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MULTIYEAR REPORT
WADEABLE STREAMS BIOASSESSMENT
Santa Ana Region: 2012 - 2015

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SWAMP Surface Water Ambient Monitoring Program

California Water Boards

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SANTA ANA
REGION 8
Sites Sampled: 2012 - 2015

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Table of Contents

List of Figures

List of Tables

Executive Summary

As part of ongoing efforts to quantify the ecological health of southern California's freshwater systems, the Santa Ana Regional Water Quality Control Board (Region 8) contracted California State University Long Beach's Stream Ecology and Assessment Laboratory to conduct bioassessment during the years 2012 through 2015. For clarity of reporting and ease of discussion, we divided Region 8 into six subregions based on their geographic location. These subregions were:

"Orange County" with sites on Coyote Creek, San Diego Creek, Peters Wash, and Santiago Creek,

"Prado Basin" with sites on the Santa Ana River, Cucamonga Creek, Chino Creek, and Temescal Wash,

"Lytle Creek/Cajon Wash" with sites on the Middle and North Forks of Lytle Creek and the main stem of Lytle Creek and sites on Cajon Wash,

"Middle Santa Ana" with sites on the Santa Ana River, Waterman Canyon Creek, East Twin Creek, City Creek, Plunge Creek, and the San Timoteo Wash,

"Upper Santa Ana" with sites on the Santa Ana River, Alder Creek, Bear Creek, Deer Creek, Metcalf Creek, Mile Creek, Barton Creek (east and west forks and the main stem), and Frog Creek,

"San Jacinto" with sites on Strawberry Creek and on the North and South Forks and the main stem of the San Jacinto River.

Within these subregions, we sampled 91 stream sites. These sites were originally part of a six-year probabilistic study conducted between 2006 and 2011. At that time, the ecological status of streams was determined by calculating the Southern California Coastal Index of Biotic Integrity (IBI) (Ode et al. 2005). These 91 stream sites were chosen for re-sampling in 2012-2015 because they scored either one standard deviation below or above the mean IBI score, i.e. they were either very poor or very good. The objective of this study was to quantify how the ecological condition of these sites had changed over time. In 2017, the IBI was replaced by a new index, the California Stream Condition Index (CSCI) (Mazor et al. 2017), as the standard scoring system used throughout the state of California. We calculated CSCI scores for each sampling event from each of the 91 sites. Many sites were resampled more than twice and these CSCI values are reported below. The change in CSCI score was then calculated for each site by subtracting the CSCI score for the oldest sampling event from the CSCI score for the most current sampling event. In order to identify sites whose CSCI scores changed more than average, the average change in CSCI score was subtracted from the change in CSCI score for each individual site, the value was then divided by the standard deviation of the change in CSCI scores. The resulting value indicates the direction of the change, i.e. did the site get 'better' or 'worse' based on the CSCI score.

Overall Trends across Region 8

The mean CSCI score for the six subregions ranged from 0.41 to 1.1, with subregions Lytle Creek/Cajon Wash, Middle Santa Ana, and the Upper Santa Ana scoring in the "Likely Intact Condition" category of ecological health. The San Jacinto subregion scored in the "Possibly Altered Condition" category, and the subregions Prado Basin and Orange County scored in the lowest category, "Very Likely Altered Condition." The mean *change* in CSCI score ranged from -0.09 to 0.09 with the San Jacinto subregion experiencing a net decline in ecological health (mean change in CSCI score = -0.9) and the Middle Santa Ana subregion showing a net increase in ecological health (mean change in CSCI score = 0.09).

Subregions Orange County, Prado Basin, Lytle Creek/Cajon Wash, and Upper Santa Ana showing mean changes in CSCI scores near zero.

Eleven sites experienced a change in CSCI score at least one standard deviation above the mean change, indicating a significant improvement of ecological condition. These included one site in Orange County on Santiago Creek, two sites in Prado Basin on the Santa Ana River, four sites in the Middle Santa Ana subregion on City Creek, East Twin Creek, and San Timoteo Wash, and four sites in the Upper Santa Ana subregion on Metcalf, Frog, Mill, and East Fork Barton Creeks. Nine sites experienced a change in CSCI score at least one standard deviation below the mean change, indicating a significant declination of ecological condition. These included two sites in Orange County on San Diego Creek, three sites in the Prado Basin subregion on the Santa Ana River and Temescal Wash, two sites in the San Jacinto subregion on Strawberry Creek and the South Fork of the San Jacinto river, and one site in each of the subregions Lytle Creek/Cajon Creek (on the Middle Fork of Lytle Creek) and Middle Santa Ana (on Plunge Creek).

Overall, the results of this study provide valuable information on the ecological health of specific stream reaches throughout the Santa Ana and San Jacinto watersheds. This information can be used by the scientific staff of the Santa Ana Regional Water Quality Control Board to design future studies investigating the potential causes driving these changes in CSCI scores. This information also updates the ecological status of 91 stream sites.

Introduction

Freshwater is an important natural resource. Understanding the health of rivers, streams, and other water resources is essential for the development of management plans that protect the nation's vital water resources. One approach that has been advocated for determining water quality is the "Aquatic Life Use Assessment", which was adopted by the California Environmental Protection Agency (Cal/EPA) for determining water quality. Bioassessment tools utilize direct measurements of biological assemblages occupying various trophic levels and can include plants, macroinvertebrates, vertebrates (fish) and periphyton (diatoms and algae), as direct methods for assessing the biological health of a waterway's ecosystem. Direct measurements of biological communities, when used in conjunction to other relevant measurements of watershed health (e.g. watershed characteristics, land-use practices, in-stream habitat and water chemistry), are effective ways to monitor long-term trends of a watershed's condition (Davis and Simon 1995). Biological assessments, which integrate the effects of water quality over time, are sensitive to many aspects of both habitat and water chemistry and provide a more familiar representation of ecological health to those who are unfamiliar with interpreting the results of chemical or toxicity tests (Gibson 1996). When integrated with physical habitat assessments and chemical test results, biological assessments describe the health of a waterway and provide an *in vivo* means of evaluating the anthropogenic effects (e.g. sediments, temperature and habitat alteration). As defined by the 2006 EPA Wadeable Streams Assessment (WSA) document, *"biological integrity represents the capability of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity and functional organization comparable to that of the natural habitat of the region."* Bioassessment is a proxy for determining stream water quality and habitat quality based on the types and numbers of organisms living there.

The monitoring of water quality using benthic macroinvertebrates (BMIs) is the most utilized bioassessment method when compared with similar assessments that use vertebrates or periphyton. BMIs are not only ubiquitous, but are relatively stationary and highly diverse. These traits can provide a variety of predictable responses to a number of environmental stresses (Rosenberg and Resh 1993).

Depending on the length of time an individual BMI taxon resides in an aquatic environment (a few months to several years), the sensitivity to physical and chemical alterations to its environment will vary. BMIs are an excellent indicator group in assessing the health of a waterway (Resh and Jackson 1993) and function as a significant food resource for both aquatic and terrestrial organisms. In addition, herbivorous BMIs aid in the control of periphyton populations and many BMI taxa contribute to the breakdown of detritus. Furthermore, the diversity of BMI taxa also plays an important role in the overall ecology and biogeography of a region (Erman 1996).

Biological assessments are often based on multimetric techniques. These techniques use a number of biologic measurements (metrics), each representing a particular aspect of the biological community, to assign a water quality value to the location under study. Locations can then be ranked by these values and classified into qualitative categories such as "very good," "good," "fair," "poor," and "very poor." Previously the system of ranking and categorizing biological conditions for wadeable California streams was referred to as the Index of Biotic Integrity (IBI), and was the recommended method for the development of biocriteria by the United States Environmental Protection Agency (USEPA; Davis and Simon 1995). The IBI used for southern California was the Southern Coastal California Index of Biological Integrity (SCC-IBI; Ode et al. 2005), developed by the California Department of Fish and Game's Aquatic Bioassessment Laboratory (Cal/DFG-ABL). The IBI was replaced with the newly developed California Stream Condition Index (CSCI). Like the IBI, this index utilizes biological measurements (metrics) to provide a system of ranking the biological condition of sites being studied. The CSCI incorporates two types of data, biological data generated from BMI samples collected and environmental data. Unlike the IBI, the CSCI is applicable statewide and takes site specific reference conditions into account.

In 2006, the Santa Ana Regional Water Quality Control Board (Region 8) contracted California State University Long Beach (CSULB) Stream Ecology and Assessment Laboratory (SEAL) to conduct a six-year study within Region 8 of California waterways utilizing a probabilistic sampling design. This six-year study provided baseline data on the ecological health of the wadeable streams within the Region. Each year an annual report was made available to the public on the Surface Water Ambient Monitoring Program (SWAMP) website that detailed the physical habitat, the composition of macroinvertebrates, and the water chemistry of each random site sampled. The number of sites sampled each year varied from 30 to 35 depending on available levels of funding. Based on the results of the probabilistic study, sites whose biological condition was determined to be 'very good' or 'very poor' were targeted for resampling during 2012 to 2015. The objective of the resampling was to investigate if and how these sites changed with respect to their CSCI scores over time.

Methods

Site Selection

An original list of coordinates for 750 potential sampling locations was generated using a probabilistic design by Dr. Tony Olsen (from EPA at Corvallis). Beginning in 2012, sites from this probabilistic monitoring plan were selected to be resampled based on their Index of Biological Integrity (IBI) scores. The mean and standard deviation (SD) of the IBI scores for these sites were placed into one of three categories: sites scoring at least one SD below the mean, sites scoring within one SD (either plus or minus) from the mean, and sites scoring greater than one SD from the mean. Sites with IBI scores at least one SD below or above the mean were selected for resampling in 2012 through 2015.

Sampling Reach Determination

The sampling procedures used during the 2012 through 2015 bioassessment survey followed the full level of the Standard Operating Procedures for Collecting Benthic Macroinvertebrate Samples and Associated Physical and Chemical Data for Ambient Bioassessments in California (Ode 2007). Briefly, at each sample location, a 150-meter reach was established (250-meters for streams with wetted-widths greater than 10 meters). Each reach was broken into 11 equidistant transects, spaced every 15 meters (25 meters for streams with widths greater than 10 meters), with each transect designated with a number representing its location along the reach (0 meters through 150/250 meters, downstream to upstream). BMI sample locations for each transect followed the reach-wide benthos procedure (RWB) for streams with gradients greater than 1% that carry particle size classes larger than sand (> 2mm particle size class); the margin-center-margin (MCM) was used for streams with gradients less than 1% that carry sand (< 2mm particle size class). This is implemented using our best professional judgement whereby sites with substrates dominated by sand were sampled using the MCM method.

Physical Habitat Characterization

At each site, standard Surface Water Ambient Monitoring Program (SWAMP) field protocols were used to survey the physical habitat along the entire reach of the sampling location (Fetscher et al. 2010). Briefly, at every 15-meter interval along the 150-meter reach (25-meter intervals along a 250-meter reach), starting at transect 0-meters, physical habitat quality was determined by recording substrate complexity, consolidation, embeddedness, sediment depth, identifying human influences, and measuring canopy cover. At each transect, a depth profile was obtained at five equidistant points starting at banks edge and ending on the opposite banks edge. Additional substrate measurements and depth profiles were measured midway between main transects throughout the entire reach. Each sampling reach was scored using the General Habitat Characterization Form. Stream velocity was measured using a 60% stream depth method at a transect representative of the flow throughout the reach using a Flowatch flow-meter that measures velocities directly (buoyant object method was used when 60% depth method could not be performed due to obstructions or depth limitations).

Water Chemistry

Standard *in situ* water parameters were measured at each site using a multiprobe and included: pH, temperature (C), dissolved oxygen (mg/L), salinity, and conductivity (µS/cm). Additionally, 50 ml of water was field filtered (for OPP) and one-liter of water was collected and returned to the lab within 36 hours for the determination of the following analytes:

Constituent	Units	Constituent	Units	Constituent	Units
Ammonia-N	mg/L	Nitrite-N	mg/L	Turbidity	NTU
Conductivity	MS	Orthophosphate as P	mg/L	Alkalinity	
Nitrate-N	mg/L	Total Suspended Solids	mg/L	Salinity	ppt

All of the water chemistry data are available through the online SWAMP database.

Benthic Macroinvertibrate (BMI) Sampling and Identification

BMI samples were collected following standard protocols (Standard Operating Procedures for Collecting Stream Algae Samples and Associated Physical Habitat and Chemical Data for Ambient Bioassessments in California, Fetscher et al. 2010). The BMIs were collected using a one foot wide, 0.5-milimeter mesh

D-frame kick-net by thoroughly manipulating the substrate in a one-foot by one-foot sampling plot directly in front of the net with a consistent sampling effort (approximately one to three minutes). Samples were collected at each of the established eleven transects within the 150 meter sampling reach for the site, alternating among 25% , 50%, and 75% instream of the right bank at each subsequent transect. The resulting 11 samples from a site were composited into 1-liter jars and preserved in the field using 95% isopropanol. The samples were transported back to the laboratory where field alcohol was rinsed and replaced with 70% ethanol.

Samples were then subsampled using a Caton tray such that at least five grids were selected to obtain the required number of BMIs (500 or 600 organisms, depending upon the current SWAMP protocols at the time). These BMIs were then identified to either Level 1 or Level 2 (depending upon SWAMP requirements at the time) of the Standard Taxonomic Effort produced by the Southwestern Association of Freshwater Invertebrate Taxonomists (SAFIT) using standard taxonomic keys, typically genus level for insects and order or class for non-insects (Brown 1972, Edmunds et al. 1976, Kathman and Brinkhurst 1998, Klemm 1985, Merritt and Cummins 2008, Pennak 1989, Stewart and Stark 1993, Surdick 1985, Thorp and Covich 1991, Usinger 1963, Wiederholm 1983, 1986, Wiggins 1996, Wold 1974).

California Stream Condition Index

Beginning with the 2012 sampling period, we shifted from using the Index of Biological Integrity to evaluate site condition to the newly developed California Stream Condition Index. The CSCI was developed to account for some of the shortcomings of the previously used indices, namely regional specificity and an inability to account for the large amount of environmental variability among California's natural stream sites. The CSCI was developed using a statewide dataset representing a broad range of environmental conditions, thus enabling statewide site comparisons as opposed to being limited to within region comparisons. The CSCI is also unique in that it sets biological benchmarks (or 'reference conditions') for each site based on its specific settings and so does not assume 'reference conditions' for each site sampled are alike, thus accounting for variability in natural stream type.

The CSCI incorporates two types of data, biological data generated from BMI samples, collected in accordance with standard SWAMP protocols and identified to required taxonomic level of effort, and environmental data generated following standard geographic information system (GIS) protocols. Briefly, ArcGIS is used to delineate catchment polygons for a site and then to calculate predictors based on the catchment. The resulting environmental predictors are used in conjunction with the field collected taxonomic data to calculate the CSCI score using custom libraries and scripts in the R statistical programming language. For the full protocol on calculating CSCI scores see SWAMP's 'California Stream Condition Index (CSCI): Interim instructions for calculating scores using GIS and R' online.

The CSCI is composed of two separate sub-metrics. The 'observed over expected' (O/E) metric assesses the taxonomic completeness of a site by comparing observed (O) BMI taxa to an expected (E) list of taxa. The expected taxa list for a given site is generated by statistically modeling the relationships between taxa compositions and natural environmental gradients at similar sites identified as 'reference sites' (Mazor et al. 2017). Predictor variables used to predict expected species at a site include average monthly precipitation, average monthly temperature, watershed area, and elevation. These values for a given site are generated using the program ArcGIS. This method is more precise than previous methods, which assumed all taxa have an equal probability of occurrence at all sites. The O/E sub-metric is a simple ratio of observed to expected taxa and so does not require scoring. If a site matches predicted reference conditions (i.e. is 'taxonomically complete') it's O/E ratio is equal to one. An O/E ratio less than one for a site indicates degraded biological conditions.

The second component of the CSCI is a multi-metric index (MMI), this metric aggregates several measures of BMI attributes (percent clinger taxa, percent Coleoptera taxa, taxonomic richness, % Ephemeroptera, Plecoptera, and Trichoptera taxa, % shredder taxa, and % intolerant taxa) into a single measure of biological condition. These attributes were chosen based on their ability to distinguish between reference and degraded condition and/or their responsiveness to human disturbance gradients. Again, predictor variables generated by ArcGIS are used to predict metric values for each specific site. Scoring is required for the MMI because individual attributes have different scales and differing responses to stress. Scoring transforms the MMI sub-metric to a standard scale ranging from 0 (most stressed) to 1 (similar to predicted reference conditions). The final MMI score for a site is calculated by averaging the scaled scores for each BMI attribute and then rescaling (dividing) by the average score of reference calibration sites. Rescaling ensures the MMI and the O/E sub-metrics are expressed on similar scales. The final CSCI score of a site is simply an average of the MMI and O/E values.

As the CSCI is a relatively new index, specific categories for scores are still tentative. Currently three thresholds (based on the 30^{th}, 10^{th}, and 1^{st} percentiles of CSCI scores at reference sites) have been established, resulting in four CSCI categories of biological condition: ≥ 0.92 = likely intact condition; 0.91 to 0.80 = possibly altered condition; 0.79 to 0.63 = likely altered condition; ≤ 0.62 = very likely altered conditions.

Quality Control and Quality Assurance

Field duplicates were collected at a rate of five percent for water samples and at a rate of ten percent for BMI samples collected in the field. Furthermore, ten percent of BMI sample identifications underwent external quality control via the Aquatic Bioassessment Laboratory, Chico, CA. Stringent internal quality control was applied to both sorting and taxonomy whereby subsamples had to pass at a 95% BMI recovery level and all taxonomy was double-checked by at least one other taxonomist.

Beginning in 2009, field crews participated in annual interlab calibration exercises hosted by the Storm Water Monitoring Coalition (SMC) and the Southern California Coastal Water Research Project (SCCWRP). Field audits were also conducted by a SMC member annually.

Results

Between 2012 and 2015 we revisited 91 stream reaches (Tables 1-4) that were originally sampled as part of the probabilistic study undertaken from 2006 to 2011. The objective of the current sampling was to determine how the biologically worst and best sites based on the SoCal IBI had changed since their first sample date. We calculated MMI, O/E, and CSCI scores using SAFIT Level 2b on all samples (Table 5). We also calculated the change in CSCI score between the most recent sample date and the first sample date for each site (Table 6). Eleven sites showed significant improvement in CSCI score (Table 7) while nine sites showed significant decline in CSCI score (Table 8).

For clarity of reporting and ease of discussion, we divided Region 8 into six subregions (A through F) based on their geographic location (Figure 1) as follows:

A = "Orange County" with sites on Coyote Creek, San Diego Creek, Peters Wash, and Santiago Creek.

B = "Prado Basin" with sites on the Santa Ana River, Cucamonga Creek, Chino Creek, and Temescal Wash.

C = "Lytle Creek/Cajon Wash" with sites on the Middle and North Forks of Lytle Creek and the main stem of Lytle Creek and sites on Cajon Wash.

D = "Middle Santa Ana" with sites on the Santa Ana River, Waterman Canyon Creek, East Twin Creek, City Creek, Plunge Creek, and the San Timoteo Wash.

E = "Upper Santa Ana" with sites on the Santa Ana River, Alder Creek, Bear Creek, Deer Creek, Metcalf Creek, Mile Creek, Barton Creek (east and west forks and the main stem), and Frog Creek.

F = "San Jacinto" with sites on Strawberry Creek and on the North and South Forks and the main stem of the San Jacinto River.

Below, we first discuss the region as a whole for both the current CSCI and the change in CSCI, then we focus on specific sites within each subregion whose change in CSCI was either above or below average by more than one standard deviation. We produced two sets of maps, one with the most current CSCI score for each site and another with the change in CSCI score and we discuss these in this order.

Overview of the Whole Region

The mean CSCI score (± standard error) for each subregion is depicted in Figure 2. Subregions Lytle Creek/Cajon Wash, Middle Santa Ana, and Upper Santa Ana had means placing them in the category of the best biological condition, "Likely Intact Condition." The San Jacinto Subregion had a mean CSCI score of 0.85, which is in the middle of the "Possibly Altered Condition" category. Both Subregions Prado Basin and Orange County have means below 0.62 placing them in the "Very Likely Altered Condition" category. All subregions show a similar degree of variation as evidenced by the standard error bars.

In order to detect trends over time, we calculated the mean change in CSCI scores for each subregion (Figure 3). All subregions consisted of highly variable site changes in biological condition as evidenced by the large standard errors and no statistical difference in mean change.

Maps of the Most Recent CSCI Scores and the Change in CSCI Scores

We used color coding to designate site status as follows:

> All maps of the most recent CSCI score depict sites with one of four colors (Figure 4). Red is the category of "Very Likely Altered Condition" with CSCI scores ≤ 0.62. Orange corresponds to "Likely Altered Condition" with CSCI scores 0.63 - 0.79. Yellow signifies the next category "Possibly Altered Condition" with CSCI scores 0.80 - 0.91. The category of the best biological condition, "Likely Intact Condition", is denoted in green with CSCI scores ≥ 0.92. For brevity we refer to these conditions using the colors as we discuss the sites below.
>
> For maps that report the change in CSCI score (Figure 5) we placed sites into three categories, red, yellow, and green. Sites whose change in CSCI were more than one standard deviation (SD) below the mean are denoted with red, sites whose change was within one standard deviation of the mean change are denoted in yellow, while sites whose condition increased by more than one standard deviation are depicted in green.

Orange County - Subregion A

We sampled ten sites in Orange County and all but one had a CSCI score below 0.62, putting them in the red category of "Very Likely Altered Condition". Site 532 on Santiago Creek was the only site not in the lowest category with a score of 0.72 falling in the orange category (Figure 6). Within this subregion, seven sites changed in CSCI score within one SD of the mean (Figure 7). Two sites, 418 and 180, located on San Diego Creek experienced significant decline in biological condition since they were first sampled in 2009 and 2006, respectively, as their scores decreased by at least one SD. They were in the lowest category of biological health originally and still declined; their CSCI scores in 2014 were 0.29 and 0.25, respectively. In contrast, Site 532 on Santiago Creek, experienced a significant improvement in biological condition from 2006 to 2012 with CSCI scores increasing from 0.26 to 0.70.

Prado Basin - Subregion B

In Prado Basin, we sampled two sites on Cucamonga Creek, one site each on Chino Creek and Temescal Wash, and nine sites on the Santa Ana River for a total of 13 sites. Sites on Chino and Cucamonga Creeks and Temescal Wash all were in the red range of biological condition (Figure 8). Sites along the Santa River were varied spanning three condition categories, red through yellow. Eight sites' CSCI scores did not change over the study period (Figure 9). These sites were located on Chino and Cucamonga Creeks, on the Santa Ana River downstream from the Interstate 15 crossing. Upstream of the I15 crossing on the Santa Ana River, site change was highly variable with two sites showing significant improvement (Sites 351 and 361), two sites showing significant decline (Sites 312 and 494), and two sites remaining stable (Sites 110 and 151).

Lytle Creek/Cajon Wash - Subregion C

We sampled six sites along Cajon Wash, four sites on the main stem of Lytle Creek, two on the Middle Fork and one on the North Fork of Lytle Creek (Figure 10). There were no sites in the red category. Two sites along Cajon Wash (Sites 327 and 396) scored in the orange category and were downstream of four sites in the green category (Sites 27, 41, 289, and 112) along Cajon Wash suggesting a change in biological condition from upstream to downstream. Three sites (Sites 362, 600, and 271) along the main stem of Lytle Creek were in the green category and one site (Site 62) scored in yellow as did the site (Site 105) on the North Fork. One site (Site 69) on the Middle Fork scored in the green while the other site (Site 57) scored in the yellow. All sites except Site 57 remained stable over the study period (Figure 11). Site 57 showed a significant decline in biological condition.

Middle Santa Ana - Subregion D

Thirteen sites were sampled in this subregion with five sites along San Timoteo Wash, three sites on the main stem of City Creek, and one site each on Waterman Canyon Creek, East Twin Creek, Plunge Creek, the West Fork of City Creek, and one on the Santa Ana River (Figure 12). Site 572 along the Santa Ana River was the only site in this subregion to score in the red category. Two sites (Sites 55 and 85) along San Timoteo Wash scored in the orange category while two sites (Sites 258 and 613) located upstream of these were in the yellow category indicating a decline in biological condition from upstream to downstream. Site 469 on Plunge Creek was also in the yellow category. All sites on City Creek (Sites 446, 167, 398, and 114), as well as Sites 226 (Waterman Canyon) and 277 (East Twin Creek) scored in the green category. The Plunge Creek site (Site 469) was the only site that significantly declined in the subregion (Figure 13). Site 572 remained in the category of the poorest biological condition over the study period. Sites 226, 167, 114, and 559 all improved in biological condition while the remaining sites remained stable (Sites 277, 446, 398, 85, 55, 258, and 613).

Upper Santa Ana - Subregion E

We sampled six sites along Mill Creek, five sites on the Santa Ana River, and ten sites along tributaries of the Santa Ana River, and one site that drains to Big Bear Lake (Figure 14). No sites scored in the category of lowest biological condition. Two sites on Mill Creek (Sites 34 and 272) and Site 50 on the Santa Ana River were the lowest scoring sites in the subregion (falling within the orange category) and this status remained stable over the study period (Figure 15). One site along Barton Creek (Site 530) scored in the yellow category, while the remaining sites all scored in the green category (see Figure 14 for site numbers). Most sites remained stable except for Sites 100 (Metcalf Creek), 686 (West Fork of Barton Creek), 380 (Frog Creek), and 501 (Mill Creek); these sites all experienced significant improvement in biological condition.

San Jacinto - Subregion F

In this subregion, five sites were sampled along Strawberry Creek, and one site each on the North and South Forks of the San Jacinto River, and one site on the main stem of the San Jacinto River. Site 419 on Strawberry Creek in the town of Idyllwild was the only site in the subregion to score in the red category. The two sites (Sites 20 and 375) upstream of Site 419 both were green sites suggesting a negative impact of the town on the biological condition of the creek. Downstream from Site 419 were a green (Site 535) and a yellow site (Site 270) further suggesting an impact of the town. Moreover, Site 419 showed a significant decline in biological condition over the study period (Figure 17). The only orange site (Site 587) in the subregion was along the South Fork of the San Jacinto River and this site also experienced significant decline (Figure 17). Sites 147 (North Fork of the San Jacinto River) and 159 (main stem San Jacinto River) were in the yellow category and remained that way from their first sample date.

Conclusions

We revisited 91 stream reaches in Region 8 over the years 2012-2015 to determine the current biological condition and to estimate the change in biological condition from the first time each of these reaches was sampled as part of a previous study. We calculated CSCI scores for each site and designated significant change as being more than or less than one standard deviation from the mean.

The CSCI scores provided us with an idea of the overall general condition of each site sampled during the 2012-2015 study period, in addition they allowed us to compare each site to the surrounding streams in order to identify sites that “stand out” compared to nearby sites. By analyzing trend data we not only get a general idea of how the biologic integrity of the streams sampled during the study period changed over time, but are also able to identify those sites changing more than average, for better or for worse. Based on the CSCI scores, the majority of sites sampled did not change significantly. We were able, however; to identify sites that either greatly improved in ecological function or declined in ecological function when compared to all of the sites sampled for the duration of the study (Table 7, Table 8).

For example site 532 along Santiago Creek was the only site in the Orange County area to score within the ‘orange’ category based on CSCI score, the surrounding sites all scored within the ‘red’ category. Not only did site 532 score higher than the surrounding sites, it also significantly improved in CSCI score during the study while the surrounding sites did not. Sites 351 and 361 along the middle portion of the Santa Ana River are also of interest. Both sites significantly improved over the course of the study, while sites immediately above and below stream of each site either did not improve (351) or declined in overall health (361). It would be interesting to revisit sites such as these to see if the upward changes are consistent and to possibly identify factors responsible for improved CSCI scores.

The results from this study will allow the staff scientists at Region 8 to make informed decisions as to the nature of future studies.

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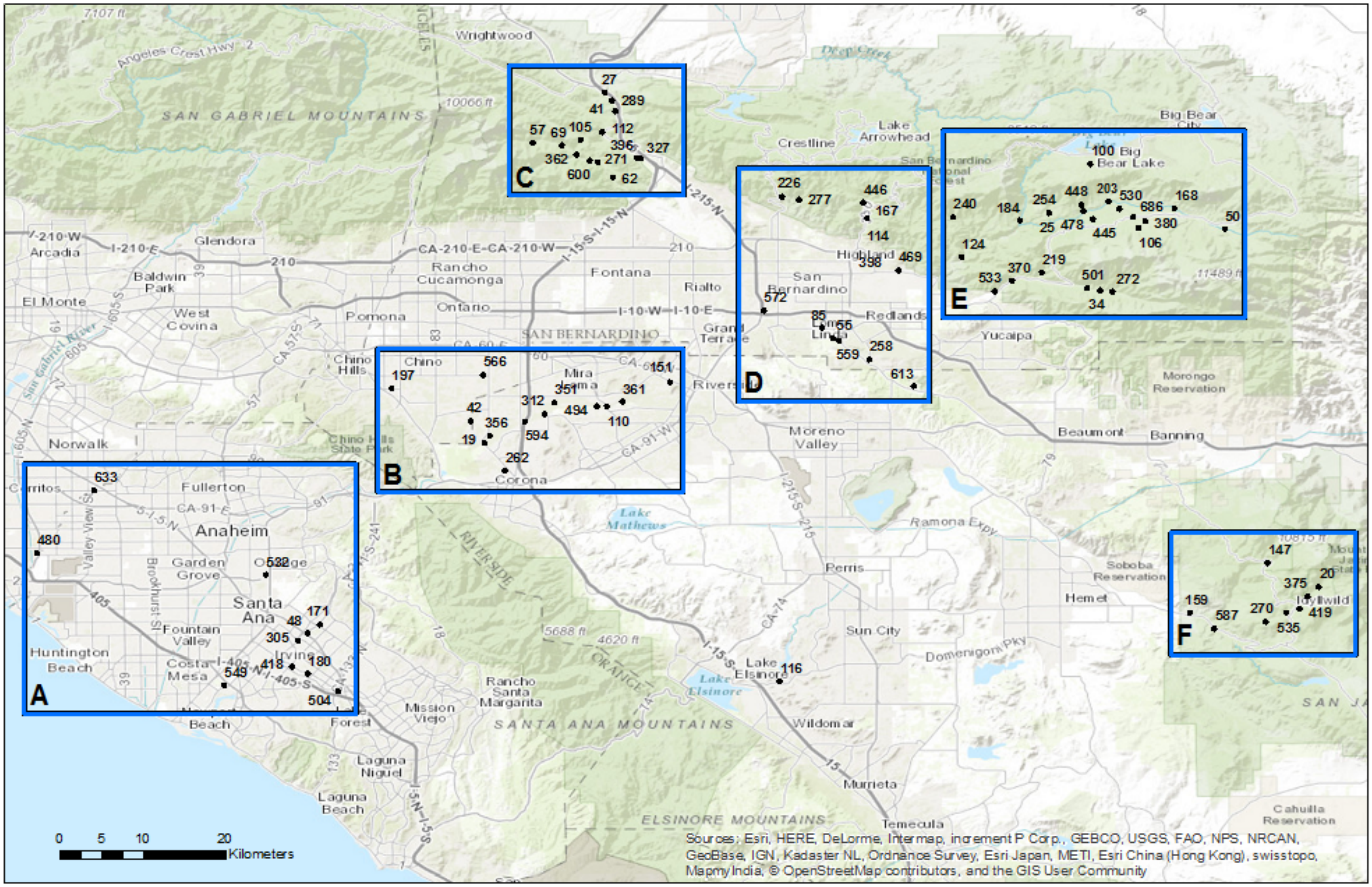


Figure 1. Overview map of Region 8. Sites are identified by the last three digits of their SWAMP code. For ease of reporting sites have been categorized into six subregions, which are outlined in blue and expanded in the figures below. The subregions are as follows: A) Orange County, B) Prado Basin, C) Lytle Creek/Cajon Wash, D) Middle Santa Ana, E) Upper Santa Ana, F) San Jacinto.

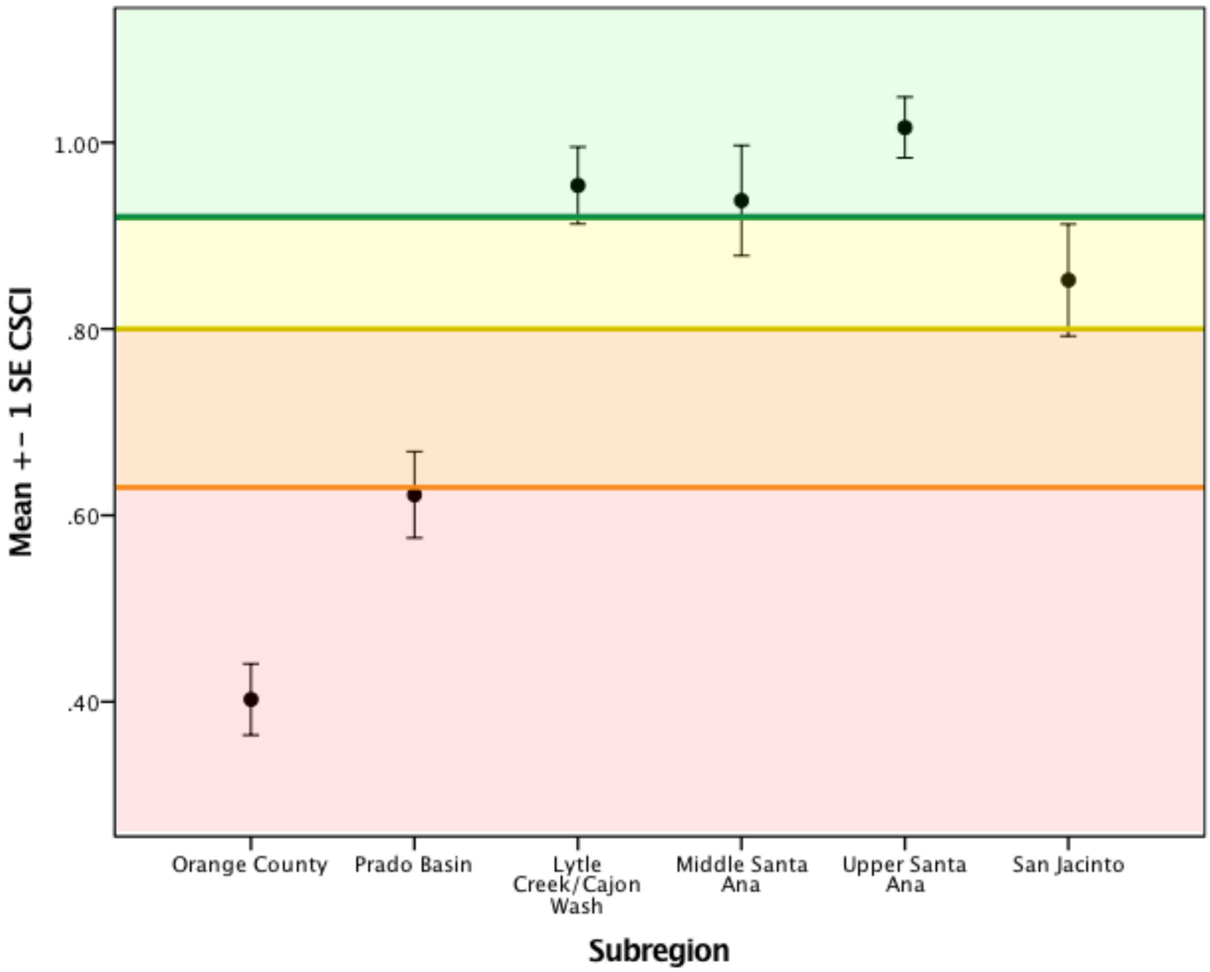


Figure 2. Mean CSCI score for each subregion. The mean (± 1 standard error) CSCI score is displayed for each subregion of Region 8. The four categories for the CSCI scores are shaded on the plot.

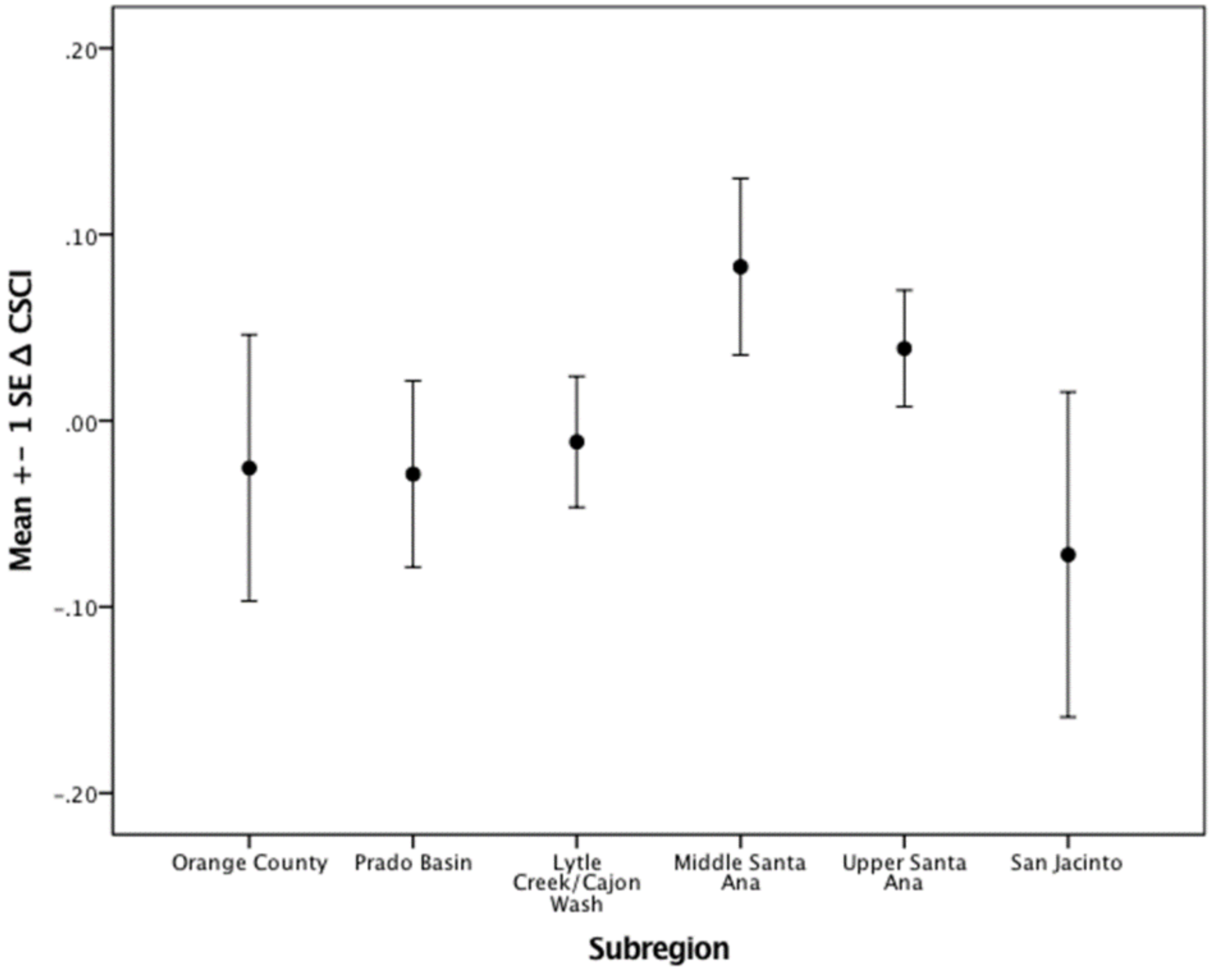


Figure 3. Mean change in CSCI score for each subregion. The mean (± 1 standard error) change in CSCI score is displayed for each subregion of Region 8. The mean was calculated by subtracting the CSCI score for the original sampling event from the CSCI score for the most current sampling event.

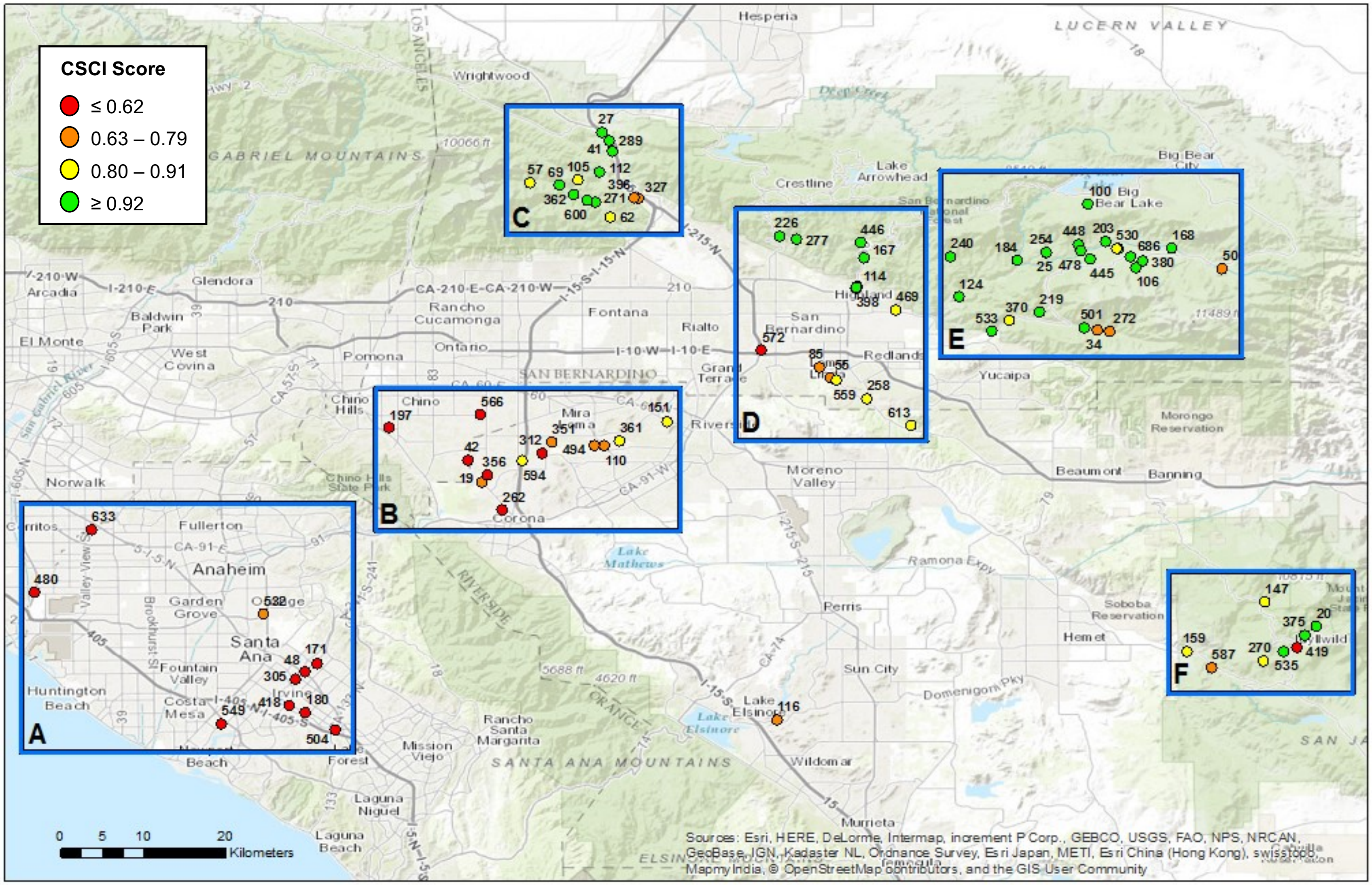


Figure 4. Overview CSCI score map of Region 8. Sites are identified by the last three digits of their SWAMP code. Each site is color coded based on the CSCI category in which it falls for the 2012 – 2015 sampling period. Subregions are outlined in blue and expanded in the figures below. The subregions are as follows: A) Orange County, B) Prado Basin, C) Lytle Creek/Cajon Wash, D) Middle Santa Ana, E) Upper Santa Ana, F) San Jacinto.

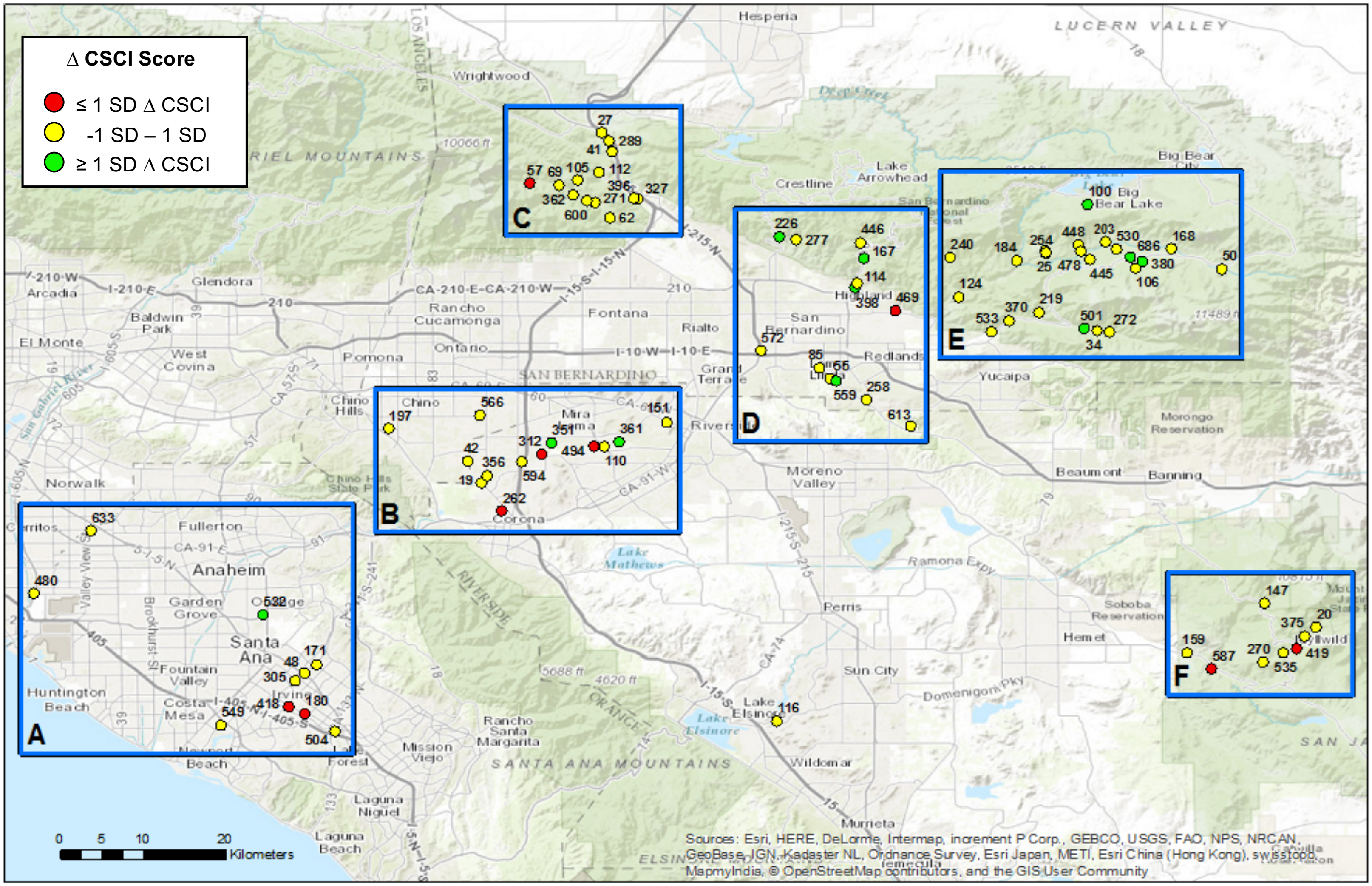


Figure 5. Overview change in CSCI score map of Region 8. Sites are identified by the last three digits of their SWAMP code. Each site is color coded based on the change in CSCI score between the past and the most recent sampling event, with sites increasing more than one standard deviation from the mean change coded green, those changing within -1 to 1 standard deviation coded yellow, and those decreasing more than one standard deviation coded red. Subregions are outlined in blue and expanded in the figures below. The sub-maps are as follows: A) Orange County, B) Prado Basin, C) Lytle Creek/Cajon Wash, D) Middle Santa Ana, E) Upper Santa Ana, F) San Jacinto.

Figure 6. CSCI scores for Orange County (subregion A) area of Region 8. Sites are identified by the last three digits of their SWAMP code. Each site is color coded based on the CSCI category in which it falls for the 2012 – 2015 sampling period.

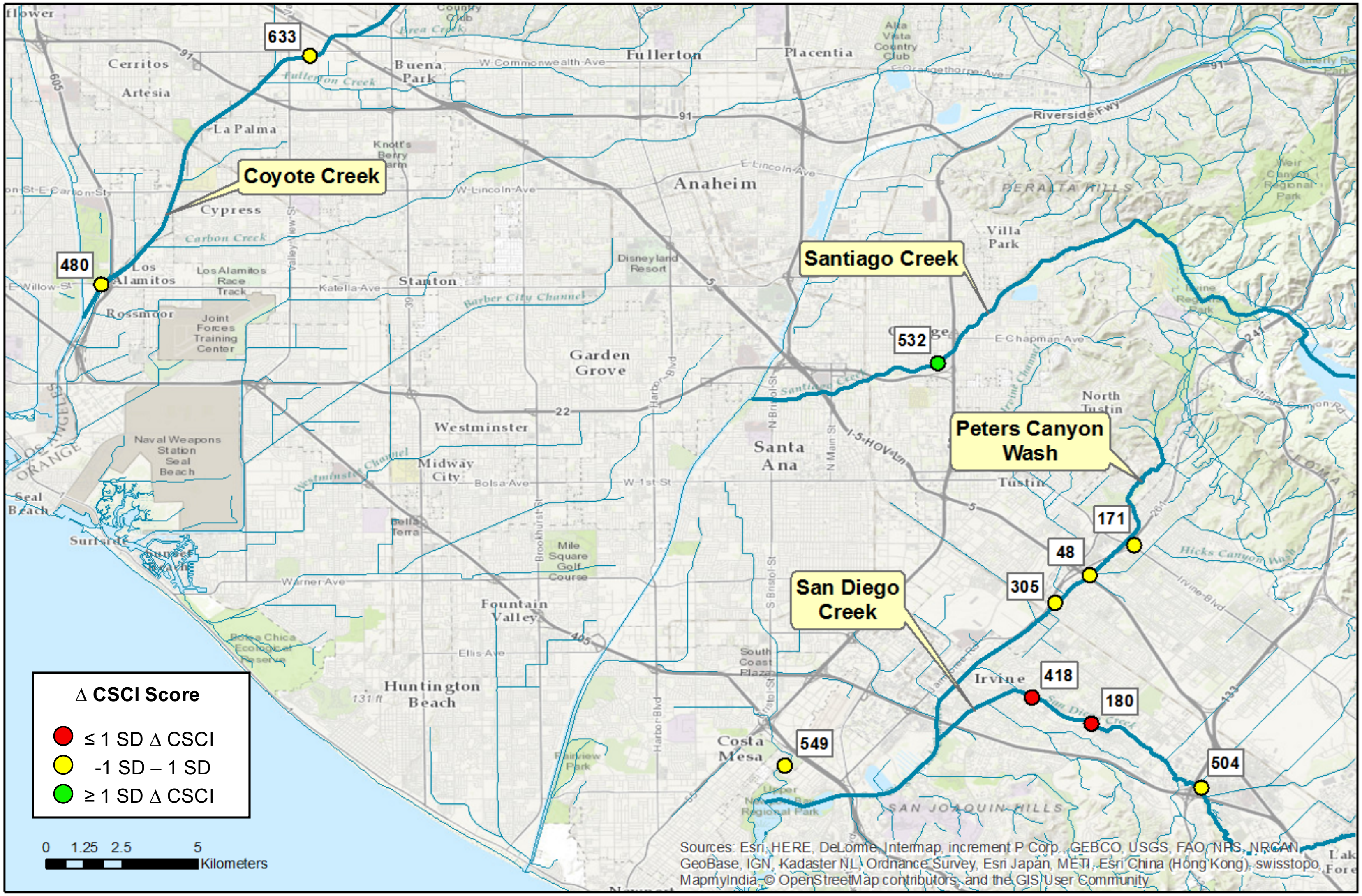


Figure 7. Change in CSCI scores for Orange County area of Region 8. Sites are identified by the last three digits of their SWAMP code. Each site is color coded based on the change in CSCI score between the past and the most recent sampling event, with sites increasing more than one standard deviation from the mean change coded green, those changing within -1 to 1 standard deviation coded yellow, and those decreasing more than one standard deviation coded red.

Figure 8. CSCI scores for Prado Basin (subregion B) area of Region 8. Sites are identified by the last three digits of their SWAMP code. Each site is color coded based on the CSCI category in which it falls for the 2012 – 2015 sampling period.

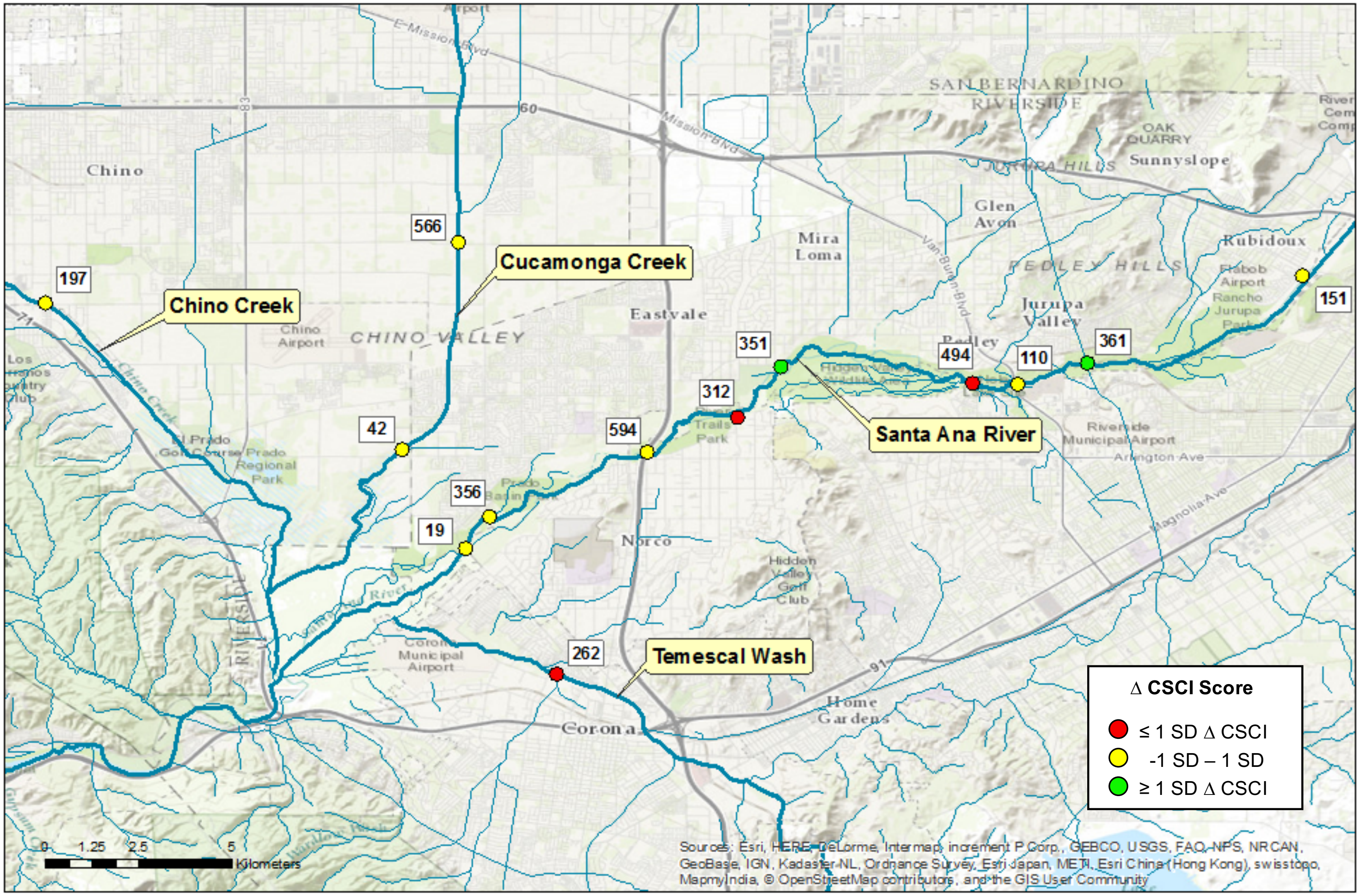


Figure 9. Change in CSCI scores for Prado Basin area of Region 8. Sites are identified by the last three digits of their SWAMP code. Each site is color coded based on the change in CSCI score between the past and the most recent sampling event, with sites increasing more than one standard deviation from the mean change coded green, those changing within -1 to 1 standard deviation coded yellow, and those decreasing more than one standard deviation coded red.

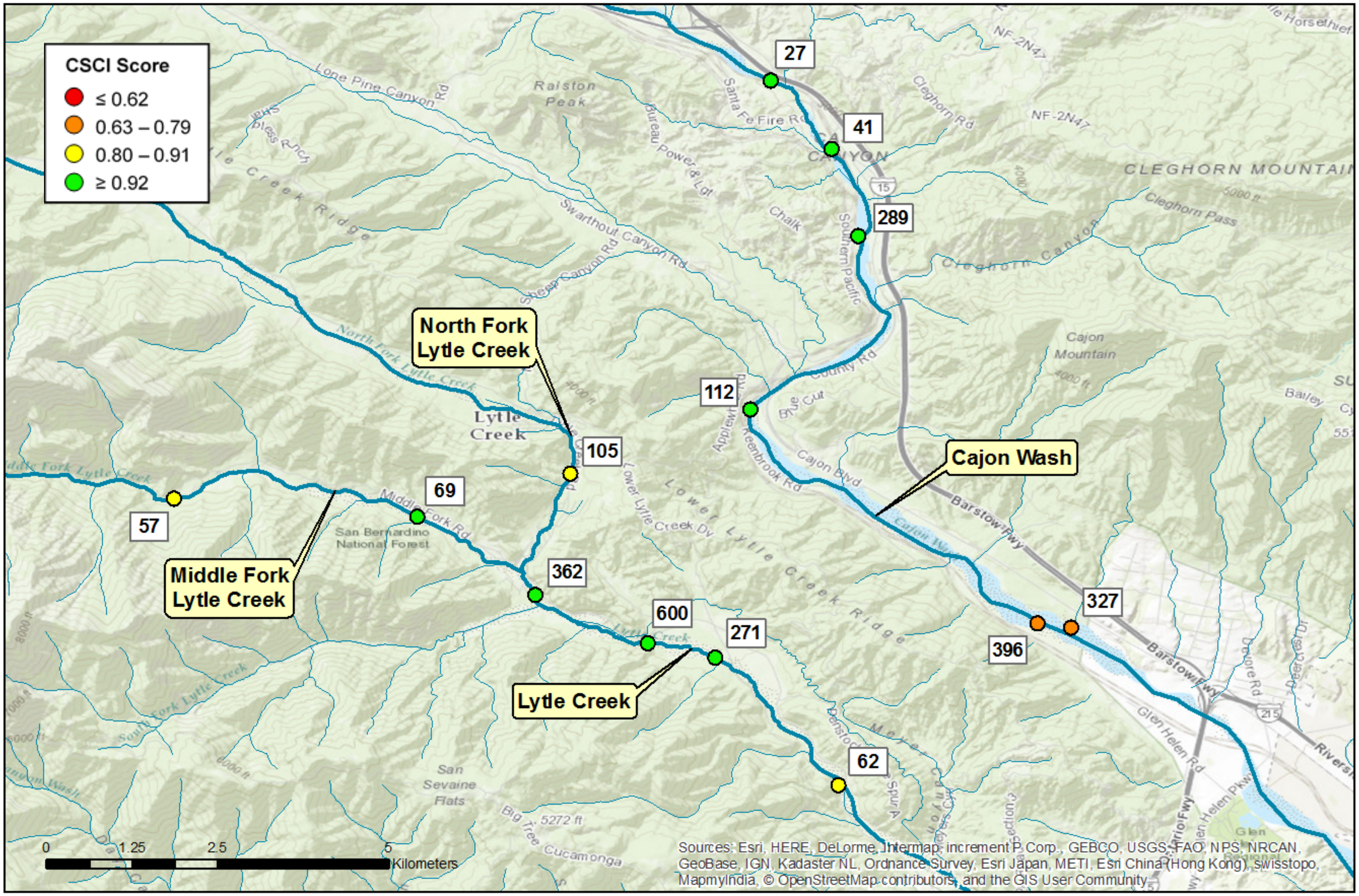


Figure 10. CSCI scores for Lytle Creek and Cajon Wash (subregion C) area of Region 8. Sites are identified by the last three digits of their SWAMP code. Each site is color coded based on the CSCI category in which it falls for the 2012 – 2015 sampling period.

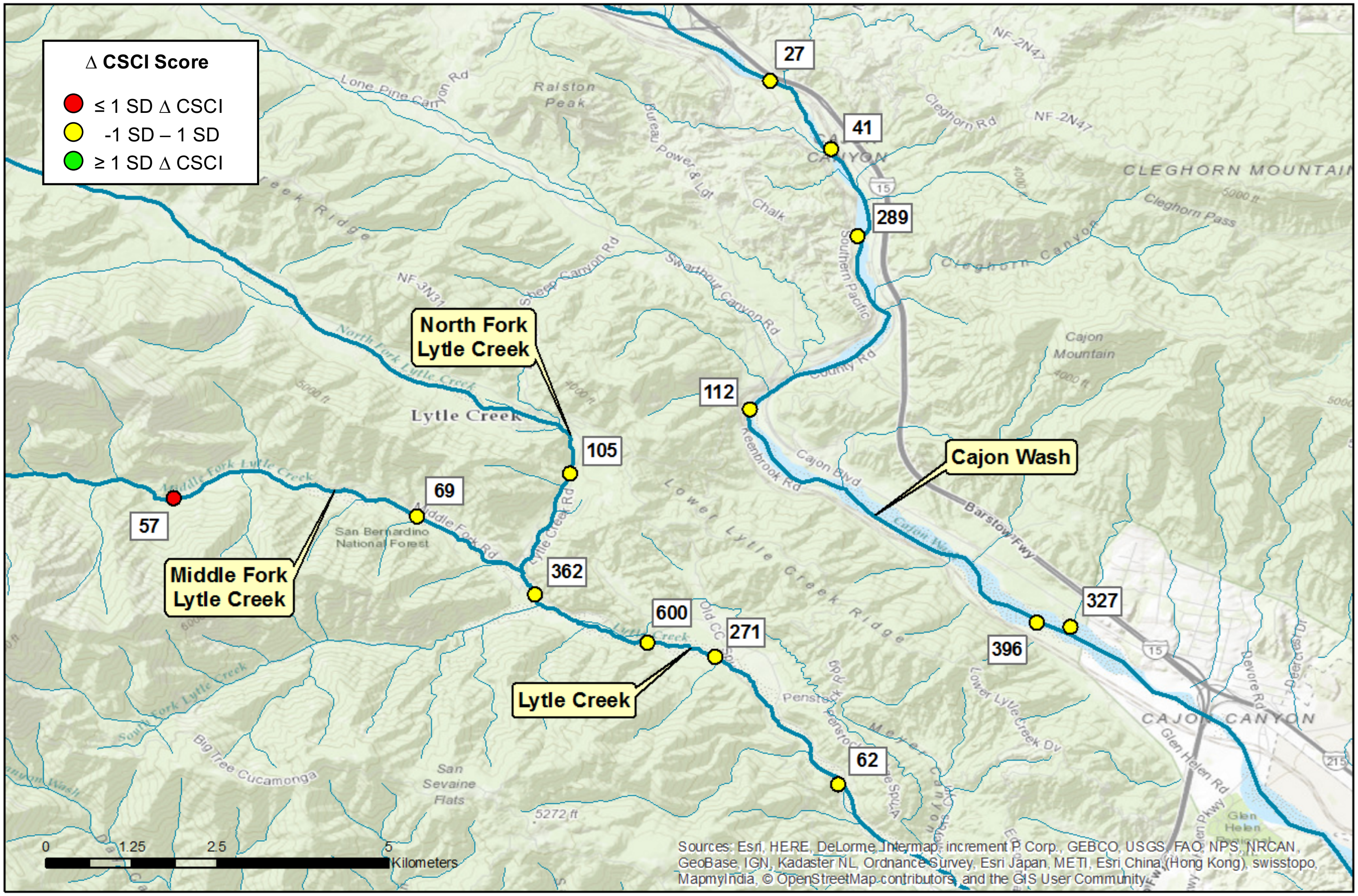


Figure 11. Change in CSCI scores for Lytle Creek and Cajon Wash area of Region 8. Sites are identified by the last three digits of their SWAMP code. Each site is color coded based on the change in CSCI score between the past and the most recent sampling event, with sites increasing more than one standard deviation from the mean change coded green, those changing within -1 to 1 standard deviation coded yellow, and those decreasing more than one standard deviation coded red.

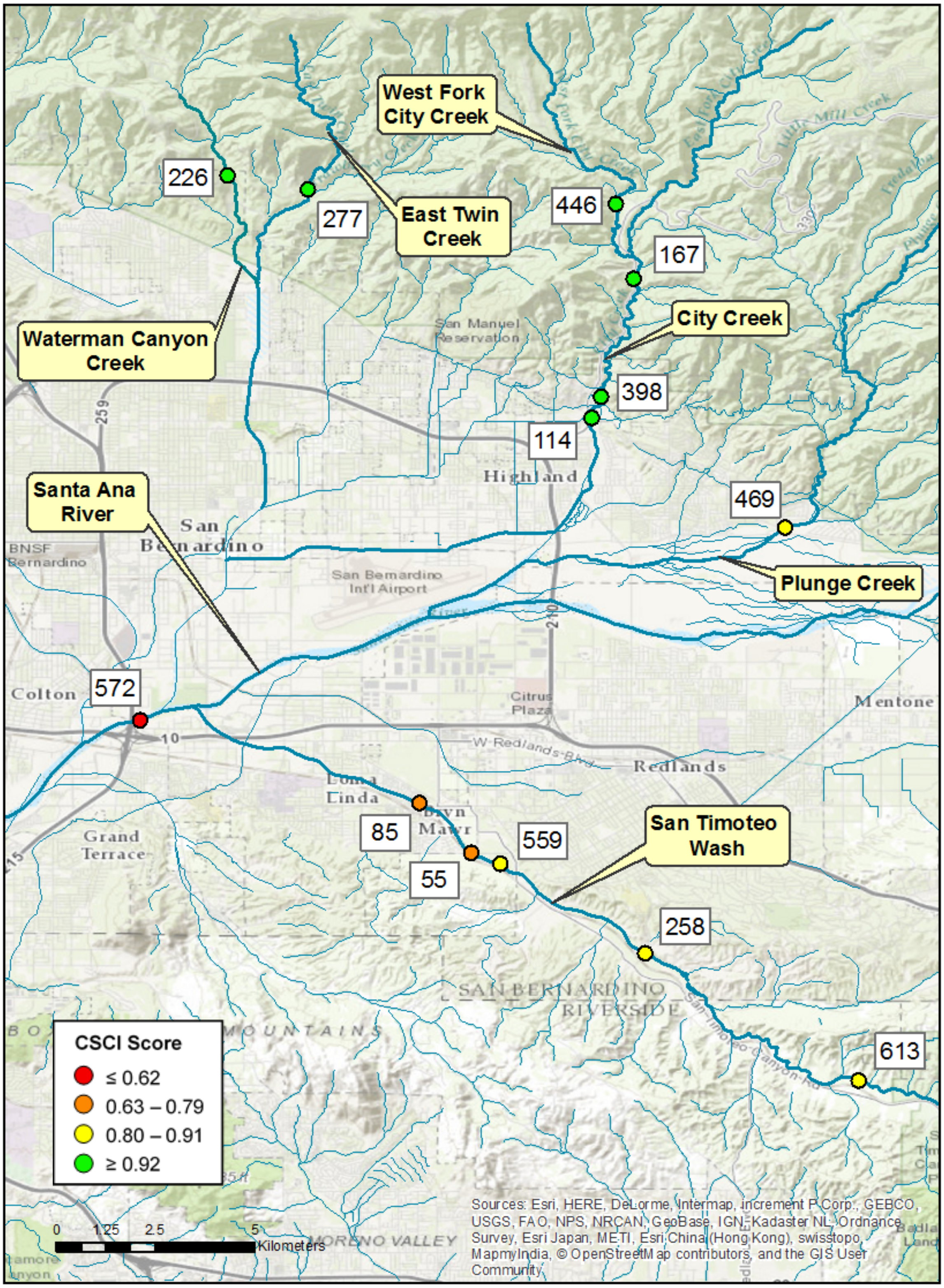


Figure 12. CSCI scores for Middle Santa Ana (subregion D) area of Region 8. Sites are identified by the last three digits of their SWAMP code. Each site is color coded based on the CSCI category in which it falls for the 2012 – 2015 sampling period.

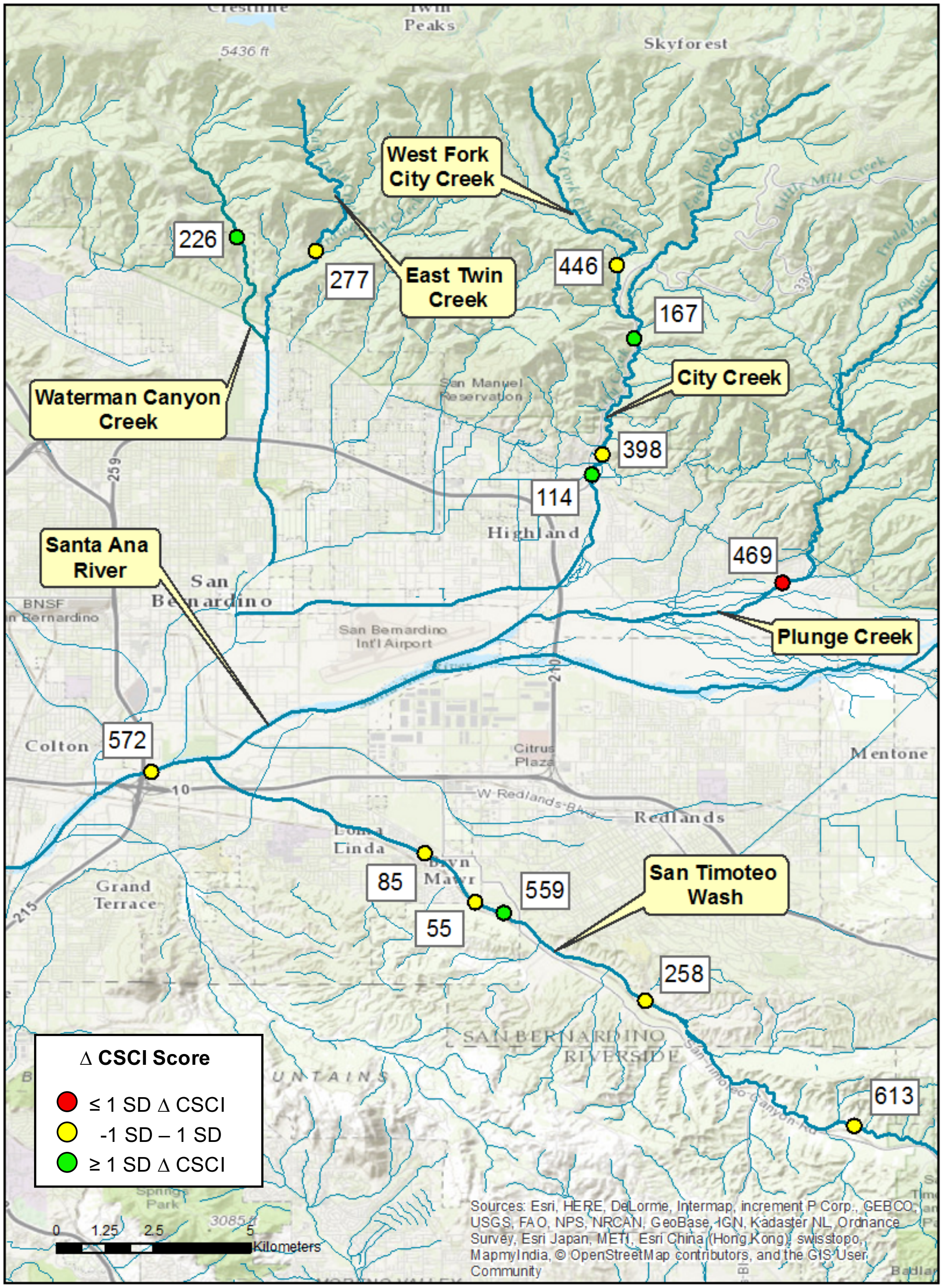


Figure 13. Change in CSCI scores for Middle Santa Ana area of Region 8. Sites are identified by the last three digits of their SWAMP code. Each site is color coded based on the change in CSCI score between the past and the most recent sampling event, with sites increasing more than one standard deviation from the mean change coded green, those changing within -1 to 1 standard deviation coded yellow, and those decreasing more than one standard deviation coded red.

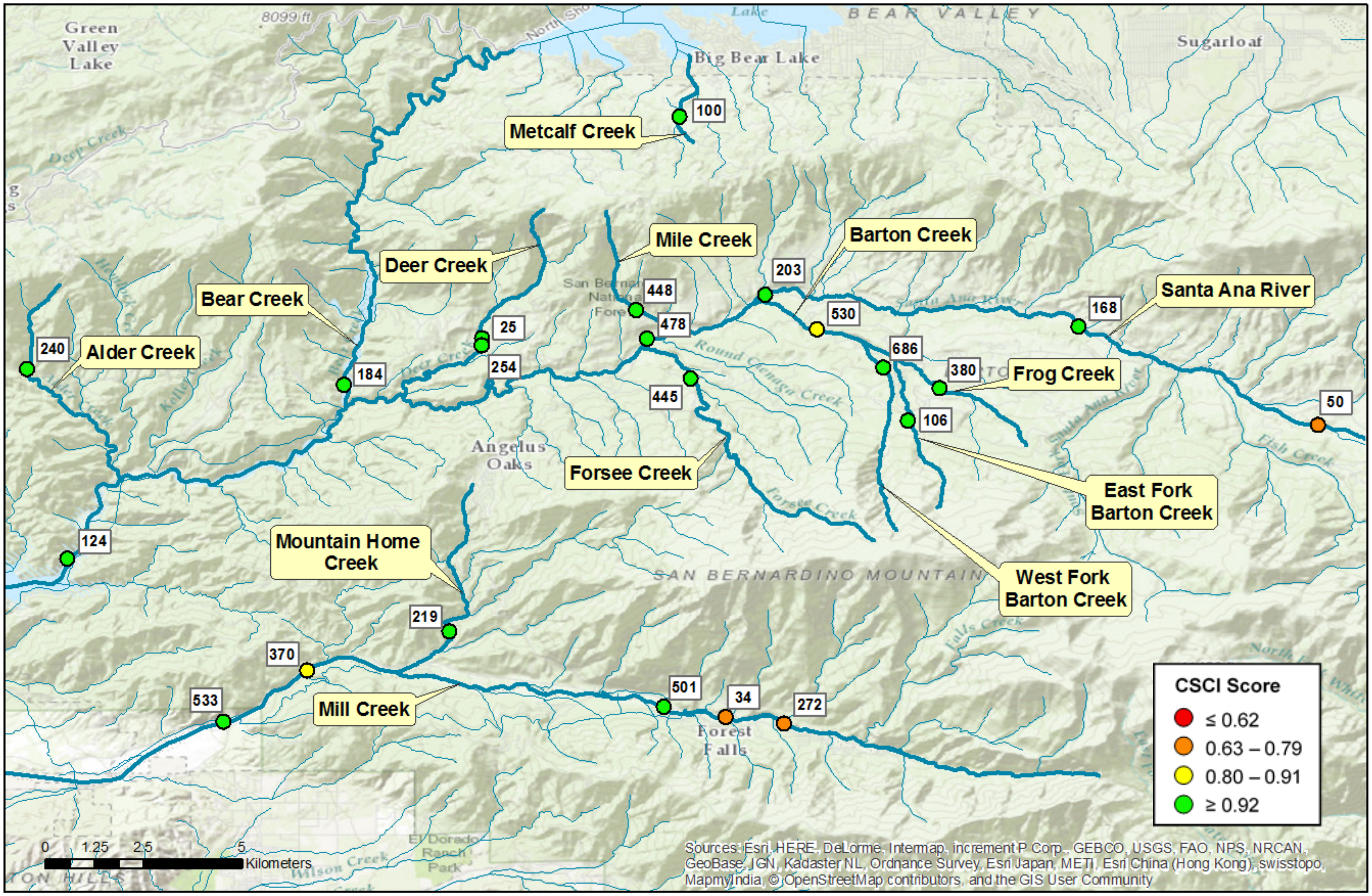


Figure 14. CSCI scores for Upper Santa Ana (subregion E) area of Region 8. Sites are identified by the last three digits of their SWAMP code. Each site is color coded based on the CSCI category in which it falls for the 2012 – 2015 sampling period.

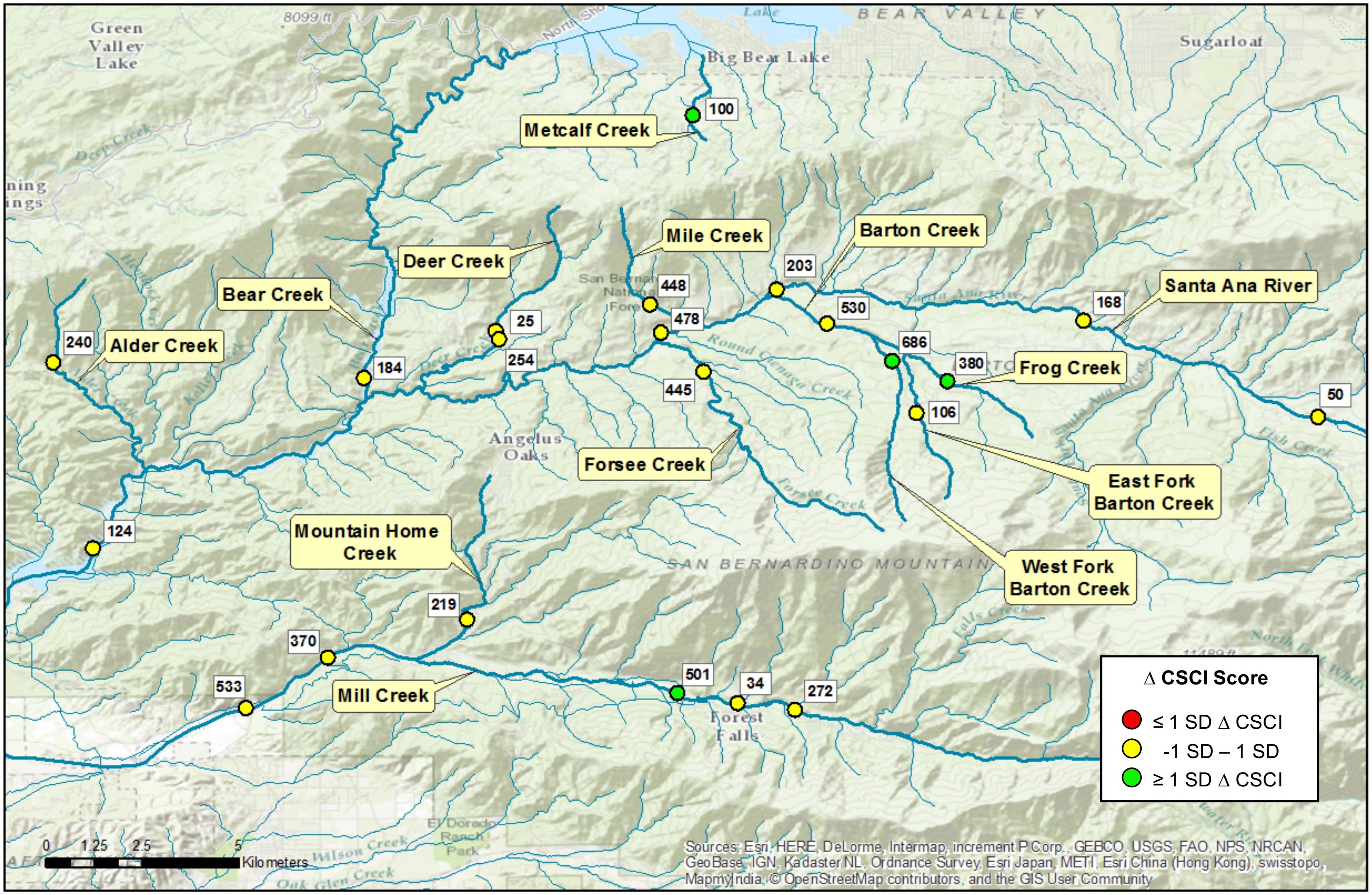


Figure 15. Change in CSCI scores for Upper Santa Ana area of Region 8. Sites are identified by the last three digits of their SWAMP code. Each site is color coded based on the change in CSCI score between the past and the most recent sampling event, with sites increasing more than one standard deviation from the mean change coded green, those changing within -1 to 1 standard deviation coded yellow, and those decreasing more than one standard deviation coded red.

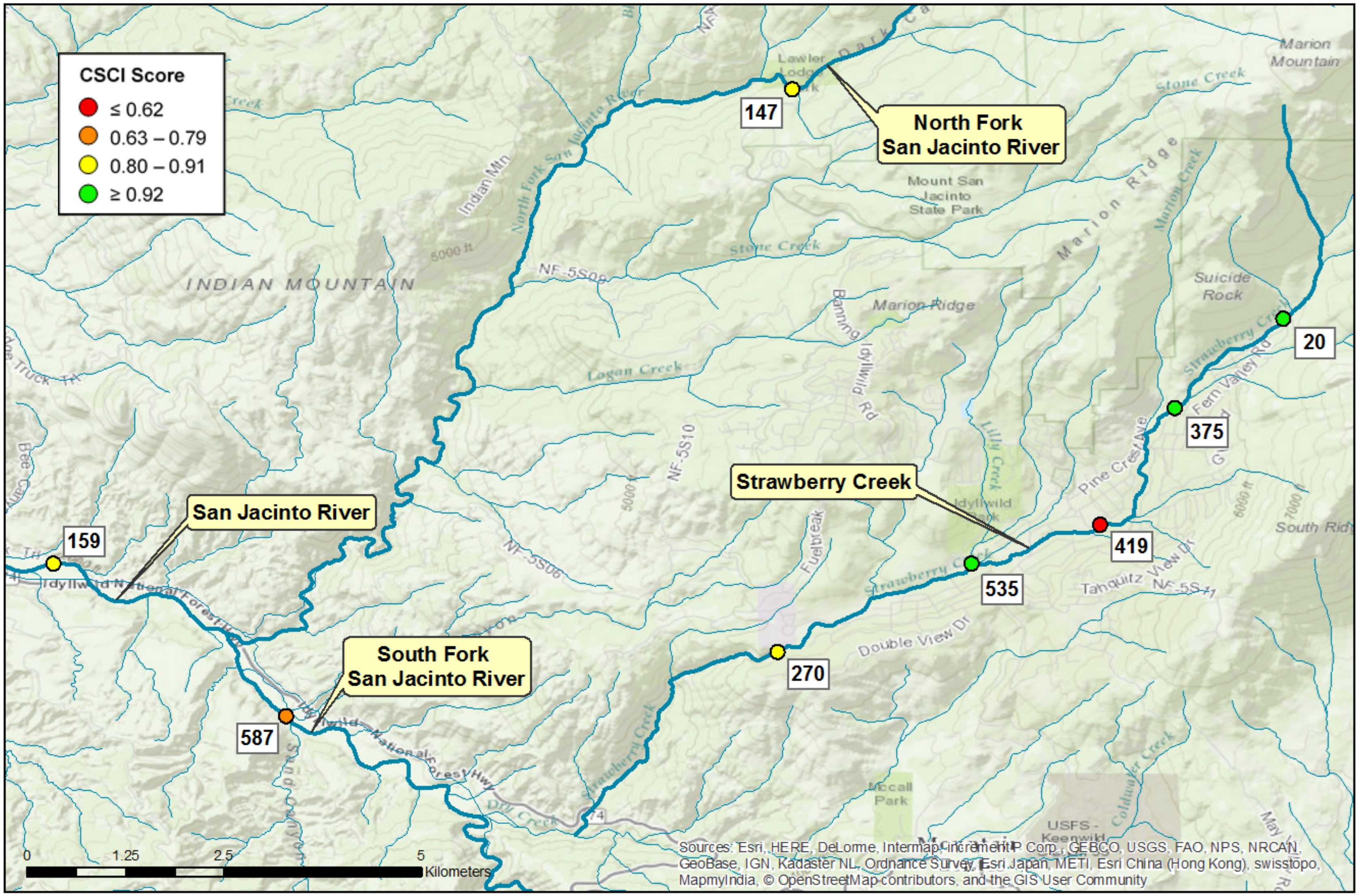


Figure 16. CSCI scores for San Jacinto (subregion F) area of Region 8. Sites are identified by the last three digits of their SWAMP code. Each site is color coded based on the CSCI category in which it falls for the 2012 – 2015 sampling period.

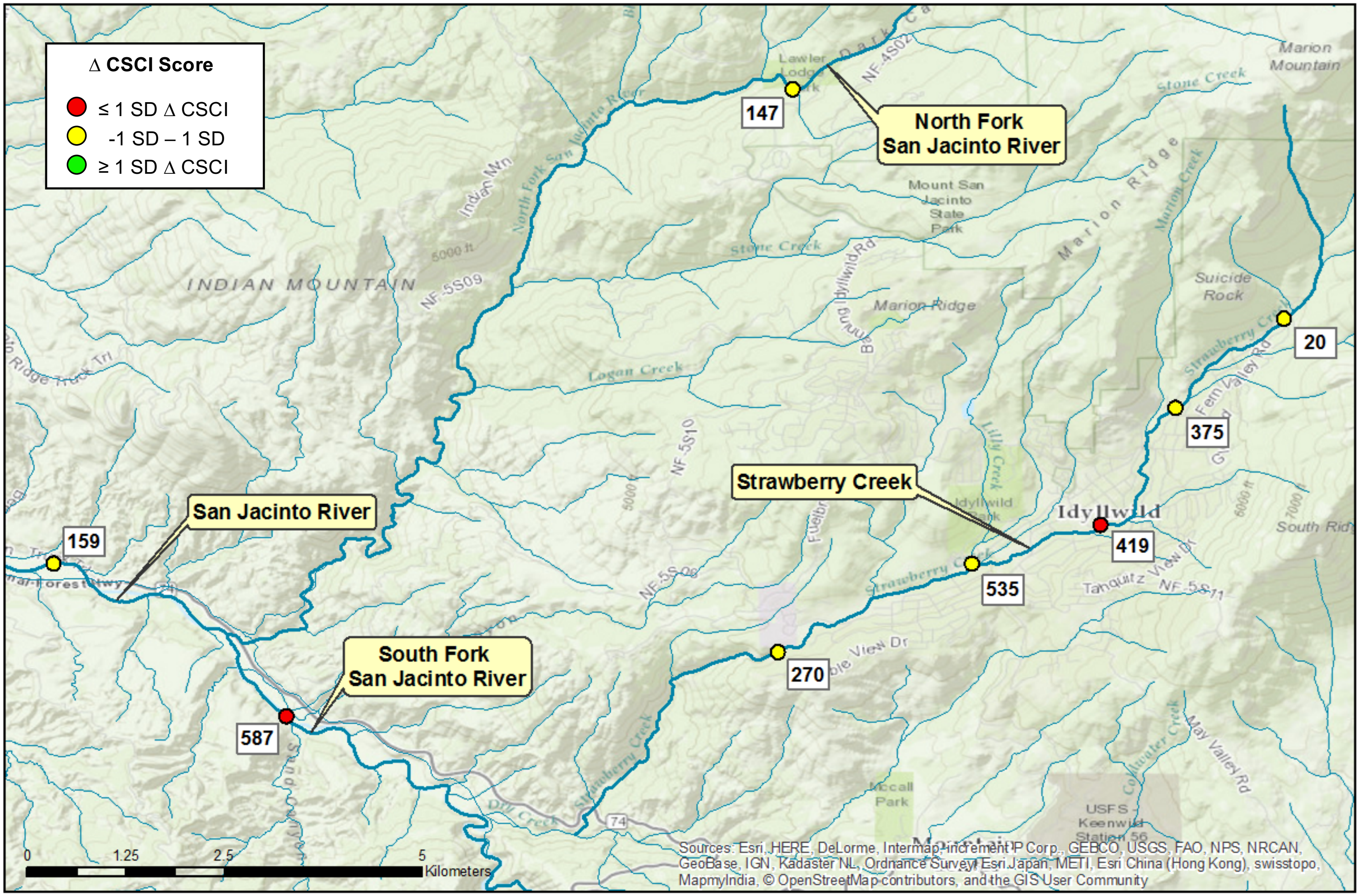


Figure 17. Change in CSCI scores for San Jacinto area of Region 8. Sites are identified by the last three digits of their SWAMP code. Each site is color coded based on the change in CSCI score between the past and the most recent sampling event, with sites increasing more than one standard deviation from the mean change coded green, those changing within -1 to 1 standard deviation coded yellow, and those decreasing more than one standard deviation coded red.

Table 1: Sites sampled during the 2012 index period (June 4 – July 17, 2012). All sites were from the original probabilistic draw. Sites in bold denote where field replicates were taken.

			Field Recorded			
SWAMP Code	Stream name	County	Latitude	Longitude	Elevation (m)	Collection date
			WGS 84			
845CTC480	Coyote Creek	Los Angeles	33.80362	-118.08447	2	11-Jun-12
801PCW171	Peters Canyon Wash	Orange	33.72585	-117.77692	32	12-Jun-12
801XXX305	Peters Canyon Wash	Orange	33.70874	-117.80067	16	12-Jun-12
801SDC504	San Diego Creek	Orange	33.65355	-117.75699	43	11-Jun-12
801PCW048	San Timoteo Wash	Orange	33.71692	-117.79018	12	11-Jun-12
801STC532	Santiago Creek	Orange	33.78013	-117.83554	64	12-Jun-12
801S10259*	Serrano Creek	Orange	33.64869	-117.69530	124	7-Jun-12
802S37697*	Kitching Channel	Riverside	33.88165	-117.21407	449	12-Jul-12
801SAR361	Middle Santa Ana River	Riverside	33.96855	-117.44767	212	18-Jun-12
802S25949*	North Fork San Jacinto River	Riverside	33.79334	-116.74573	1593	4-Jun-12
801PFB019	Prado Flood Control Basin	Riverside	33.92593	-117.59679	162	13-Jun-12
802SJR116	San Jacinto River	Riverside	33.66461	-117.27670	393	26-Jun-12
801RB8613	San Timoteo Wash	Riverside	33.98552	-117.13077	527	19-Jun-12
801RB8356	Santa Ana River	Riverside	33.93140	-117.59185	164	13-Jun-12
801SAR110	Santa Ana River	Riverside	33.96250	-117.46896	205	14-Jun-12
801SAR351	Santa Ana River	Riverside	33.96753	-117.52167	195	14-Jun-12
802S33361*	Strawberry Creek	Riverside	33.73790	-116.72790	1577	5-Jun-12
802S33561*	Strawberry Creek	Riverside	33.74347	-116.71104	1645	4-Jun-12
802SWC020	Strawberry Creek	Riverside	33.76701	-116.69023	1881	16-Jul-12
802SWC375	Strawberry Creek	Riverside	33.75681	-116.70258	1743	16-Jul-12
802SWC535	Strawberry Creek	Riverside	33.73906	-116.72575	1584	16-Jul-12
801RB8262	Temescal Wash	Riverside	33.89342	-117.57573	166	18-Jun-12
801BNC530	Barton Creek	San Bernardino	34.17820	-116.90560	1520	17-Jul-12
801RB8289	Cajon Wash	San Bernardino	34.28424	-117.45554	851	5-Jun-12
801RB8327	Cajon Wash	San Bernardino	34.23287	-117.42760	665	21-Jun-12
801XXX112	Cajon Wash	San Bernardino	34.26148	-117.46969	785	28-Jun-12
801RB8197	Chino Creek	San Bernardino	33.98275	-117.69891	184	26-Jun-12
801S04078*	Chino Creek	San Bernardino	33.99577	-117.72192	190	11-Jul-12
801RB8167	City Creek	San Bernardino	34.16797	-117.18181	1060	26-Jun-12
801RB8277	Coldwater Canyon	San Bernardino	34.18824	-117.25569	568	20-Jun-12
801CJW027	Cajon Wash	San Bernardino	34.30463	-117.46703	913	25-Jun-12
801CJW041	Cajon Wash	San Bernardino	34.29567	-117.45903	879	21-Jun-12
801RB8445	Forsee Creek	San Bernardino	34.16686	-116.93613	1602	17-Jul-12
801HNC203	Hamilton Creek	San Bernardino	34.18603	-116.91906	1597	17-Jul-12
801S03111*	Icehouse Canyon	San Bernardino	34.24841	-117.61720	1780	6-Jun-12
801S03488*	Icehouse Canyon	San Bernardino	34.24918	-117.16071	1577	6-Jun-12
801RB8572	Middle Santa Ana River	San Bernardino	34.06754	-117.29377	291	18-Jun-12
801MIC042	Mill Creek	San Bernardino	33.94658	-117.61443	164	13-Jun-12
801MIC370	Mill Creek	San Bernardino	34.10056	-117.02357	998	27-Jun-12
801MHC219	Mountain Home Creek	San Bernardino	34.10904	-116.99131	1232	27-Jun-12
801NLC105	North Fork Lytle Creek	San Bernardino	34.25302	-117.49335	964	25-Jun-12
801PLC469	Plunge Creek	San Bernardino	34.11132	-117.14747	454	19-Jun-12
801S04471*	Plunge Creek	San Bernardino	34.11133	-117.14747	445	9-Jul-12
801S01805*	San Timoteo	San Bernardino	33.98760	-117.14240	505	9-Jul-12
801STW085	San Timoteo Wash	San Bernardino	34.03957	-117.22010	371	19-Jun-12
801STW258	San Timoteo Wash	San Bernardino	34.19141	-117.27390	614	20-Jun-12
801S01671*	Santa Ana River	San Bernardino	34.16978	-116.82667	1902	10-Jul-12
801S02567*	Santa Ana River	San Bernardino	34.18544	-116.89831	1630	10-Jul-12
801S01783*	Waterman Canyon	San Bernardino	34.19148	-117.27396	613	11-Jul-12
801WCC446	West Fork City Creek	San Bernardino	34.18501	-117.18582	734	21-Jun-12

Table 2: Sites sampled during the 2013 index period (June 3 – July 10, 2013). All sites were from the original probabilistic draw. Sites in bold denote where field replicates were taken.

			Field Recorded			
SWAMP Code	Stream name	County	Latitude	Longitude	Elevation (m)	Collection date
			WGS 84			
801RB8633	Coyote Creek	Los Angeles	33.87181	-118.02232	15	8-Jul-13
801RB8549	Unknown Channel	Orange	33.66013	-117.88100	6	26-Jun-13
802SJR116	San Jacinto River	Riverside	33.66460	-117.27673	401	8-Jul-13
801RB8312	Santa Ana River	Riverside	33.95528	-117.53214	183	27-Jun-13
801RB8494	Santa Ana River	Riverside	33.96354	-117.47546	208	20-Jun-13
801RB8594	Santa Ana River	Riverside	33.94696	-117.55390	178	20-Jun-13
801SAR151	Santa Ana River	Riverside	33.98946	-117.39604	238	9-Jul-13
802SWC270	Strawberry Creek	Riverside	33.72897	-116.74882	1486	17-Jun-13
802SWC419	Strawberry Creek	Riverside	33.74348	-116.71111	1618	17-Jun-13
801RB8240	Alder Creek	San Bernardino	34.16903	-117.08796	1145	25-Jun-13
801RB8396	Cajon Wash	San Bernardino	34.23344	-117.43201	695	10-Jul-13
801RB8197	Chino Creek	San Bernardino	33.98289	-117.69882	188	27-Jun-13
801CYC114	City Creek	San Bernardino	34.13596	-117.19025	542	9-Jul-13
801RB8566	Cucamonga Creek	San Bernardino	33.99756	-117.59932	218	8-Jul-13
801RB8254	Deer Creek	San Bernardino	34.17395	-116.98380	1366	24-Jun-13
801RB8478	Forsee Creek	San Bernardino	34.17601	-116.94609	1490	25-Jun-13
801RB8380	Frog Creek	San Bernardino	34.16465	-116.87914	2012	26-Jun-13
801RB8448	Mile Creek	San Bernardino	34.18255	-116.94861	1554	24-Jun-13
801RB8501	Mill Creek	San Bernardino	34.09185	-116.94225	1469	18-Jun-13
801RB8533	Mill Creek	San Bernardino	34.08840	-117.04299	864	8-Jun-13
801PLC362	North Fork Lytle Creek	San Bernardino	34.23716	-117.49791	900	10-Jul-13
801RB8559	San Timoteo Wash	San Bernardino	34.03486	-117.21206	385	10-Jul-13
801HBC050	Santa Ana River	San Bernardino	34.15628	-116.79259	2052	19-Jun-13
801SAR168	Santa Ana River	San Bernardino	34.17876	-116.84738	1844	19-Jun-13

Table 3: Sites sampled during the 2014 index period (June 2– June 30, 2014). All sites were from the original probabilistic draw. Sites in bold denote where field replicates were taken.

			Field Recorded			
SWAMP Code	Stream name	County	Latitude	Longitude	Elevation (m)	Collection date
			WGS 84			
801XXX305	Peters Canyon Wash	Orange	33.70864	-117.80052	17	2-Jun-14
801SDC180	San Diego Creek	Orange	33.67263	-117.78971	35	4-Jun-14
801SDC418	San Diego Creek	Orange	33.68050	-117.80742	24	2-Jun-14
801MIC042	Mill Creek	Riverside	33.94759	-117.61287	164	9-Jun-14
802NJR147	North Fork San Jacinto River	Riverside	33.79318	-116.74619	1565	26-Jun-14
801PFB019	Prado Flood Control Basin	Riverside	33.92371	-117.59762	162	11-Jun-14
801SJR159	San Jacinto River	Riverside	33.73907	-116.83044	592	3-Jun-14
802SJR116	San Jacinto River	Riverside	33.66457	-117.27671	401	12-Jun-14
801SAR110	Santa Ana River	Riverside	33.96331	-117.46465	207	12-Jun-14
801SAR361	Santa Ana River	Riverside	33.96844	-117.44783	215	12-Jun-14
802SJR587	South Fork San Jacinto River	Riverside	33.72166	-116.80390	671	3-Jun-14
801BNC530	Barton Creek	San Bernardino	34.17815	-116.90725	1706	19-Jun-14
801BRC184	Bear Creek	San Bernardino	34.16541	-117.01542	1068	30-Jun-14
801CYC398	City Creek	San Bernardino	34.13592	-117.19023	453	5-Jun-14
801DRC025	Deer Creek	San Bernardino	34.17385	-116.98392	1374	25-Jun-14
801EBC686	East Fork Barton Creek	San Bernardino	34.16940	-116.89207	1936	19-Jun-14
801ETC226	East Twin Creek	San Bernardino	34.19145	-117.27396	510	10-Jun-14
801LYC271	Lytle Creek	San Bernardino	34.22894	-117.47427	804	10-Jun-14
801LYC600	Lytle Creek	San Bernardino	34.23082	-117.48314	829	23-Jun-14
801MIC370	Mill Creek	San Bernardino	34.10013	-117.02383	987	9-Jun-14
801MHC219	Mountain Home Creek	San Bernardino	34.10904	-116.99130	1304	24-Jun-14
801NLC105	North Fork Lytle Creek	San Bernardino	34.25305	-117.49330	969	10-Jun-14
801STW055	San Timoteo Wash	San Bernardino	34.03735	-117.21868	379	11-Jun-14
801STW085	San Timoteo Wash	San Bernardino	34.04866	-117.23042	358	11-Jun-14
801STW258	San Timoteo Wash	San Bernardino	34.01450	-117.17920	438	4-Jun-14
801SAR124	Santa Ana River	San Bernardino	34.12568	-117.07869	707	17-Jun-14
801WBC106	West Fork Barton Creek	San Bernardino	34.15725	-116.88641	2143	25-Jun-14
801WCC247	West Fork City Creek	San Bernardino	34.18720	-117.18521	749	5-Jun-14

Table 4: Sites sampled during the 2015 index period (June 25– July 9, 2015). All sites were from the original probabilistic draw. Sites in bold denote where field replicates were taken.

			Field Recorded			
SWAMP Code	**Stream name**	**County**	**Latitude**	**Longitude**	**Elevation (m)**	**Collection date**
			WGS 84			
801LYC062	Lytle Creek	San Bernardino	34.21220	-117.45811	718	1-Jul-15
801MFC100	Metcalf Creek	San Bernardino	34.22673	-116.93864	2218	8-Jul-15
801MIC034	Mill Creek	San Bernardino	34.08950	-116.92814	1559	25-Jun-15
801MIC272	Mill Creek	San Bernardino	34.08800	-116.91478	1678	9-Jul-15
801MLC057	Middle Fork Lytle Creek	San Bernardino	34.24979	-117.54534	1296	1-Jul-15
801MLC069	Middle Fork Lytle Creek	San Bernardino	34.24741	-117.51341	1000	6-Jul-15

Table 5: MMI and O/E sub-metrics and CSCI scores for all sites sampled. All sites were from the original probabilistic draw. Sites in bold denote field replicates. Sites marked with an asterisk indicate a low number of MMI iterations, O/E iterations, or both (and so scores should be interpreted with caution).

SiteID	SWAMP Code	Year	MMI	O/E	CSCI
19	801PFB019	2006	0.98	0.61	0.79
19*	801PFB019	2012	0.67	0.55	0.61
19	801PFB019	2014	0.75	0.62	0.68
20	802SWC020	2006	1.00	1.01	1.01
20*	802SWC020	2011	1.21	1.07	1.14
20	802SWC020	2012	1.04	0.94	0.99
25	801DRC025	2007	1.08	1.13	1.11
25	801DRC025	2014	0.94	1.05	0.99
25	**801DRC025**	2014	0.94	1.18	1.06
27*	801CJW027	2006	0.82	0.84	0.83
27	801CJW027	2012	1.04	0.88	0.96
34*	801MIC034	2006	0.65	0.91	0.78
34	801MIC034	2015	0.79	0.60	0.69
41	801CJW041	2006	0.93	0.90	0.92
41	801CJW041	2012	1.18	0.89	1.03
42	801MIC042	2006	0.52	0.38	0.45
42	801MIC042	2012	0.34	0.26	0.30
42	801MIC042	2014	0.40	0.42	0.41
48	801PCW048	2008	0.34	0.36	0.35
48	801PCW048	2012	0.33	0.23	0.28
50*	801HBC050	2008	0.80	0.79	0.79
50	801HBC050	2013	0.78	0.46	0.62
55	801STW055	2006	0.77	0.69	0.73
55	801STW055	2014	0.92	0.65	0.78
57	801MLC057	2008	1.09	0.98	1.03
57	801MLC057	2015	0.79	0.84	0.82
62	801LYC062	2006	1.04	0.88	0.96
62*	801LYC062	2015	1.04	0.77	0.91
69	801MLC069	2007	1.15	1.08	1.12
69	801MLC069	2015	1.14	1.02	1.08
69*	**801MLC069**	2015	1.15	1.04	1.10
85	801STW085	2006	0.72	0.60	0.66
85	801STW085	2012	0.75	0.65	0.70
85	801STW085	2014	0.75	0.55	0.65

Table 5: Continued

SiteID	SWAMP Code	Year	MMI	O/E	CSCI
100	801MFC100	2007	0.82	1.09	0.95
100	801MFC100	2015	1.21	1.10	1.16
105*	801NLC105	2007	1.26	0.78	1.02
105*	801NLC105	2011	0.77	0.94	0.86
105	801NLC105	2012	1.30	0.80	1.05
105	801NLC105	2014	0.95	0.80	0.87
106*	801WBC106	2007	1.08	1.07	1.08
106	801WBC106	2014	1.27	0.96	1.12
106	**801WBC106**	2014	1.19	0.89	1.04
110	801SAR110	2006	0.96	0.71	0.83
110	801SAR110	2012	0.80	0.71	0.75
110	801SAR110	2014	0.72	0.71	0.72
112	801XXX112	2008	1.01	0.73	0.87
112	801XXX112	2012	1.06	0.95	1.01
112	**801XXX112**	2012	0.93	0.81	0.87
114	801CYC114	2008	0.92	0.92	0.92
114	801CYC114	2013	1.21	1.03	1.12
116	802SJR116	2006	0.71	0.37	0.54
116	802SJR116	2011	0.68	0.38	0.53
116	802SJR116*	2012	0.44	0.24	0.34
116	802SJR116	2013	0.41	0.24	0.33
116	802SJR116*	2014	0.87	0.37	0.62
124	801SAR124	2009	1.14	1.05	1.10
124	801SAR124	2014	1.01	1.08	1.04
147*	802NJR147	2007	0.96	0.97	0.97
147	802NJR147	2014	0.97	0.79	0.88
151	801SAR151	2007	0.91	0.62	0.77
151	801SAR151	2013	0.91	0.69	0.80
159	801SJR159	2007	0.71	0.73	0.72
159	801SJR159	2014	0.94	0.78	0.86
167	801RB8167	2010	1.05	0.90	0.98
167	**801RB8167**	2010	0.68	0.98	0.83
167	801RB8167	2012	1.17	1.16	1.16

Table 5: Continued

SiteID	SWAMP Code	Year	MMI	O/E	CSCI
168	801SAR168	2007	0.95	1.01	0.98
168*	**801SAR168**	2007	1.00	1.18	1.09
168	801SAR168	2013	1.12	1.17	1.15
171	801PCW171	2008	0.34	0.19	0.26
171	**801PCW171**	2008	0.34	0.20	0.27
171	801PCW171	2012	0.34	0.21	0.27
180*	801SDC180	2006	0.83	0.66	0.75
180	801SDC180	2014	0.35	0.25	0.30
184	801BRC184	2009	1.10	1.06	1.08
184	**801BRC184**	2009	1.21	1.03	1.12
184	801BRC184	2014	1.10	1.10	1.10
184	**801BRC184**	2014	1.10	1.09	1.10
197	801RB8197	2009	0.47	0.34	0.41
197	801RB8197	2011	0.64	0.50	0.57
197	801RB8197	2012	0.61	0.51	0.56
197	801RB8197	2013	0.51	0.48	0.49
203*	801HNC203	2007	0.96	1.14	1.05
203	801HNC203	2012	1.09	1.19	1.14
219	801MHC219	2009	1.01	1.21	1.11
219	801RB8219	2012	1.11	1.32	1.21
219	801MHC219	2014	1.01	1.25	1.13
226*	801ETC226	2006	0.99	0.84	0.91
226	801ETC226	2014	1.28	1.15	1.21
240	801RB8240	2010	0.92	1.26	1.09
240	801RB8240	2013	1.21	1.08	1.15
247	801WCC247	2014	1.18	1.32	1.25
254	801RB8254	2009	1.25	1.17	1.21
254	801RB8254	2011	0.93	1.31	1.12
254	**801RB8254**	2011	1.05	1.00	1.02
254	801RB8254	2013	1.19	1.22	1.21
258	801STW258	2006	0.77	0.71	0.74
258	801STW258	2012	1.17	0.99	1.08
258	801STW258	2014	1.10	0.57	0.84

Table 5: Continued

SiteID	SWAMP Code	Year	MMI	O/E	CSCI
262	801RB8262	2009	0.63	0.48	0.55
262	801RB8262	2012	0.41	0.28	0.35
270*	802SWC270	2008	1.01	0.44	0.73
270	802SWC270	2013	0.87	0.89	0.88
271*	801LYC271	2007	1.18	1.06	1.12
271	801LYC271	2014	1.20	0.89	1.04
272	801MIC272	2008	0.67	0.85	0.76
272	801MIC272	2015	0.74	0.60	0.67
277	801RB8277	2010	1.08	1.21	1.15
277	801RB8277	2012	1.15	1.24	1.19
289	801RB8289	2009	0.91	0.89	0.90
289	801RB8289	2012	1.19	0.95	1.07
305*	801XXX305	2008	0.60	0.38	0.49
305	801XXX305	2012	0.60	0.44	0.52
305	801XXX305	2014	0.58	0.29	0.43
312	801RB8312	2009	0.77	0.51	0.64
312	801RB8312	2011	0.73	0.79	0.76
312*	801RB8312	2013	0.45	0.45	0.45
327*	801RB8327	2009	0.76	0.65	0.71
327	801RB8327	2012	0.74	0.54	0.64
351*	801SAR351	2008	0.34	0.63	0.48
351*	801SAR351	2012	0.90	0.58	0.74
356	801RB8356	2010	0.79	0.56	0.67
356	801RB8356	2012	0.67	0.47	0.57
361*	801SAR361	2007	0.34	0.68	0.51
361*	801SAR361	2012	0.78	0.69	0.73
361	801SAR361	2014	0.98	0.73	0.86
362	801PLC362	2008	1.25	0.95	1.10
362	801PLC362	2013	1.23	1.18	1.20
370	801MIC370	2007	1.03	0.66	0.85
370	**801MIC370**	2007	0.89	0.90	0.89
370	801MIC370	2012	1.01	0.97	0.99
370	**801MIC370**	2012	1.04	0.98	1.01
370	801MIC370	2014	1.07	0.57	0.82

Table 5: Continued

SiteID	SWAMP Code	Year	MMI	O/E	CSCI
375	802SWC375	2007	1.01	1.21	1.11
375	802SWC375	2012	1.14	0.88	1.01
380	801RB8380	2010	0.73	0.74	0.73
380	801RB8380	2013	1.10	0.76	0.93
396	801RB8396	2010	0.96	0.57	0.76
396	801RB8396	2013	0.67	0.66	0.66
398	801CYC398	2007	0.99	0.77	0.88
398	801CYC398	2014	0.99	0.88	0.93
418	801SDC418	2009	0.44	0.57	0.51
418	**801SDC418**	2009	0.49	0.43	0.46
418	801SDC418	2011	0.73	0.50	0.61
418	801SDC418	2014	0.37	0.29	0.33
419	802SWC419	2007	1.20	1.03	1.12
419	802SWC419	2013	0.80	0.32	0.56
445*	801RB8445	2010	1.09	1.30	1.20
445	801RB8445	2012	1.23	1.08	1.15
446*	801WCC446	2007	1.22	1.22	1.22
446	**801WCC446**	2007	1.12	0.75	0.94
446	801WCC446	2012	0.99	1.35	1.17
448	801RB8448	2010	1.09	1.20	1.14
448	801RB8448	2013	1.18	1.20	1.19
448	**801RB8448**	2013	1.29	1.20	1.25
469	801PLC469	2008	1.21	0.81	1.01
469	**801PLC469**	2008	1.08	0.79	0.93
469	801PLC469	2012	0.69	0.90	0.80
478*	801RB8478	2010	0.95	1.18	1.07
478*	**801RB8478**	2010	1.14	1.22	1.18
478	801RB8478	2013	0.95	0.91	0.93
478	**801RB8478**	2013	1.15	1.05	1.10
480	845CTC480	2008	0.39	0.25	0.32
480	845CTC480	2012	0.39	0.52	0.45
494*	801RB8494	2011	1.01	0.89	0.95
494	801RB8494	2013	0.68	0.70	0.69

Table 5: Continued

SiteID	SWAMP Code	Year	MMI	O/E	CSCI
501	801RB8501	2011	0.49	0.70	0.60
501	801RB8501	2013	1.14	0.72	0.93
504	801SDC504	2008	0.26	0.29	0.27
504	801SDC504	2012	0.39	0.38	0.38
530	801BNC530	2012	0.99	0.95	0.97
530	801BNC530	2014	0.92	0.86	0.89
532*	801STC532	2006	0.34	0.26	0.30
532	801STC532	2012	0.74	0.69	0.72
533	801RB8533	2011	0.87	0.80	0.83
533	801RB8533	2013	0.95	0.92	0.93
535	802SWC535	2008	1.21	0.49	0.85
535	802SWC535	2012	1.13	0.89	1.01
549	801RB8549	2011	0.66	0.50	0.58
549	801RB8549	2013	0.40	0.49	0.44
549	**801RB8549**	2013	0.51	0.44	0.48
559*	801RB8559	2010	0.39	0.48	0.43
559*	801RB8559	2013	1.03	0.65	0.84
566	801RB8566	2011	0.67	0.64	0.66
566	801RB8566	2013	0.60	0.44	0.52
566	**801RB8566**	2011	0.73	0.53	0.63
572	801RB8572	2009	0.76	0.72	0.74
572	801RB8572	2012	0.51	0.68	0.60
587	802SJR587	2007	0.98	0.83	0.91
587	802SJR587	2014	0.74	0.53	0.63
594*	801RB8594	2011	0.78	0.71	0.75
594*	801RB8594	2013	1.01	0.61	0.81
600	801LYC600	2009	1.24	1.06	1.15
600	801LYC600	2014	1.23	0.85	1.04
613	801RB8613	2009	0.91	0.57	0.74
613*	801RB8613	2012	1.04	0.73	0.89
633	801RB8633	2011	0.39	0.38	0.38
633	801RB8633	2013	0.39	0.30	0.34
686*	801EBC686	2007	0.72	0.87	0.79
686	801EBC686	2014	1.21	1.15	1.18
686	**801EBC686**	2014	1.33	1.05	1.19

Table 6: Change in CSCI scores for all sites sampled. The sites ordered by the last three digits of their SWAMP code. The change in CSCI score was calculated by subtracting the CSCI score of the original sampling event from that of the most recent. The number of standard deviations from the mean change is also listed for each site (mean change = 0.00823 ± 0.176).

SiteID	Station Code	Stream Name	Δ CSCI	# Std Dev from Mean
19	801PFB019	Prado Flood Control Basin	-0.11	-0.68
20	802SWC020	Strawberry Creek	-0.02	-0.13
25	801DRC025	Deer Creek	-0.11	-0.68
27	801CJW027	El Cajon Wash	0.13	0.68
34	801MIC034	Mill Creek	-0.09	-0.55
41	801CJW041	Cajon Wash	0.12	0.62
42	801MIC042	Mill Creek	-0.04	-0.26
48	801PCW048	San Timoteo Wash	-0.07	-0.43
50	801HBC050	Santa Ana River	-0.17	-1.00
55	801STW055	San Timoteo Wash	0.05	0.26
57	801MLC057	Middle Fork Lytle Creek	-0.21	-1.26
62	801LYC062	Lytle Creek	-0.05	-0.35
69	801MLC069	Middle Fork Lytle Creek	-0.04	-0.26
85	801STW085	San Timoteo Wash	-0.01	-0.11
100	801MFC100	Metcalf Creek	0.20	1.09
105	801NLC105	North Fork Lytle Creek	-0.15	-0.90
106	801WBC106	West Fork Barton Creek	0.04	0.18
110	801SAR110	Santa Ana River	-0.12	-0.70
112	801XXX112	Cajon Wash	0.14	0.73
114	801CYC114	City Creek	0.20	1.08
116	802SJR116	San Jacinto River	0.08	0.42
124	801SAR124	Santa Ana River	-0.05	-0.36
147	802NJR147	North Fork San Jacinto River	-0.09	-0.54
151	801SAR151	Santa Ana River	0.04	0.15
159	801SJR159	San Jacinto River	0.14	0.72
167	801RB8167	City Creek	0.19	1.03
168	801SAR168	Santa Ana River	0.17	0.91
171	801PCW171	Peters Canyon Wash	0.01	0.02
180	801SDC180	San Diego Creek	-0.45	-2.58
184	801BRC184	Bear Creek	0.02	0.07

Table 6: Continued

SiteID	Station Code	Stream Name	Δ CSCI	# Std Dev from Mean
197	801RB8197	Chino Creek	0.09	0.44
203	801HNC203	Hamilton Creek	0.09	0.47
219	801MHC219	Mountain Home Creek	0.02	0.07
226	801ETC226	East Twin Creek	0.30	1.66
240	801RB8240	Alder Creek	0.06	0.28
254	801RB8254	Deer Creek	-0.01	-0.09
258	801STW258	San Timoteo Wash	0.09	0.49
262	801RB8262	Temescal Wash	-0.21	-1.22
270	802SWC270	Strawberry Creek	0.16	0.84
271	801LYC271	Lytle Creek	-0.07	-0.46
272	801MIC272	Mill Creek	-0.09	-0.56
277	801RB8277	Coldwater Canyon	0.05	0.21
289	801RB8289	Cajon Wash	0.17	0.93
305	801XXX305	Peters Canyon Wash	-0.06	-0.37
312	801RB8312	Santa Ana River	-0.19	-1.13
327	801RB8327	Cajon Wash	-0.07	-0.44
351	801SAR351	Santa Ana River	0.26	1.41
356	801RB8356	Santa Ana River	-0.10	-0.61
361	801SAR361	Middle Santa Ana River	0.35	1.92
362	801PLC362	North Fork Lytle Creek	0.11	0.55
370	801MIC370	Mill Creek	-0.03	-0.21
375	802SWC375	Strawberry Creek	-0.10	-0.61
380	801RB8380	Frog Creek	0.20	1.08
396	801RB8396	Cajon Wash	-0.10	-0.63
398	801CYC398	City Creek	0.06	0.29
418	801SDC418	San Diego Creek	-0.18	-1.06
419	802SWC419	Strawberry Creek	-0.56	-3.20
445	801RB8445	Forsee Creek	-0.04	-0.29
446	801WCC446	West Fork City Creek	-0.05	-0.34
448	801RB8448	Mile Creek	0.04	0.21

Table 6: Continued

SiteID	Station Code	Stream Name	Δ CSCI	# Std Dev from Mean
469	801PLC469	Plunge Creek	-0.21	-1.25
478	801RB8478	Forsee Creek	-0.14	-0.84
480	845CTC480	Coyote Creek	0.13	0.71
494	801RB8494	Santa Ana River	-0.26	-1.53
501	801RB8501	Mill Creek	0.33	1.84
504	801SDC504	San Diego Creek	0.11	0.58
530	801BNC530	Barton Creek	-0.08	-0.48
532	801STC532	Santiago Creek	0.42	2.34
533	801RB8533	Mill Creek	0.10	0.51
535	802SWC535	Strawberry Creek	0.16	0.86
549	801RB8549	Unknown Channel	-0.14	-0.85
559	801RB8559	San Timoteo Wash	0.41	2.26
566	801RB8566	Cucamonga Creek	-0.14	-0.81
572	801RB8572	Middle Santa Ana River	-0.15	-0.87
587	802SJR587	South Fork San Jacinto River	-0.27	-1.58
594	801RB8594	Santa Ana River	0.06	0.30
600	801LYC600	Lytle Creek	-0.11	-0.67
613	801RB8613	San Timoteo Wash	0.15	0.79
633	801RB8633	Coyote Creek	-0.04	-0.26
686	801EBC686	East Fork Barton Creek	0.39	2.17

Table 7: Sites which improved based on CSCI scores. Sites with a change in CSCI score greater than 1 standard deviation above the average change are listed by the subregion in which they fall and their site ID code.

IMPROVED			
Subregion	**Site ID**	**SWAMP Code**	**Stream Name**
A (Orange County)	532	801STC532	Santiago Creek
B (Prado Basin)	351	801SAR351	Santa Ana River
B (Prado Basin)	361	801SAR361	Santa Ana River
D (Mid Santa Ana)	114	801CYC114	City Creek
D (Mid Santa Ana)	167	801RB8167	City Creek
D (Mid Santa Ana)	226	801ETC226	East Twin Creek
D (Mid Santa Ana)	559	801RB8559	San Timoteo Wash
E (Upper Santa Ana)	100	801MFC100	Metcalf Creek
E (Upper Santa Ana)	380	801RB8380	Frog Creek
E (Upper Santa Ana)	501	801RB8501	Mill Creek
E (Upper Santa Ana)	686	801EBC686	East Fork Barton Creek

Table 8: Sites which declined based on CSCI scores. Sites with a change in CSCI score less than 1 standard deviation above the average change are listed by the subregion in which they fall and their site ID code.

DECLINED			
Subregion	**Site ID**	**SWAMP Code**	**Stream Name**
A (Orange County)	180	801SDC180	San Diego Creek
A (Orange County)	418	801SDC418	San Diego Creek
B (Prado Basin)	262	801RB8262	Temescal Wash
B (Prado Basin)	312	801RB8312	Santa Ana River
B (Prado Basin)	494	801RB8494	Santa Ana River
C (Lytle/Cajon)	57	801MLC057	Middle Fork Lytle Creek
D (Mid Santa Ana)	469	801PLC469	Plunge Creek
F (San Jacinto)	419	802SWC419	Strawberry Creek
F (San Jacinto)	587	802SJR587	South Fork San Jacinto River

Appendix A: Site Photos for Transect A

Site Photos for 2012

Site 801PFB019: Prado Flood Control Basin

Site 802SWC020: Strawberry Creek

Site 801CJW027: Cajon Wash

Site 801CJW041: Cajon Wash

Site 801MIC042: Mill Creek

Site 801PCW048: San Timoteo Wash

Site Photos for 2012

Site 801STW085: San Timoteo Wash

Site 801NLC105: North Fork Lytle Creek

Site 801SAR110: Santa Ana River

Site 801XXX112: Cajon Wash

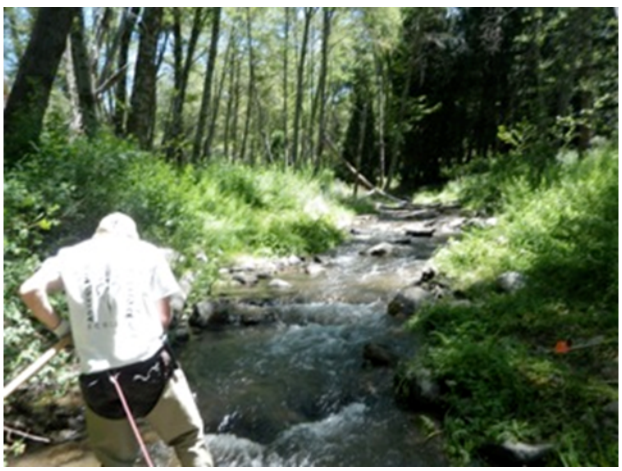
Site 802SJR116: San Jacinto River

Site 801RB8167: City Creek

Site Photos for 2012

Site 801PCW171: Peters Canyon Wash

Site 801RB8197: Chino Creek



Site 801HNC203: Hamilton Creek

Site 801MHC219: Mountain Home Creek

Site 801STW258: San Timoteo Wash

Site 801RB8262: Temescal Wash

Site Photos for 2012

Site 801RB8277: Coldwater Canyon

Site 801RB8289: Cajon Wash

Site 801XXX305: Peters Canyon Wash

Site 801RB8327: Cajon Wash

Site 801SAR351: Santa Ana River

Site 801RB8356: Santa Ana River

Site Photos for 2012

Site 801SAR361: Middle Santa Ana River

Site 801MIC370: Mill Creek

Site 8 802SWC375: Strawberry Creek

Site 801RB8445: Forsee Creek

Site 801WCC446: West Fork City Creek

Site 801PLC469: Plunge Creek

Site Photos for 2012

Site 845CTC480: Coyote Creek

Site 801SDC504: San Diego Creek

Site 801BNC530: Barton Creek

Site 801STC532: Santiago Creek

Site: 802SWC535: Strawberry Creek

Site 801RB8572: Middle Santa Ana River

Site Photos for 2012

Site 801RB8613: San Timoteo Wash

Site Photos for 2013

Site 801HBC050: Santa Ana River

Site 801CYC114: City Creek

Site 802SJR116: San Jacinto River

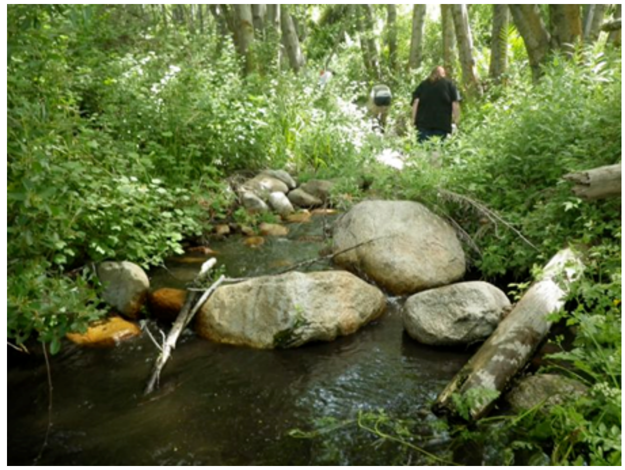
Site 801SAR151: Santa Ana River

Site: 801SAR168: Santa Ana River

Site 801RB8197: Chino Creek

Site Photos for 2013

Site 801RB8240: Alder Creek



Site 801RB8254: Deer Creek

Site 802SWC270: Strawberry Creek

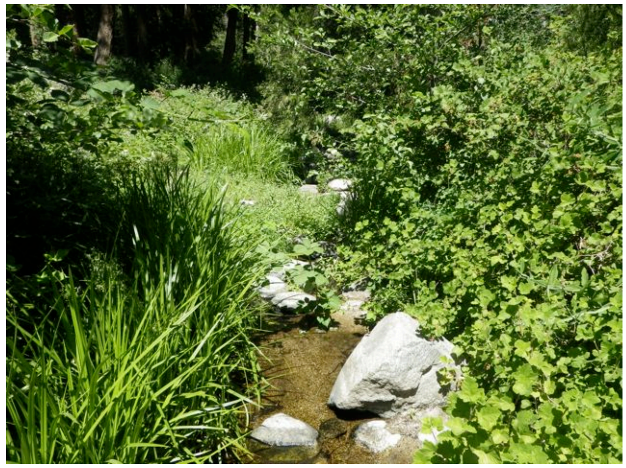
Site 801RB8312: Santa Ana River

Site: 801PLC362: North Fork Lytle Creek

Site 801RB8380: Frog Creek

Site Photos for 2013

Site 801RB8396: Cajon Wash



Site 802SWC419: Strawberry Creek

Site 801RB8448: Mile Creek

Site 801RB8478: Forsee Creek

Site: 801RB8494: Santa Ana River

Site 801RB8501: Mill Creek

Site Photos for 2013

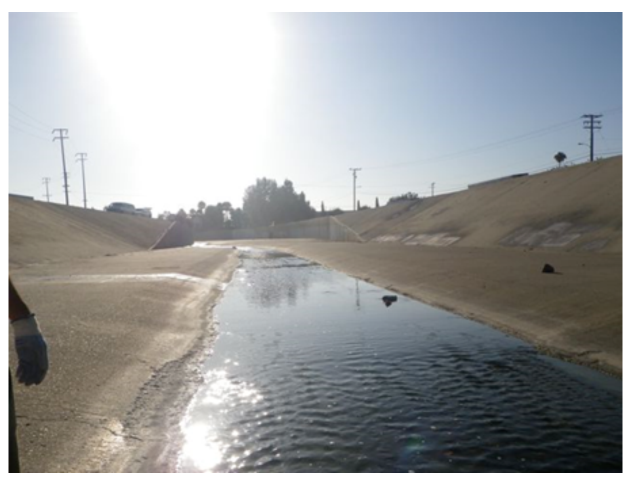
Site 801RB8533: Mill Creek

Site 801RB8549: Unknown Channel

Site 801RB8559: San Timoteo Wash

Site 801RB8566: Cucamonga Creek

Site: 801RB8594: Santa Ana River



Site 801RB8633: Coyote Creek

Site Photos for 2014

Site 801PFB019: Prado Flood Control Basin

Site 801DRC025: Deer Creek

Site 801MIC042: Mill Creek

Site 801STW055: San Timoteo Wash

Site: 801STW085: San Timoteo Wash

Site 801NLC105: North Fork Lytle Creek

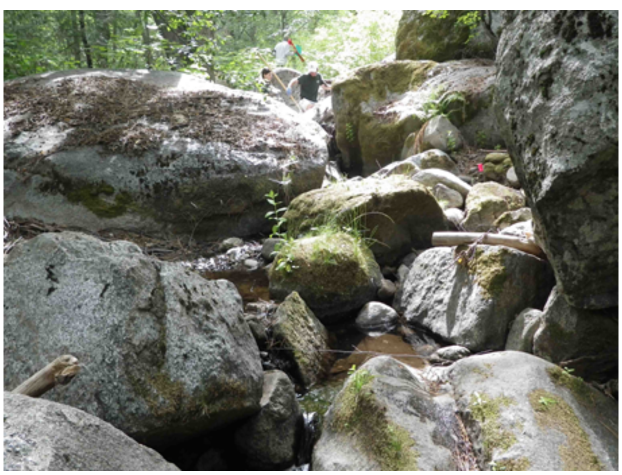
Site Photos for 2014

Site 801WBC106: West Fork Barton Creek

Site 801SAR110: Santa Ana River

Site 802SJR116: San Jacinto River

Site 801SAR124: Santa Ana River



Site: 802NJR147: North Fork San Jacinto River

Site 801SJR159: San Jacinto River

Site Photos for 2014

Site 801SDC180: San Diego Creek

Site 801BRC184: Bear Creek

Site 801MHC219: Mountain Home Creek

Site 801ETC226: East Twin Creek

Site: 801WCC247: West Fork City Creek

Site 801STW258: San Timoteo Wash

Site Photos for 2014

Site 801LYC271: Lytle Creek

Site 801XXX305: Peters Canyon Wash

Site 801SAR361: Santa Ana River

Site 801MIC370: Mill Creek

Site: 801CYC398: City Creek

Site 801SDC418: San Diego Creek

Site Photos for 2014

Site 801BNC530: Barton Creek

Site 802SJR587: South Fork San Jacinto River

Site 801LYC600: Lytle Creek

Site 801EBC686: East Fork Barton Creek

Site Photos for 2015

Site 801MIC034: Mill Creek

Site 801MLC057: Middle Fork Lytle Creek

Site 801LYC062: Lytle Creek

Site 801MLC069: Middle Fork Lytle Creek

Site: 801MFC100: Metcalf Creek

Site 801MIC272: Mill Creek