510	2010	71
JM33_rep111ngul	San Diego	Tijuana	Pine Valley	32.755247	-116.647825	2010	71
JM34	San Diego	Tijuana	Pine Valley	32.754890	-116.647827	2010	71
JM35	San Diego	Tijuana	Pine Valley	32.755212	-116.647780	2010	71
JM36	San Diego	Tijuana	Pine Valley	32.755193	-116.647772	2010	71
JM37	San Diego	Tijuana	Pine Valley	32.755202	-116.647765	2010	71
JM38	San Diego	Tijuana	Pine Valley	32.755297	-116.647938	2010	71
JM39	San Diego	Tijuana	Pine Valley	32.755190	-116.647862	2010	71
HBS119167	San Diego	Tijuana	Pine Valley Upper	32.837923	-116.537509	c1990	71
HBS119174	San Diego	Tijuana	Pine Valley Upper	32.837923	-116.537508	c1990	71
HBS39763	San Diego	Tijuana	Pine Valley Upper	32.837923	-116.537508	c1990	71
HBS39812	San Diego	Tijuana	Pine Valley Upper	32.837923	-116.537509	c1990	71
HBS116118	Baja California	Tijuana	Vallecitos	32.253265	-116.534647	c1990	72
HBS116119	Baja California	Tijuana	Vallecitos	32.253265	-116.534647	c1990	72
HBS116120	Baja California	Tijuana	Vallecitos	32.253265	-116.534647	c1990	72
HBS116122	Baja California	Tijuana	Vallecitos	32.253265	-116.534647	c1990	72
HBS116123	Baja California	Tijuana	Vallecitos	32.253265	-116.534647	c1990	72
HBS116124	Baja California	Tijuana	Vallecitos	32.253265	-116.534647	c1990	72
HBS39848	Baja California	Tijuana	Vallecitos	32.253265	-116.534647	c1990	72
HBS113820	Baja California	Santo Domingo	Arroyo del Rancho Potrero	30.858525	-115.704485	c1990	73
HBS113821	Baja California	Santo Domingo	Arroyo del Rancho Potrero	30.858525	-115.704485	c1990	73
HBS113840	Baja California	Santo Domingo	Arroyo del Rancho Potrero	30.858525	-115.704485	c1990	73
HBS113841	Baja California	Santo Domingo	Arroyo del Rancho Potrero	30.858525	-115.704485	c1990	73
HBS113842	Baja California	Santo Domingo	Arroyo del Rancho Potrero	30.858525	-115.704485	c1990	73
HBS113843	Baja California	Santo Domingo	Arroyo del Rancho Potrero	30.858525	-115.704485	c1990	73
HBS113844	Baja California	Santo Domingo	Arroyo del Rancho Potrero	30.858525	-115.704485	c1990	73

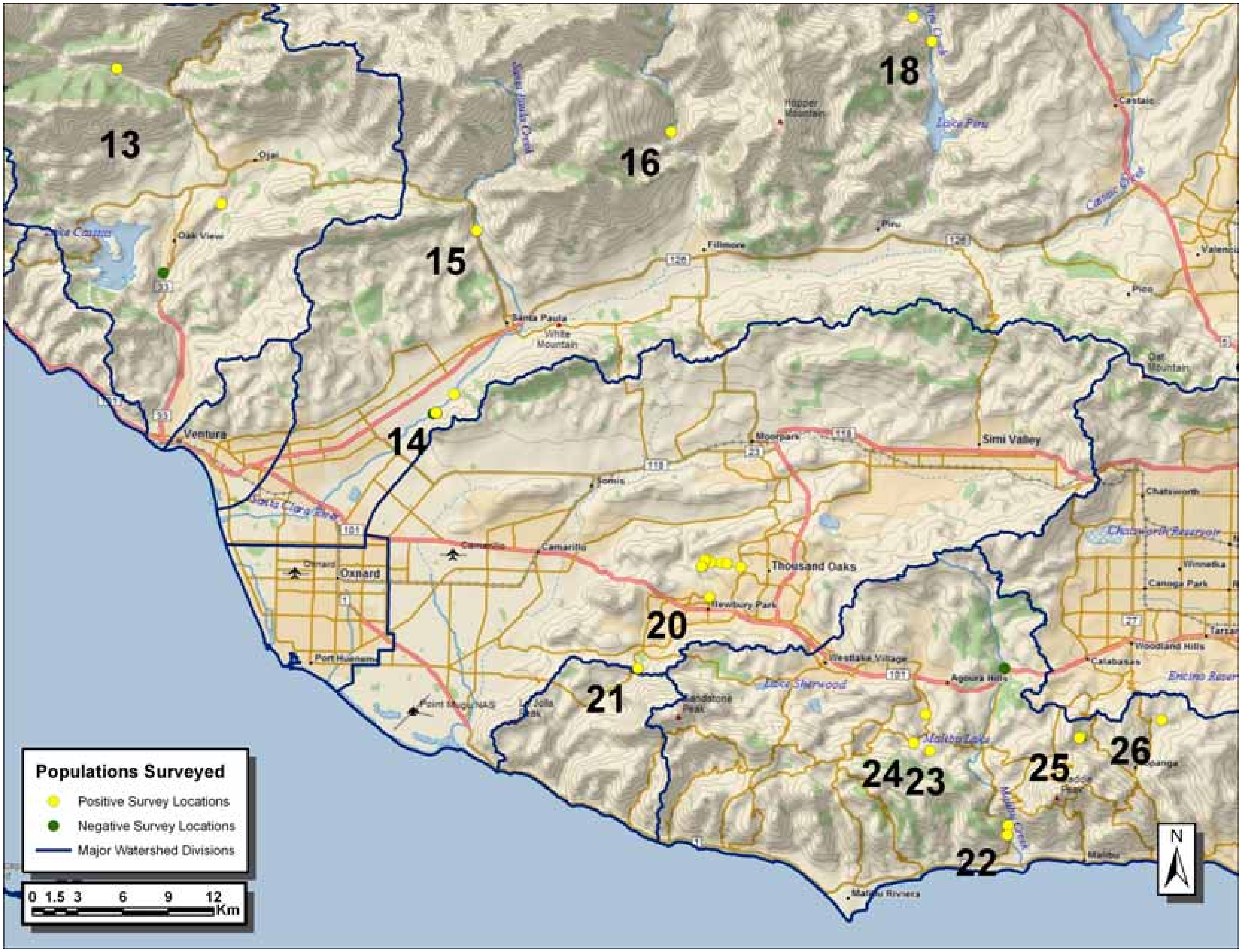
HBS113845	Baja California	Santo Domingo	Arroyo del Rancho Potrero	30.858525	-115.704485	c1990	73
HBS113846	Baja California	Santo Domingo	Arroyo del Rancho Potrero	30.858525	-115.704485	c1990	73
HBS113847	Baja California	Santo Domingo	Arroyo del Rancho Potrero	30.858525	-115.704485	c1990	73
HBS113848	Baja California	Santo Domingo	Arroyo del Rancho Potrero	30.858525	-115.704485	c1990	73
HBS113849	Baja California	Santo Domingo	Arroyo del Rancho Potrero	30.858525	-115.704485	c1990	73
HBS113850	Baja California	Santo Domingo	Arroyo del Rancho Potrero	30.858525	-115.704485	c1990	73
HBS113851	Baja California	Santo Domingo	Arroyo del Rancho Potrero	30.858525	-115.704485	c1990	73
HBS113852	Baja California	Santo Domingo	Arroyo del Rancho Potrero	30.858525	-115.704485	c1990	73
HBS113853	Baja California	Santo Domingo	Arroyo del Rancho Potrero	30.858525	-115.704485	c1990	73
HBS113854	Baja California	Santo Domingo	Arroyo del Rancho Potrero	30.858525	-115.704485	c1990	73
HBS113856	Baja California	Santo Domingo	Arroyo del Rancho Potrero	30.858525	-115.704485	c1990	73
HBS113857	Baja California	Santo Domingo	Arroyo del Rancho Potrero	30.858525	-115.704485	c1990	73
HBS113858	Baja California	Santo Domingo	Arroyo del Rancho Potrero	30.858525	-115.704485	c1990	73
HBS113859	Baja California	Santo Domingo	Arroyo del Rancho Potrero	30.858525	-115.704485	c1990	73
HBS113860	Baja California	Santo Domingo	Arroyo del Rancho Potrero	30.858525	-115.704485	c1990	73
HBS39753	Baja California	Santo Domingo	Arroyo del Rancho Potrero	30.858525	-115.704485	c1990	73
HBS39771	Baja California	Santo Domingo	Arroyo del Rancho Potrero	30.858525	-115.704485	c1990	73
HBS39811	Baja California	Santo Domingo	Arroyo del Rancho Potrero	30.858525	-115.704485	c1990	73

Appendix II: Maps of study sites.

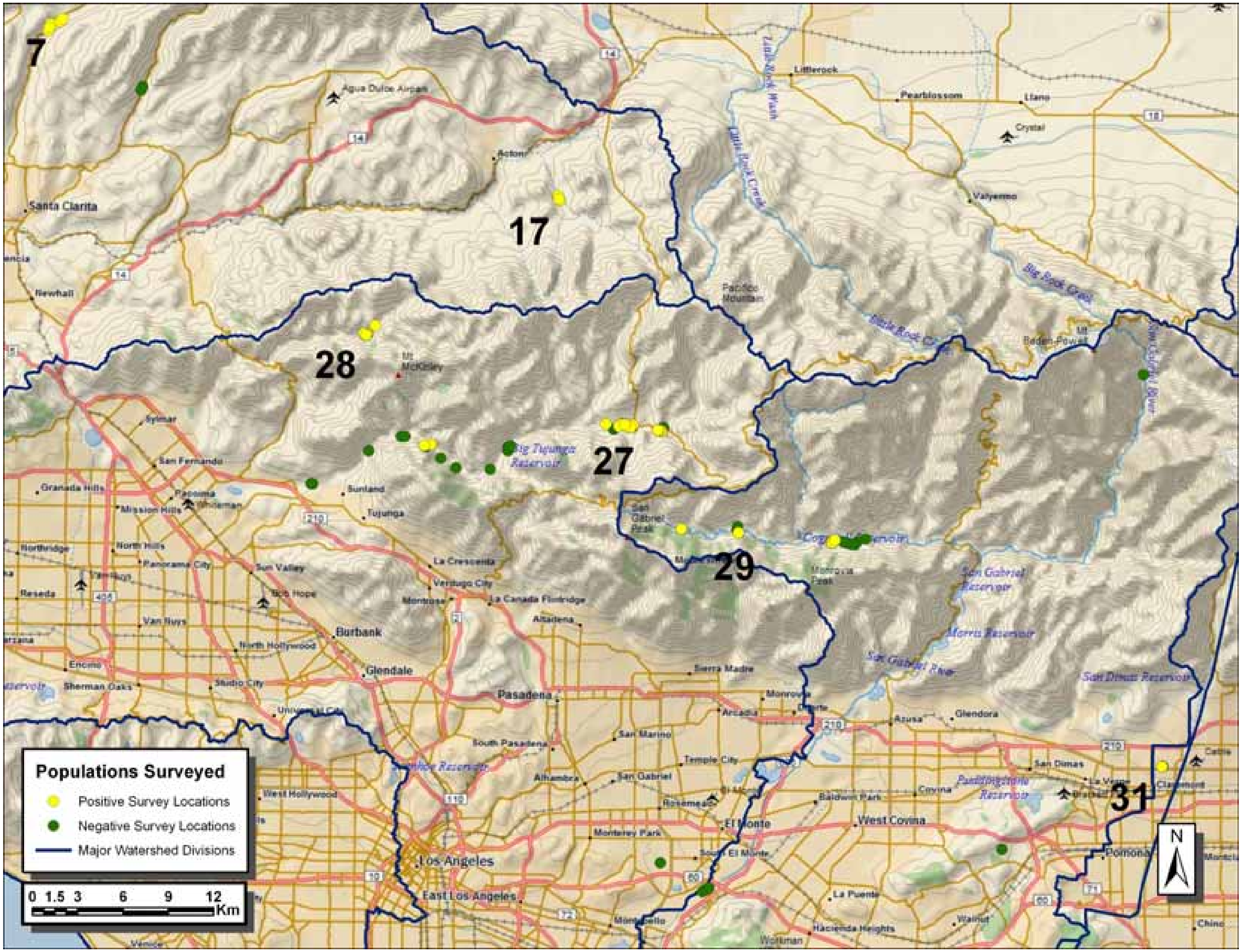
Maps of study sites include general population locations (population numbers are illustrated on the maps), positive survey locations and negative survey locations.



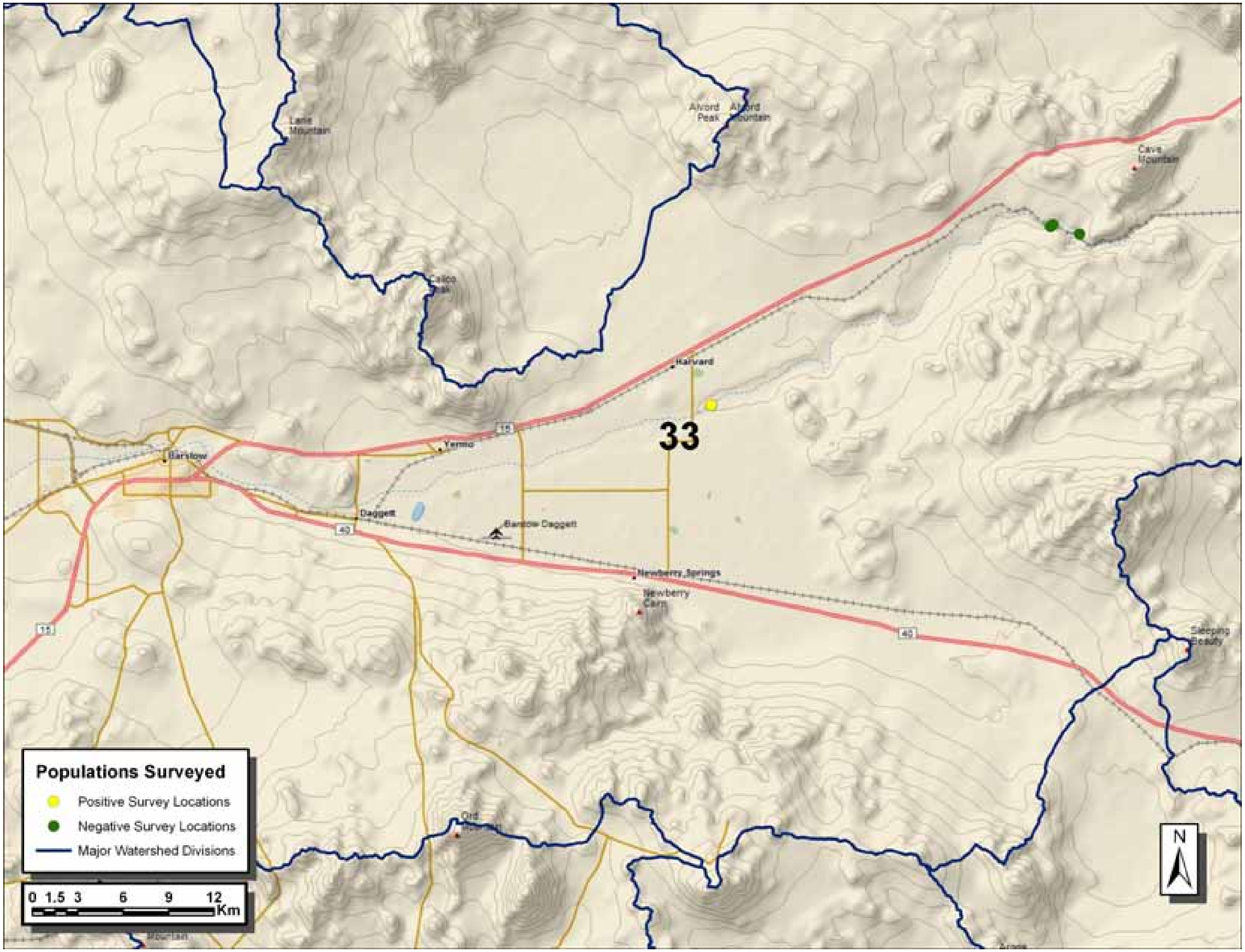
Map 1. Survey locations along the Santa Clara and Los Angeles watersheds.



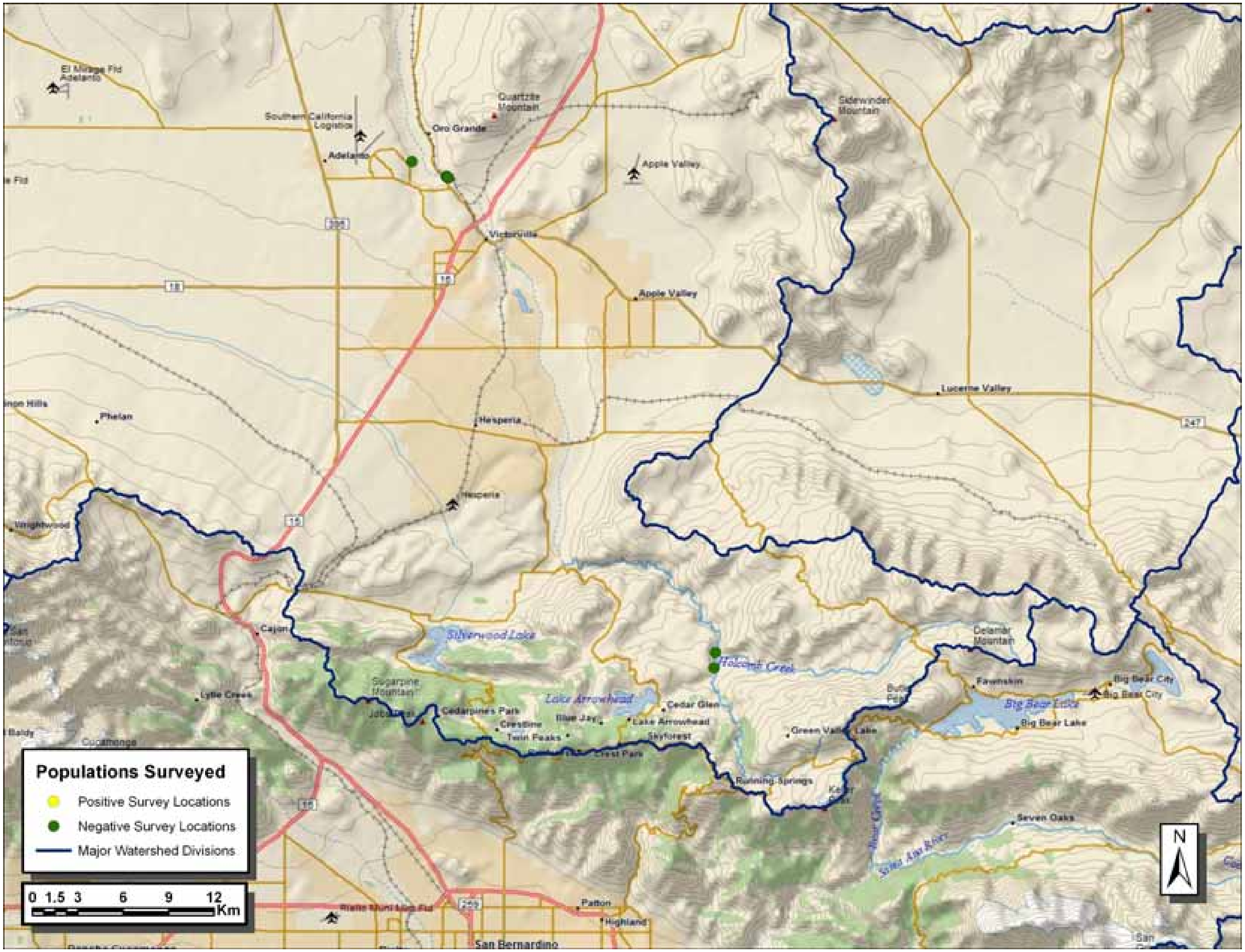
Map 2. Survey locations along the Santa Clara, Calleguas, Topanga, and Malibu watersheds.



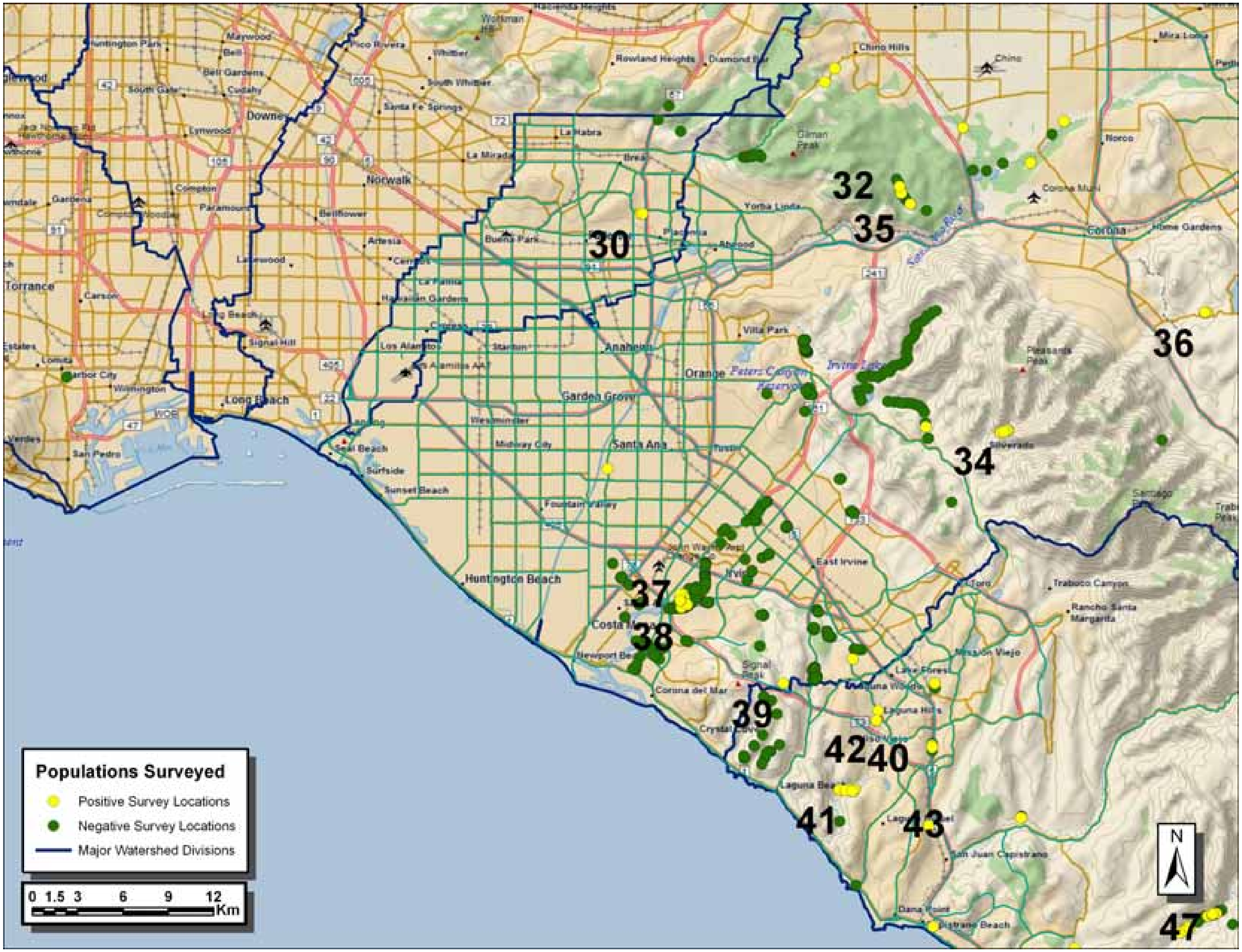
Map 3. Survey locations along the Los Angeles watershed.



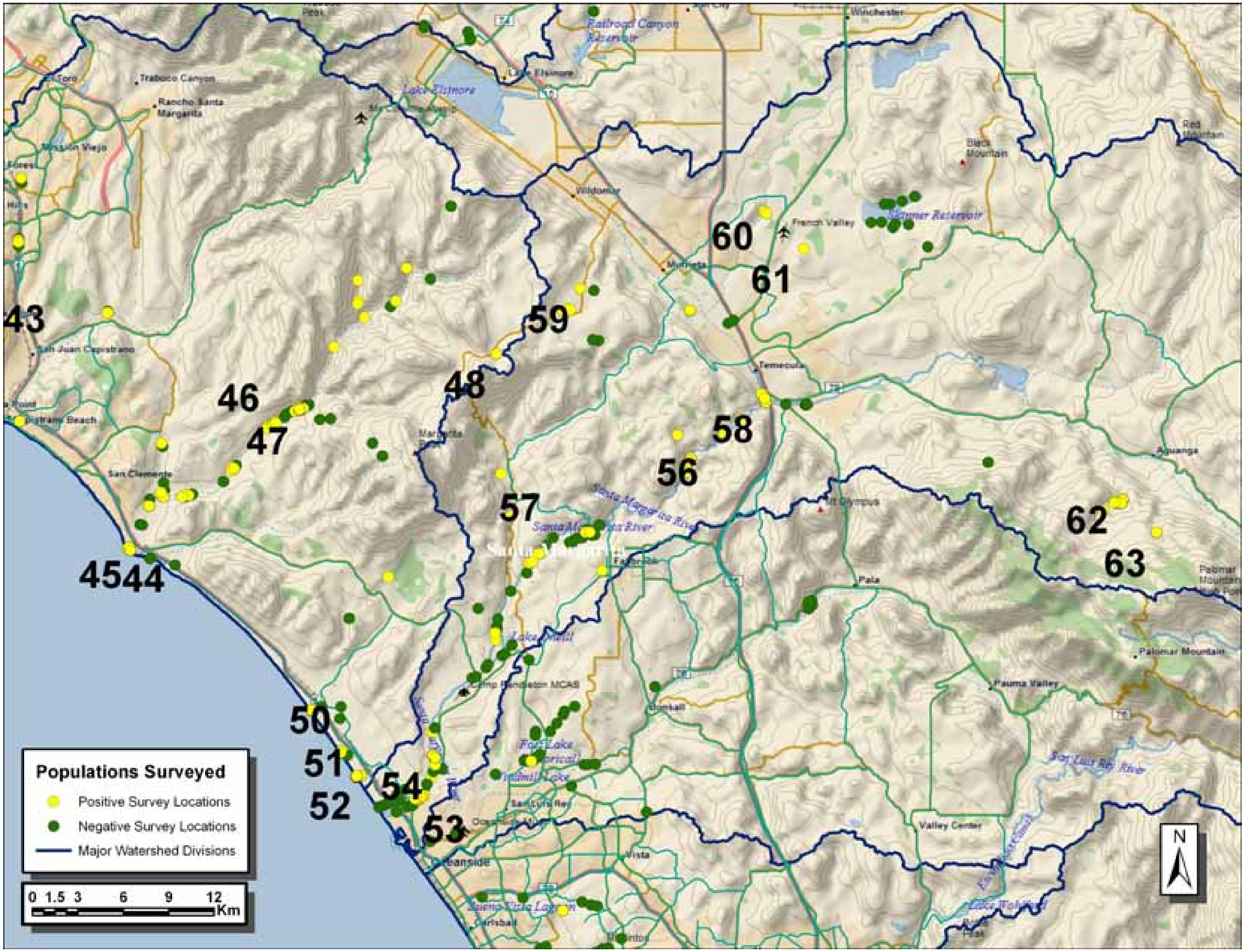
Map 4. Survey locations along the lower Mojave watershed.



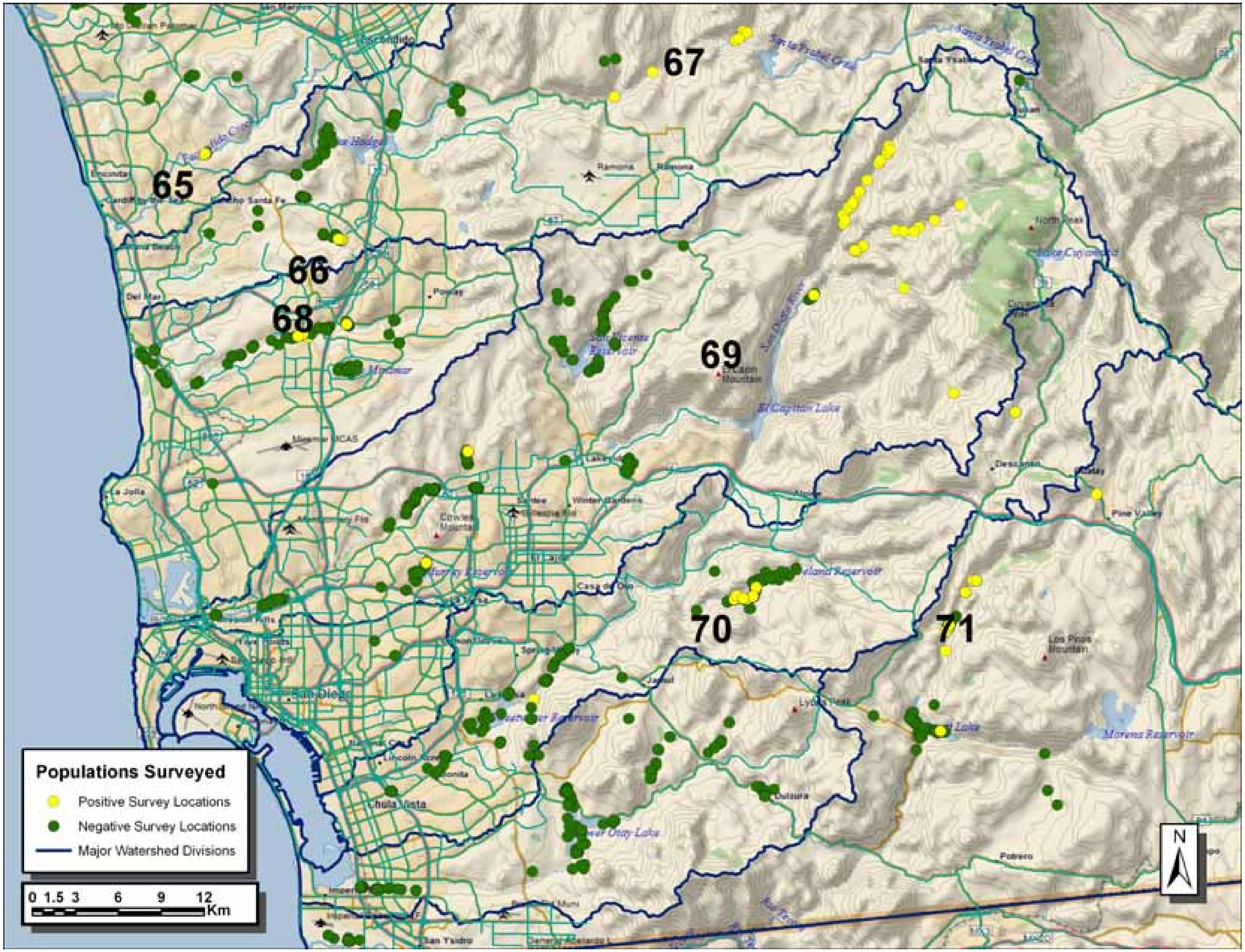
Map 5. Survey locations along the upper Mojave watershed.



Map 6. Survey locations along the Santa Ana, San Diego Creek, Aliso, San Juan and upper San Mateo watersheds.



Map 7 Survey locations along the upper Santa Ana, San Mateo, Santa Margarita, San Luis Rey, and Carlsbad watersheds.



Map 8. Survey locations along the Carlsbad, Escondido, San Dieguito, San Diego, Sweetwater, Otay, and Tijuana watersheds.