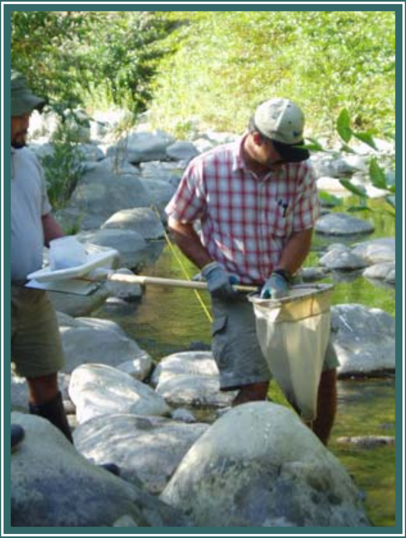
# Ventura County Stormwater Monitoring Program
# Ventura River Watershed
# 2004 Bioassessment Monitoring Report

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Prepared August 2005

August 11th, 2005

Ms. Darla Wise
County of Ventura
Watershed Protection District
800 S. Victoria Ave.
Ventura, CA 93009

Dear Ms. Wise:

In accordance with the Consulting Services Contract AE No. 05-27, Project No. 10504 dated April 19th, 2005 between the County of Ventura and Aquatic Bioassay and Consulting Laboratories, Inc., we are pleased to present the Ventura County Stormwater Monitoring Program, Ventura River Watershed, 2004 Bioassessment Monitoring Report. The enclosed report includes the summary results for the September 2004 annual requirements set forth by the California Regional Water Quality Control Board, Los Angeles Region.

Yours very truly,

*Scott Johnson*

Scott C. Johnson
Director of Environmental Programs

# Ventura County Stormwater Monitoring Program
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# 2004 Bioassessment Monitoring Report

Submitted to:

The County of Ventura
Watershed Protection District
800 S. Victoria Ave.
Ventura, CA 93009

Submitted by:

Aquatic Bioassay and Consulting Laboratories
29 N Olive Street
Ventura, CA 93001

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## Major Findings

The following were the main findings for the 2004 benthic macroinvertebrate (BMI) survey of the Ventura River watershed:

- Rainfall in the Ventura watershed was below normal during the 2003 to 2004 rain year and did not fall during the five months preceding the 2004 BMI sampling event in September. As a result only nine of the fifteen sampling locations had sufficient water flow for sampling.

- Physical habitat conditions at the nine sampling sites ranged from suboptimal to optimal. The best habitat scores were at locations on the main stem of the Ventura River, upper San Antonio Creek and Matilija Creek. The lowest scores were at locations on San Antonio Creek and Stewart Canyon Creek.

- Based on the Southern California Index of Biological Integrity (So CA IBI) the aquatic health of the Ventura watershed during 2004 ranged from poor to good. One site located in the upper watershed on Matilija Creek ranked in the good range, one site each on the Ventura River and Matilija Creek ranked in the poor range and the other six sites in the watershed ranked in the fair range. The sites that ranked in the poor range were located in areas of the watershed that were impacted by either a large human transient population on the Ventura River or was located downstream of a small residential community on Matilija Creek.

- During the previous three years, the San Diego IBI (SD IBI) has been used to assess the aquatic health of the Ventura watershed. The scores for the SD IBI and the So CA IBI were compared for the previous four years (2001 to 2004). The SD IBI consistently ranked sites in the watershed as either good or very good, while the So CA IBI ranked the same sites as poor or fair. The development of the So CA IBI included reference stations covering a much wider geographic range than was used for the development of the SD IBI. As a result, the So CA IBI is comparing the Ventura watershed against more appropriate reference conditions and provides a better measure of the aquatic health of this system.

- A historical analysis that included all the BMI data collected from 2001 through 2004 showed that the BMI communities were delineated more by their location in the watershed, than by survey year. The types and abundances of species found throughout the watershed during the four year period changed very little. Most of the changes were subtle shifts in the relative abundances of groups of species that were common throughout the watershed. These results indicated that water quality in the watershed remained relatively stable during this four year period.

## Executive Summary

The 2004 bioassessment survey of the Ventura watershed was conducted by staff members from the Ventura County Watershed Protection District, the Ojai Valley Sanitation District and Aquatic Bioassay and Consulting Laboratories on September 15th, 16th and 17h, 2004. Staff members from the California Department of Fish and Game (CDFG) and/or the Sustainable Land Stewardship Institute (SLSI) have been present during each of the four survey years to audit all sample collection activities and to provide data analysis and reporting services (CDFG = Jim Harrington, SLSI = Monique Born).

Fifteen benthic macroinvertebrate (BMI) sampling locations were visited during the survey, with nine sites having sufficient flow for sample collection. Physical/habitat observations, flow and water quality samples were also collected at each site. The taxonomic identification of BMI organisms, data analysis and report generation was conducted by Aquatic Bioassay and Consulting Laboratories in Ventura, CA. All of the QC guidelines for collection, sorting and identification of BMI organisms specified in the California Stream Bioassessment Protocol (2003) were met.

The physical habitat quality of the survey stations ranged from suboptimal to optimal. Stations located on the main stem of the Ventura River (Stations 0, 4 and 12) the upper portion of San Antonio Creek (Station 9) and on the Matilija Creek system (10, 11, 13) scored at or just below the optimal range. These sites were characterized by relatively high substrate complexity, were composed of high percentages of cobble and boulders, had good bank stability, had little evidence of sedimentation due to upstream erosion and had good vegetative protection. The lowest physical habitat scores were measured at Station 15 on San Antonio Creek and Station 8 on Stewart Canyon Creek. These sites were characterized by having less instream cover and, especially in the case of Station 15, increased amounts of sedimentation and embeddedness (a measure of the amount of space surrounding cobble and gravel in the streambed). The increased sedimentation is most likely the result of erosion due to upstream grazing, poor bank stability, poor vegetative cover and stable operations. Water quality (pH, dissolved oxygen, temperature, specific conductance) was similar at all sites during the survey.

The aquatic health of the Ventura watershed was assessed using the Southern California Index of Biological Integrity (So CA IBI). Based on this index, BMI communities that are ranked as poor can be considered to be impaired. The IBI rankings for the nine stations sampled for BMIs in 2004 ranged from good (1 station) to fair (6 stations) to poor (2 stations). The two stations that were rated as poor were located at the Main St. bridge near where the Ventura River discharges into the Pacific Ocean (Station 0) and Station 13 located downstream of a small residential community on Matilija Creek in the upper watershed. Station 11 in the North Fork of Matilija Creek received an IBI score of good, indicating that the BMI community found there is comparable to other reference site locations in southern California. Stations located on San Antonio Creek, at Foster Park on the Ventura River and below the Matilija Dam all scored in the fair range.

An historical analysis was conducted which included all the BMI data collected from 2001 through 2004. This analysis showed that the BMI communities were delineated more by their location in the watershed, than by survey year. The composition of the BMI community was mostly similar throughout the watershed both spatially and temporally. Most of the community changes during the four year period included only subtle shifts in the relative abundances of species. These results indicated that water quality in the watershed remained relatively stable during this four year period.

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## INTRODUCTION

### Ventura Watershed

The 228 square mile Ventura watershed includes rugged mountains, a coastal chaparral ecosystem and valleys that lead to the Pacific Ocean. Almost half of the watershed is in the Los Padres National Forest. The Ventura River is the main watercourse within the watershed, with several major tributaries that includes Matilija Creek, San Antonio Creek and Canada Larga Creek (Figure 1). Matilija Creek drains the mountainous northern most portion of the watershed and can be divided into the main stem of the Creek above Matilija Dam and the North Fork of Matilija Creek which discharges into the main stem below the dam. San Antonio Creek drains the northeastern portion of the watershed and has two main tributaries, Lions Canyon Creek and Stewart Canyon Creek. Canada Larga Creek drains the eastern portion of the watershed.

The land use patterns within the watershed vary, but for the most part is undeveloped land and open space (89%). There are urbanized areas (1.5%) that include the cities of Ojai and Ventura (southeast side), and unincorporated communities including Oak View, Matilija Canyon, Live Oak Acres, Meiners Oaks and Casitas Springs. The approximate human population of these communities is 20,000. The land use designations in the developed areas vary widely from rural to residential to industrial. Human impacted areas include activities related to grazing and livestock, agriculture, oil production and recreation.

### Bioassessment Monitoring

Major issues facing streams and rivers in California include modification of in-stream and riparian structure, contaminated water and increases in impervious surfaces, which has led to the increased frequency of flooding. There have been many studies and reports showing the deleterious effects of land-use activities to macroinvertebrate and fish communities (Jones and Clark 1987; Lenat and Crawford 1994; Weaver and Garman 1994; and Karr 1998). A major focus of freshwater scientists has been the prevention of further degradation and restoration of streams to their more pristine conditions (Karr et al. 2000).

During the past 150 years direct measurements of biological communities including plants, invertebrates, fish, and microbial life have been used as indicators of degraded water quality. In addition, biological assessments (bioassessments) can be used as a watershed management tool for surveillance and compliance of land-use best management practices. Combined with measurements of watershed characteristics, land-use practices, in-stream habitat, and water chemistry, bioassessment can be a cost-effective tool for long-term trend monitoring of watershed conditions (Davis and Simons 1995).

Biological communities act to integrate the effects of water quality conditions in a stream by responding with changes in their population abundances and species composition over time. These populations are sensitive to multiple aspects of water and habitat quality and provide the public with more familiar expressions of ecological health than the results of chemical and toxicity tests (Gibson 1996). Furthermore, biological assessments when integrated with physical and chemical assessments, better define the effects of point-source discharges of contaminates and provide a more appropriate means for evaluating discharges of non-chemical substances (e.g. nutrients and sediment).

Water resource monitoring using benthic macroinvertebrates (BMI) is by far the most popular method used throughout the world. BMIs are ubiquitous, relatively stationary and their large species diversity provides a spectrum of responses to environmental stresses (Rosenberg and Resh 1993). Individual species of BMIs reside in the aquatic environment for a period of months to several years and are sensitive, in varying degrees, to temperature, dissolved oxygen, sedimentation, scouring, nutrient enrichment and chemical and organic pollution (Resh and Jackson 1993). Finally, BMIs represent a significant food source for aquatic and terrestrial animals and provide a wealth of ecological and bio-geographical information (Erman 1996).

In the United States the evaluation of biotic conditions from community data uses a multi-metric technique. In multi-metric techniques, a set of biological measurements ("metrics"), each representing a different aspect of the community data, is calculated for each site. An overall site score is calculated as the sum of individual metric scores. Sites are then ranked according to their scores and classified into groups with "good", "fair" and "poor" water quality. This system of scoring and ranking sites is referred to as an Index of Biotic Integrity (IBI) and is the end point of a multi-metric analytical approach recommended by the EPA for development of biocriteria (Davis and Simon 1995). The original IBI was created for assessment of fish communities (Karr 1981) but was subsequently adapted for BMI communities (Kerans and Karr 1994).

The first demonstration of a California regional IBI was applied to the Russian River watershed in 1999 (DFG 1998). As the Russian River IBI was being developed, the Department of Fish and Game (DFG) began a much larger project for the San Diego Regional Board. After a pilot project conducted on the San Diego River in 1995 and 1996, the San Diego Regional Board contracted DFG to help them incorporate bioassessment into their ambient water quality monitoring program. During 1997 through 2000, data was collected from 93 locations distributed throughout the San Diego region. Finally, between 2000 and 2003, bioassessment data were collected from the Mexican border to the south, Monterey County to the north and to the eastern extent of the coastal mountain range. These data were used to create an IBI that is applicable to southern California and is applied to the data in this report (Ode 2005).

In fulfillment of the District's NPDES storm water permit requirement, the goal of this report was to assess the aquatic health of the Ventura River and its main tributaries based on the results of the physical habitat and BMI community data collected at nine sites in September 2004. In addition, these data were compared and contrasted to the previous three years of data to look for any spatial or temporal water quality trends.

## MATERIALS AND METHODS

### Sampling Site Descriptions

Fifteen BMI sampling locations were visited in the Ventura River watershed from September 15th to 17th, 2004 (Figure 1, Table 1). Photographs of each site are displayed in Figure 2. The 15 sites can be grouped into four geographic areas: Stations 0, 4, 6 and 12 located in the main stem of the Ventura River; Stations 2 and 3 located in Canada Larga Creek; the upper watershed which includes Stations 10, 11, 13 and 14 in Matilija Creek and the North Fork of Matilija Creek; and Stations 5, 7, 8, 9 and 15 located in San Antonio Creek and its tributaries, Lions Canyon Creek and Stewart Canyon Creek.

#### *Ventura River, Lower Watershed (Stations 0, 4, 6 and 12)*

The stations located on the main stem of the Ventura River range in elevation from 19 ft. at Station 0 near the ocean to 1020 ft. at Station 12 below the Matilija Dam. The Ventura River is the main drainage for the entire watershed and receives runoff from three main tributary systems: the Matilija Creek system above the dam; the San Antonio Creek system; and the Canada Larga Creek system.

Station 0 is located upstream of the Main St. bridge just above where the Ventura River discharges into the Pacific Ocean. It is the first site in the Ventura River that is not influenced by salinity changes caused by tidal flushing. The river bed at Station 0 is heavily influenced by a large transient human population which lives there. The banks on each side of the river are stabilized by rock levees designed to protect the City of Ventura from flooding. The Ojai Valley Sanitation Plant is located 2.5 miles upstream of Station 0 and discharges 2.0 million gallons per day (MGD) of tertiary treated effluent, a process that includes nitrogen and phosphorus removal.

Station 4 is located at Foster Park, 1.85 miles downstream of the confluence of the San Antonio Creek with the Ventura River. This reach is located downstream of a traffic bridge, has small levees stabilizing both banks. The river bottom is composed of boulders and cobble. During the dry season filamentous algae is prevalent.

Station 6 is located upstream of the traffic bridge at Santa Ana Road. The channel at this site is concrete reinforced and covered with cobble on the sides and bottom. This site has been dry during September for the last four years.

Station 12 is located at the base of the Matilija Dam. The dam, which is fed by Matilija Creek, is filled with sediment and no longer serves as a flood control structure and is scheduled for future removal. The habitat at Station 12 is composed of boulders and natural vegetation.

#### *Canada Larga Creek (Stations 2 and 3)*

Stations 2 and 3 are located on Canada Larga Creek, the first major tributary to the Ventura River upstream of the ocean. The Canada Larga drains a rural area composed of ranch land and open space. Station 3 is located near its headwaters and above areas of heavy grazing. Station 2 is located just upstream of the Canada Larga's confluence with the Ventura River and downstream of the heavily grazed portion of the watershed. Both of these sites were dry during the September 2004 sampling event.

### *Matilija Creek, Upper Watershed (Stations 10, 11, 13 and 14)*

Each of the stations in the upper watershed is located above the influence of the Matilija Dam, at elevations near or above 1,000 ft. The Matilija Creek system drains a small portion of the Los Padres National Forest and is composed of mostly rural and recreational lands. Each of the monitoring sites is located in relatively pristine areas and is composed of high gradient, bolder and cobble habitats. Stations 10 and 11 are located on the North Fork of Matilija Creek, above (Station 11) and below (Station 10) an active rock quarry. Stations 13 and 14 are located on the main stem of Matilija Creek, above (Station 14) and below (Station 13) a small residential community that uses septic tanks as its means of sanitation. In previous years excessive algal growth had been present at Station 13, leading to concerns that the community could be contributing nutrients to the Creek. Station 14 was dry during the September 2004 sampling event.

### *San Antonio Creek (Stations 5, 7, 8, 9 and 15)*

Stations 5, 7, 8, 9 and 15 are located in the San Antonio Creek system and include sites on San Antonio Creek (Stations 5, 9 and 15), as well as its main tributaries, Lions Canyon Creek (Station 7) and Stewart Canyon Creek (Station 8). Station 5 is located upstream of the bike path on San Antonio Creek just above its confluence with the Ventura River. The streambed is predominantly cobble with dense bank vegetation. Station 7 is located in Lions Canyon Creek above its confluence with San Antonio Creek in an area with stables, heavy grazing and sedimentation. Station 15 is located in San Antonio Creek upstream of Lions Canyon Creek and is composed of boulders, cobble and sand. Station 8 is located in Stewart Canyon Creek above the confluence with the San Antonio Creek and has a streambed composed of cobble, gravel and sand. Station 9 is located in San Antonio Creek upstream of Stewart Canyon Creek and is composed of cobble, gravel and sand with heavy vegetation on both banks. Both Stewart Canyon and San Antonio Creek at Stations 8 and 9 drain the City of Ojai’s downtown and residential areas. Of these sites, Stations 5 and 7 were dry during the September 2004 sampling event.


Figure 1. Fifteen BMI sampling locations in the Ventura River watershed.

Table 1. Sampling locations descriptions for 15 locations in the Ventura River watershed. u/s = upstream; d/s = downstream.

| Sta.ID | Name | Description and Comments | Latitude | Longitude | Elev. |
|---|---|---|---|---|---|
| 0 | Ventura River – Main Street Bridge | Mainstem Ventura River, first site above estuary with fresh water. | 34 16 54.23 | 119 18 24.09 | 19 |
| 4 | Ventura River - Foster Park | Mainstem Ventura River. Closest downstream site to confluence with San Antonio Creek. Station is also mass emission station. Bioassessment d/s from Foster Park Bridge. | 34 21 07.9 | 119 18 23.7 | 200 |
| 6 | Ventura River -Santa Ana Rd. | Mainstem Ventura River **Dry - not sampled** | 34 23 59.1 | 119 18 29.7 | 403 |
| 12 | Ventura River - below Matilija Dam | Matilija Creek. First station below Matilija dam and first existing station above urban influence. | 34 29 2.4 | 119 18 1.7 | 1020 |
| 2 | Canada Larga Creek | Canada Larga Creek, d/s of grazing **Dry - not sampled** | 34 20 31.7 | 119 17 08.2 | 293 |
| 3 | Canada Larga Creek | Canada Larga Creek, above main area of grazing impact. **Dry - not sampled** | 34 22 23.3 | 119 14 8.8 | 334 |
| 5 | San Antonio Creek - near Ventura River | San Antonio Creek, first upstream site from confluence with Ventura River. **Dry - not sampled** | 34 22 50.9 | 119 18 23.9 | 347 |
| 7 | Lion Canyon Creek – u/s conf. San Antonio Creek | Lion Canyon Creek (tributary to San Antonio Creek) First u/s location from confluence. Site with heavy sediment load and influenced by nearby stables and grazing. **Dry - not sampled** | 34 25 19.3 | 119 15 46.8 | 623 |
| 15 | San Antonio Creek above Lion Creek | San Antonio Creek above Lion Creek | 34 25 19.3 | 119 15 46.8 | 623 |
| 8 | Stewart Canyon Creek – u/s conf. San Antonio Creek | Stewart Creek (tributary to San Antonio Creek) First u/s location from confluence. Within close proximity to the City of Ojai and less densely developed residential lots. | 34 26 07.1 | 119 14 49.3 | 685 |
| 9 | San Antonio Creek near Stewart Canyon Creek | San Antonio Creek. Within close proximity to the City of Ojai and less densely developed residential lots. | 34 26 1.8 | 119 14 52.7 | 650 |
| 10 | North Fork Matilija Creek- u/s Ventura River conf. | North Fork Matilija Creek above influence of Matilija Dam and below rock quarry. | 34 29 06.0 | 119 17 59.4 | 978 |
| 11 | North Fork Matilija Creek- at gauging station | North Fork Matilija Creek above influence of Matilija Dam and above rock quarry. | 34 29 35.1 | 119 18 18.6 | 1,360 |
| 13 | Matilija Creek - below community | Matilija Creek. Above dam and below community. Site has excessive amount of algae. | 34 30 04.5 | 119 20 51.7 | 1,355 |
| 14 | Matilija Creek - at gate at end of road | Matilija Creek. Above dam and above community. **Dry - Not Sampled** | 34 30 16.9 | 119 22 26.3 | 1,553 |

**Station 0 - Ventura River, just upstream of the ocean at the Main St. bridge.**

**Station 4 - Ventura River at Foster Park**

Figure 2. Photographs of each site in the Ventura River Watershed.

**Station 6 - Ventura River at Santa Ana Rd.**
**Dry**

**Station12 - Ventura River, below Matilija Dam**

Figure 2. Continued.

**Station 2 - Canada Larga Creek, downstream of grazing**
**Dry**


**Station 3 - Canada Larga Creek, upstream of grazing**
**Dry**


Figure 2. Continued.

**Station 5 - San Antonio Creek, upstream of confluence with the Ventura River**
**Dry**

**Station 7 - Lions Canyon Creek, upstream of confluence with San Anotonio Creek**
**Dry**

**Station 8 - Stewart Canyon Creek, upstream of confluence with San Antonio Creek**

Figure 2. Continued.

**Station 9 - San Antonio Creek upstream of Stewart Canyon Creek**

**Station15 - San Antonio Creek, above Lions Canyon Creek**

Figure 2. Continued.

**Station 10 - North Fork Matilija Creek, upstream of Ventura River**

**Station 11 - North Fork Matilija, upstream of gauging station**

Figure 2. Continued.

**Station13 - Matilija Creek, below community**

**Station14 - Matilija Creek, above community**
**Dry**

Figure 2. Continued.

### Collection of Benthic Macroinvertebrates

September was chosen for sampling the BMI communities in the Ventura watershed since fall represents the time when the water quality conditions are the most stressful for biotic communities. However, the Ventura River and its tributaries can be dry during the late summer and fall months as is typical of most southern California river systems. In addition, average rainfall during the 2003 – 2004 rainy season was below normal. As a result, only nine of the 15 sites had sufficient water for BMI sampling during September 2004.

Sampling and laboratory procedures for this survey followed the California Stream Bioassessment Procedure (CSBP 2003). The CSBP is a regional adaptation of the U.S. Environmental Protection Agency (EPA) Rapid Bioassessment Protocols (Barbour et al. 1999) and has been used in various parts of the world to measure biological integrity of aquatic systems (Davis et al. 1996). Sampling procedures were audited by Jim Harrington of the California Department of Fish and Game.

Benthic macroinvertebrate (BMI) samples were collected in strict adherence to the CSBP in terms of both sampling methodology and QC procedures. At each station, a 100 m reach was measured and 3 riffles were randomly selected from all the possible riffles that were present within the reach. When access to the full 100 m reach was not possible due to obstacles (i.e. heavy vegetation), riffles were chosen from the portion of the reach where access was possible. Riffles were defined as areas in the reach where the velocity of flow was greatest due to shallow water coupled with a high relief bottom. At each site the California Bioassessment Worksheet (CBW) was used to collect all of the necessary station information.

Once three riffles were randomly identified, the most downstream riffle was occupied and the length of the riffle was measured. A random number table was used to randomly establish three points along the riffle where transects were established perpendicular to stream flow. Starting with the downstream riffle, the benthos within a 2 $ft^2$ area was sampled upstream of a 1 ft wide, 0.5 mm mesh D-frame kick-net. Sampling of the benthos was performed manually by rubbing cobble and boulder substrates in front of the net, followed by "kicking" the upper layers of substrate to dislodge any remaining invertebrates. The duration of sampling ranged from 60-120 seconds, depending on the amount of boulder and cobble-sized substrate that required rubbing by hand; more and larger substrates required more time to process.

Three locations along each transect that were representative of habitat diversity were sampled and combined into a composite sample. Each composite sample was transferred into a 1 gallon wide-mouth plastic jar containing approximately 300 ml of 95% ethanol. This technique was repeated for each of three riffles in each reach, thus, three composite samples were collected for each site. Chain of Custody (COC) sheets were completed for samples as each station was completed.

### Physical/Habitat Quality Assessment, Water Quality and Chemical Measurements

Physical habitat quality was assessed for the monitoring reaches using U.S. Environmental Protection Agency (EPA) Rapid Bioassessment Protocols (RBPs) (Barbour et al. 1999). The team collected the physical/habitat measurements at each station and recorded the information on the CBW. These measurements are summarized as follows:

1. Water temperature, specific conductance, pH and dissolved oxygen were measured using a hand held YSI 85 water quality meter that was pre-calibrated in the laboratory.

2. Riffle length, width and depth in meters were recorded. Width measures were averages taken at each transect and depth measures were averages taken along each transect.
3. A hand held Marsh McBirney Flowmate 2000 velocity meter was used to measure current velocity. Three measures were collected along each transect and then averaged together. Flow was calculated using the cross sectional flow measurement method.
4. A densitometer was used to measure % canopy cover.
5. Substrate complexity, embeddedness, consolidation and categories (fines, gravel, cobble, boulder, and bedrock) were estimated using the CSBP Physical/Habitat Quality Form.
6. Stream gradient was estimated using an inclinometer.
7. Nutrient samples for nitrate and nitrite nitrogen, and phosphate phosphorus were collected and analyzed by the Ojai Valley Sanitation District laboratory.
8. Aquatic Bioassay and Consulting Laboratories analyzed all bacterial samples. Samples were collected in sterile 250 mL plastic containers and analyzed according to *Standard Methods for the Examination of Water and Wastewater*, APHA, 19$^{th}$ Edition, methods 9222 (total and fecal coliforms) and 9230 (enterococcus bacteria).

**Sample Analysis/Taxonomic Identification of Benthic Macroinvertebrates (BMIs)**

Sample sorting and taxonomy were conducted by Aquatic Bioassay and Consulting Laboratories. Sorting was conducted in the Aquatic Bioassay laboratory in Ventura, CA and taxonomic identifications were conducted by Dr. Kim Kratz in Lake Oswego, OR. Identifications were made using standard taxonomic keys (Literature Cited, Taxonomic References). In most cases taxa for this study were identified to the species level. In adherence with Taxonomic Effort Level 1 specified in the CSBP, identifications were rolled up to the appropriate taxonomic level for the calculation of biological metrics and the Southern California IBI. Samples entering the lab were processed as follows:

A maximum number of 300 organisms were sub-sampled from the composite sample using a divided tray, and then sorted into major taxonomic groups. All remnants were stored for future reference. The 300 organisms were identified to the genus level for most insects and order or class for non-insects. As new species to the survey area were identified, examples of each were added to the voucher collection. The voucher collection includes at least one individual of each species collected and ensures that naming conventions can be maintained and changed as necessary into the future.

The taxonomic quality control (QC) procedures followed for this survey included:

- Sorting efficiencies were checked on all samples. The leftover material from each sample was inspected by the laboratory supervisor. Minimum required sorting efficiency was 95%, i.e. no more than 5% of the total number of organisms sorted from the grids could be left in the remnants. Sorting efficiency results were documented on each station's sample tracking sheet.
- Once identification work was completed, 10% of all samples were sent to the Department of Fish and Game (DF&G) offices in Rancho Cordova for a QC check. Samples were sorted by species into individual vials that included an internal label. Any discrepancies in counts or identification found by the DF&G

taxonomists were discussed, and then resolved. All data sheets were corrected and, when necessary, bioassessment metrics were updated.

## Data Development and Analysis

### *Multi-metric Analysis*

As species were identified, they were included in an Excel data sheet that, once complete, automatically calculated the bioassessment metrics used to assess the spatial and temporal BMI community changes in the watershed or necessary to calculate the southern California IBI (Ode 2004). The following metrics were calculated and their responses to impaired conditions are listed in Table 2:

1. Richness measures: taxa richness, cumulative taxa, EPT taxa, cumulative EPT taxa, Coleopteran taxa.
2. Composition measures: EPT index, sensitive EPT index, Shannon diversity.
3. Tolerance/intolerance measures: mean tolerance value, intolerant organisms (%), tolerant organisms (%), dominant taxa (%), Chironomidae (%), non-insect taxa (%).
4. Functional feeding group: collectors (%), filterers (%), grazers (%), predators (%), shredders (%).

Table 2. Bioassessment metrics used to describe characteristics of the BMI community.

| BMI Metric | Description | Response to Impairment |
|---|---|---|
| **Richness Measures** | | |
| Taxa Richness | Total number of individual taxa | decrease |
| EPT Taxa | Number of taxa in the Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly) insect orders | decrease |
| Ephemeroptera Taxa | Number of taxa in the insect order Ephemeroptera (mayflies) | decrease |
| Plecoptera Taxa | Number of taxa in the insect order Plecoptera (stoneflies) | decrease |
| Trichoptera Taxa | Number of taxa in the insect order Trichoptera (caddisflies) | decrease |
| **Composition Measures** | | |
| EPT Index | Percent composition of mayfly, stonefly and caddisfly larvae | decrease |
| Sensitive EPT Index | Percent composition of mayfly, stonefly and caddisfly larvae with tolerance values between 0 and 3 | decrease |
| Shannon Diversity | General measure of sample diversity that incorporates richness and evenness (Shannon and Weaver 1963) | decrease |
| **Tolerance / Intolerance Measures** | | |
| Tolerance Value | Value between 0 and 10 weighted for abundance of individuals designated as pollution tolerant (higher values) or intolerant (lower values) | increase |
| Percent Intolerant Organisms | Percent of organisms in sample that are highly intolerant to impairment as indicated by a tolerance value of 0, 1 or 2 | decrease |
| Percent Tolerant Organisms | Percent of organisms in sample that are highly tolerant to impairment as indicated by a tolerance value of 8, 9 or 10 | increase |
| Percent Dominant Taxa | Percent composition of the single most abundant taxon | increase |
| Percent Hydropsychidae | Percent of organisms in the caddisfly family Hydropsychidae | increase |
| Percent Baetidae | Percent of organisms in the mayfly family Baetidae | increase |
| **Functional Feeding Groups (FFG)** | | |
| Percent Collectors | Percent of macrobenthos that collect or gather fine particulate matter | increase |
| Percent Filterers | Percent of macrobenthos that filter fine particulate matter | increase |
| Percent Grazers | Percent of macrobenthos that graze upon periphyton | variable |
| Percent Predators | Percent of macrobenthos that feed on other organisms | variable |
| Percent Shredders | Percent of macrobenthos that shreds coarse particulate matter | decrease |
| Estimated Abundance | Estimated number of BMIs in sample calculated by extrapolating from the proportion of organisms counted in the subsample | variable |

### Southern California IBI

The seven biological metric values used to compute the Southern California Index of Biological Integrity (So CA IBI) are presented in Table 3 (Ode et al. 2005). The So CA IBI is based on the calculation of biological metrics from a group of 500 organisms from a composite sample collected at each stream reach. The sampling design for the Ventura Watershed for each of the last four sampling events (2001 through 2004) included a total of 900 organisms per reach (three replicate samples, 300 organisms each). As a result, before the So CA IBI could be computed for each station, 500 individual organisms were randomly selected from the list of 900 organisms at each station. These 500 organisms were used to compute the seven biological metrics used in the IBI computation. Ode et. al. (2005) showed that this adjustment does not affect the outcome of the IBI. This adjustment was also applied to the data for the prior three years, so that historical trends could be elucidated.

### San Diego IBI

The seven biological metric values used to compute the San Diego Index of Biological Integrity (SD IBI) are presented in Table 4 (Ode et. al. 2002). The SD IBI was developed solely for the San Diego region, but has been applied to the BMI data collected from the Ventura watershed during the past three years for lack of a more appropriate assessment tool.

Table 3. Scoring ranges for the seven metrics included in the Southern California IBI and the cumulative IBI score ranks.

| Metric Scoring Ranges for the Southern California IBI | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Metric Score** | **Coleoptera Taxa** | **EPT Taxa** | | **Predator Taxa** | **% Collector Individuals** | | **% Intolerant Individuals** | | **% Non-Insect Taxa** | **% Tolerant Taxa** |
| | **All Sites** | **6** | **8** | **All Sites** | **6** | **8** | **6** | **8** | **All Sites** | **All Sites** |
| **10** | >5 | >17 | >18 | >12 | 0-59 | 0-39 | 25-100 | 42-100 | 0-8 | 0-4 |
| **9** | | 16-17 | 17-18 | 12 | 60-63 | 40-46 | 23-24 | 37-41 | 9-12 | 5-8 |
| **8** | 5 | 15 | 16 | 11 | 64-67 | 47-52 | 21-22 | 32-36 | 13-17 | 9-12 |
| **7** | 4 | 13-14 | 14-15 | 10 | 68-71 | 53-58 | 19-20 | 27-31 | 18-21 | 13-16 |
| **6** | | 11-12 | 13 | 9 | 72-75 | 59-64 | 16-18 | 23-26 | 22-25 | 17-19 |
| **5** | 3 | 9-10 | 11-12 | 8 | 76-80 | 65-70 | 13-15 | 19-22 | 26-29 | 20-22 |
| **4** | 2 | 7-8 | 10 | 7 | 81-84 | 71-76 | 10-12 | 14-18 | 30-34 | 23-25 |
| **3** | | 5-6 | 8-9 | 6 | 85-88 | 77-82 | 7-9 | 10-13 | 35-38 | 26-29 |
| **2** | 1 | 4 | 7 | 5 | 89-92 | 83-88 | 4-6 | 6-9 | 39-42 | 30-33 |
| **1** | | 2-3 | 5-6 | 4 | 93-96 | 89-94 | 1-3 | 2-5 | 43-46 | 34-37 |
| **0** | 0 | 0-1 | 0-4 | 0-3 | 97-100 | 95-100 | 0 | 0-1 | 47-100 | 38-100 |

| Cumulative IBI Scores | | | | |
|---|---|---|---|---|
| **Very Poor** | **Poor** | **Fair** | **Good** | **Very Good** |
| **0-19** | **20-39** | **40-59** | **60-79** | **80-100** |

Table 4. Scoring ranges for the seven metrics included in the San Diego IBI and the cumulative IBI score ranks.

| Metric Scoring Ranges for the San Diego IBI | | | | | | | |
|---|---|---|---|---|---|---|---|
| Score | Cumulative Taxa | Dominant Taxon | Sensitive EPT Index | Cumulative EPT Taxa | Shannon Diversity | Intolerant Taxa | Percent Grazers |
| 0 | 0-16 | >56 | 0-0.6 | 0-1 | 0-1.31 | 0-.5 | 0-0.6 |
| 1 | 17-19 | 54-56 | 0.7-1.3 | 2 | 1.31-1.4 | 0.6-1.0 | 0.7-1.3 |
| 2 | 20-21 | 51-53 | 1.4-2.0 | 3 | 1.41-1.49 | 1.1-1.6 | 1.4-2.0 |
| 3 | 22-23 | 49-50 | 2.1-2.7 | 4 | 1.5-1.58 | 1.7-2.1 | 2.1-2.7 |
| 4 | 24-25 | 47-48 | 2.8-3.3 | 5 | 1.59-1.67 | 2.2-2.7 | 2.8-3.4 |
| 5 | 26-27 | 45-46 | 3.4-4 | 6 | 1.68-1.76 | 2.8-3.2 | 3.5-4.1 |
| 6 | 28-29 | 42-44 | 4.1-4.6 | 7 | 1.77-1.84 | 3.3-3.8 | 4.2-4.8 |
| 7 | 30-31 | 40-41 | 4.7-5.3 | 8 | 1.85-1.93 | 3.9-4.3 | 4.9-5.5 |
| 8 | 32-33 | 37-39 | 5.4-6 | 9 | 1.94-2.02 | 4.4-4.9 | 5.6-6.2 |
| 9 | 34-35 | 34-36 | 6.1-6.9 | 10 | 2.03-2.11 | 5.0-5.4 | 6.3-7 |
| 10 | >35 | 0-33 | >6.9 | 11 | >2.11 | >5.4 | >7 |
| | | Very Poor 0-12 | Poor 13-25 | Fair 26-37 | Good 38-54 | Very Good 55-70 | |

### *Historical Analysis*

An historical data analysis was performed using all of the BMI, physical habitat and water quality data collected during the past four sampling surveys (2001 through 2004). The goal of this analysis was to determine if any spatial or temporal trends in the BMI community could be detected and, if changes had occurred, what their cause(s) might be.

Historical IBI Scores

Data from 2001 through 2004 were used to compute the So CA IBI. For the So CA IBI, data from each year were converted from 900 count species abundances to 500 using the randomization process described above. The historic San Diego IBI data presented in previous reports (SLSI 2001, 2002, 2003) were used and for 2004 were computed using the 900 species count as specified in the protocol (Ode et. al. 2002).

Cluster Analysis

The spatial and temporal patterns of the BMI communities in the Ventura River watershed were defined using cluster analyses that were based on Bray-Curtis dissimilarities for pairs of stations. Species with relatively high abundances within a station group characterize the unique species composition of the group. Symbols on the two-way coincidence tables indicate relative abundance by the size of the symbol. Cluster analysis considers relative abundance of each tested taxa across the stations it occupies and is not weighted towards dominant species and therefore provides a more complete assessment of community structure.

## RESULTS

Results for the 2004 BMI are presented in the section below, followed by a historical analysis of the combined data from 2001 through 2004.

## 2004

### Rainfall

Rainfall measured at the Stewart Creek gauging station during the 2003 to 2004 rain year (12.6 inches) was 8.5 inches below normal (21.2 inches) (Figure 3). Only the 2001 to 2002 rain year had less rain (7.2 inches) during the four years that the Ventura watershed BMI survey has been conducted. The greatest amount of rain fell during eh 2000 to 2001 rain year (27.1 inches), followed by the 2002 to 2003 rain year (21.7 inches). Typical of southern California, the rain season started in the fall (October or November) and ended in either May or June. Peak months for rain were November through March. In 2004, the last measurable rain fell in April. Therefore, BMI sampling in September followed five months of dry weather and lead to the absence of water at six of the fifteen sampling locations.

### Physical Habitat Characteristics

*Velocity and Flow*

The physical characteristics of the riffles sampled in the Ventura watershed during September 2004 are presented in Table 5. Riffle velocities ranged from 0.4 ft/sec at Stations 8 (Stewart Canyon Creek) and 10 (North Fork Matilija Creek) to 1.85 ft/sec at Station 13 on Matilija Creek. Flow in the watershed was greatest at Station 0 (2.29 cfs). This flow measurement was taken in one of several channels found in this reach and is therefore an underestimate of the flow that was present across the entire reach. The next greatest flow was measured at Station 13 (1.81 cfs), below the residential community in Matilija Creek. Lowest flows were measured at Station 8 in Stewart Canyon (0.08 cfs) and Station 9 in San Antonio Creek (0.05 cfs).

*Canopy Cover and Substrates*

Vegetative canopy cover ranged from 4% at Station 10 on the North Fork of Matilija Creek to 68% at Station 11 which is located just upstream of Station 10. Substrate complexity was relatively good at most sites and ranged from 13 at Station 15 (Lions Canyon Creek) to 18 at Station 0 (Main St. bridge). The exceptions to this were low scores (7) at both Stations 8 and 9 located in San Antonio Creek and Stewart Canyon Creeks, respectively. Streambed substrates in the lower watershed (Stations 0, 4, 12, 15, 8, and 9) were, for the most part, composed of similar percentages of fines, gravel, cobble, and boulders. The exceptions to this were Station 12 located under the Matilija Dam where boulders predominated and Station 8 in Stewart's Canyon where cobble predominated. Each of the highest elevation, upper watershed Stations (10, 11 and 14) were composed predominately of boulders. All of the sites were high gradient streams (≥ 2%), except Station 8 in Stewart Canyon where the gradient was 1%.

### Water Quality, Nutrients & Bacteria

The range for pH measurements was narrow among all sites and ranged from 7.4 at Station 8 to 8.2 at Stations 15 and 12 (Table 5). Dissolved oxygen concentrations ranged from 5.03 mg/L at Station 13 to 9.28 mg/L at Station 4 on the main stem of the Ventura River. Dissolved oxygen concentrations can vary widely at the same site throughout the day due to changes in water temperature and, based on the amount of available sunlight, the photosynthetic rate of oxygen producing algae. Water temperatures were typical of summer conditions and ranged from 18.1 °C to 22.5 °C. Specific conductance ranged from 575 S/cm at Station 9 in Stewart Canyon to 1621 S/cm at Station 0.

Nitrate nitrogen was greatest at Stations 8 (1.1 mg/L) and 9 (2.5 mg/L), was just above the detection limit at Station 0 (0.2 mg/L), and was below detection at all other sites. Nitrite nitrogen was below detection at all sites. Phosphate phosphorus was greatest at Station 0 (0.9 mg/L), above detection at Station 8 (0.2 mg/L) and below detection at all other sites.

Total coliform bacteria concentrations were elevated throughout the watershed and were greatest at Station 8 (3500 MPN/100 mL) and lowest at Station 13 below the community on Matilija Creek (900 MPN/100 mL). Fecal coliform concentrations were greatest at Stations 15 (3000 MPN/100 mL), 8 (1100 MPN/100 mL) and 9 (2400 MPN/100 mL) all in the San Antonio Creek system. When the ratio between total and fecal coliform bacteria approaches one, the likelihood that the source of contamination is of either human or animal origin increases. Fecal coliform concentrations at all other sites were much lower. Enterococcus bacteria concentrations were also greatest at stations in San Antonio Creek (Station 8 = 1100, Station 9 = 500).

**Physical / Habitat Scores**

Assessment of the physical/habitat conditions of a stream reach is necessary for two reasons: one is to assess the overall quality of a stream reach and another is to assess the physical/habitat of the bioassessment site. In many cases organisms may not be exposed to chemical contaminants, yet their populations indicate that impairment has occurred. These population shifts can be due to degradation of the streambed and bank habitats. Excess sediment, caused by bank erosion due to human activities, is the leading pollutant in streams and rivers of the United States (Harrington and Born 2000). Sediments fill pools and interstitial areas of the stream substrate where fish spawn and invertebrates live, causing their populations to decline or to be altered. Physical/habitat characterization of the site is also important to help ensure that habitats are uniform between riffles so that population differences can be accurately assessed.

Out of a total possible score of 200, physical/habitat scores ranged from 108 at Station 15 at Lions Canyon Creek to 169 at Station 12 below the Matilija Dam (Table 5, Figure 4). Of the nine sites where samples were collected in 2004, six scored in the optimal range (Stations 0, 12, 9, 10, 11 and 13) and the other three sites (Stations 4, 15, and 8) scored in the suboptimal range. Of note were the following findings:

Instream cover is a measure of the amount of suitable BMI habitat in a reach and includes cobble, tree fall, undercut banks, etc. It was best at Station 0 (18) near the Main St. Bridge and worst at Station 8 (12) in Stewart Canyon.

Embeddedness is a measure of the amount of empty space (interstitial space) surrounding the rocks and cobble in a streambed. The higher the embeddedness score, the more interstitial space there is surrounding the streambed cobble, and the more available habitat there is for BMI's. Excessive upstream erosion and sedimentation can lead to low embeddedness at a site. The embeddedness score (11) was lowest at Station 15 in Lions Canyon, which is downstream of stables and grazing. Additionally, Station 15 had the most sediment deposition (score of 3) of all sites in the watershed. Sediment deposition at all other sites ranged from 12 (Station 8, Stewart Canyon) to 19 (Station 9, San Antonio Creek).

Channel flows were low at most stations due to the low rainfall conditions that preceded this sampling event. Exceptions to this were below the Matilija Dam (Station 12) and on the North Fork of the Matilija (Stations 10 and 11) where stream flow was close to normal. Bank stability scores ranged from 12 at Station 15 to 20 at Station 4. Vegetative protection was highest at Stations 0 and 4 on the main stem of the Ventura River and Station 11 on the North Fork of the Matilija. The lowest score for vegetative protection was at Station 15 in Lions Canyon.

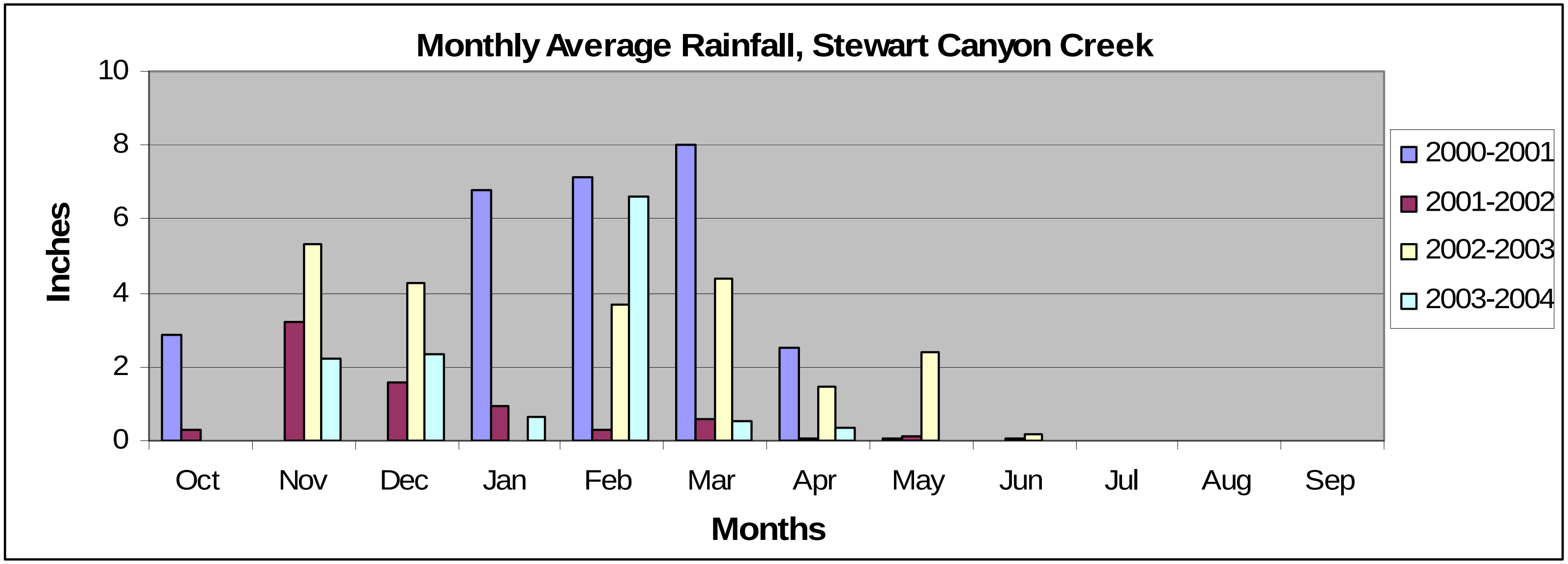


Figure 3. Monthly average rainfall (inches) at Stewart Canyon Creek for the 2000-2001 through 2003-2004 rain years.

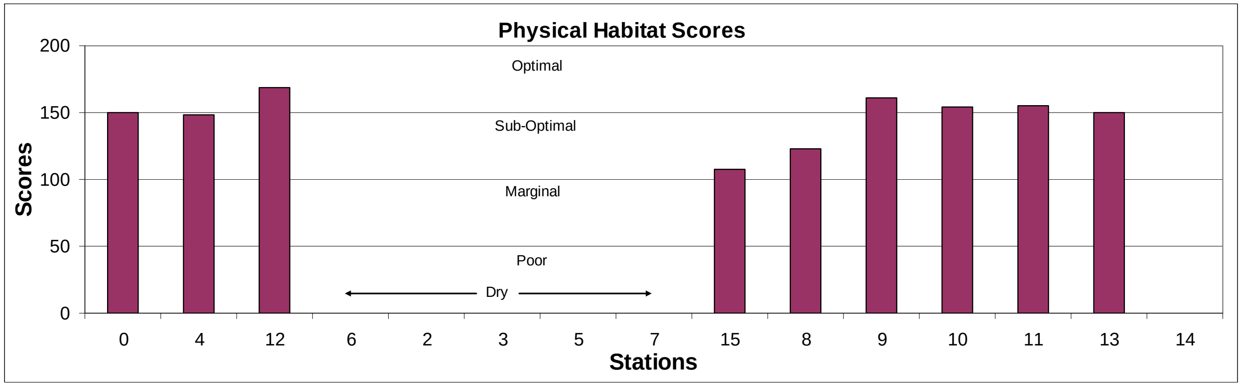


Figure 4. Physical habitat scores for reaches in the Ventura River watershed.

Table 5. Physical habitat scores and characteristics for reaches in the Ventura River Watershed (CADFG 2003).

| | Ventura River | | | | Canada Larga | | San Antonio Creek | | | | | North Fork Matilija Creek | | Matilija Creek | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Main Street Bridge | Foster Park | Below Matilija Dam | @Santa Ana Rd. | Below Grazing | Above Grazing | u/s Ventura River Confluence | Lion Canyon u/s San Antonio | u/s Lion Canyon | Stewart Canyon u/s San Antonio | u/s Stewart Canyon Creek | u/s Ventura River Confluence | At gauging station | Below community | Above Community |
| Station | 0 | 4 | 12 | 6 Dry | 2 Dry | 3 Dry | 5 Dry | 7 Dry | 15 | 8 | 9 | 10 | 11 | 13 | 14 Dry |
| **Physical Habitat Parameter** | | | | | | | | | | | | | | | |
| 1. Instream Cover | 18 | 14 | 16 | | | | | | 13 | 12 | 16 | 17 | 17 | 15 | |
| 2. Embeddedness | 16 | 14 | 19 | | | | | | 11 | 16 | 17 | 17 | 16 | 17 | |
| 3. Velocity/Depth Regime | 10 | 10 | 17 | | | | | | 14 | 9 | 10 | 18 | 17 | 15 | |
| 4. Sediment Deposition | 16 | 18 | 18 | | | | | | 3 | 12 | 19 | 16 | 14 | 16 | |
| 5. Channel Flow | 7 | 4 | 15 | | | | | | 9 | 8 | 9 | 13 | 14 | 10 | |
| 6. Channel Alteration | 12 | 16 | 18 | | | | | | 13 | 9 | 18 | 13 | 15 | 16 | |
| 7. Riffle Frequency | 19 | 18 | 17 | | | | | | 13 | 19 | 19 | 16 | 17 | 18 | |
| 8. Bank Stability | 18 | 20 | 18 | | | | | | 12 | 15 | 18 | 17 | 16 | 14 | |
| 9. Vegetative Protection | 18 | 18 | 14 | | | | | | 10 | 13 | 16 | 17 | 18 | 15 | |
| 10. Riparian Vegetative Zone | 16 | 16 | 17 | | | | | | 10 | 10 | 19 | 10 | 11 | 14 | |
| Reach Total | 150 | 148 | 169 | | | | | | 108 | 123 | 161 | 154 | 155 | 150 | |
| Condition Category | Optimal | Sub-optimal | Optimal | | | | | | Sub-optimal | Sub-optimal | Optimal | Optimal | Optimal | Optimal | |
| **Physical Habitat Characteristics** | | | | | | | | | | | | | | | |
| Average Riffle Length (ft) | 15 | 11 | 14 | | | | | | 37 | 24 | 11 | 25 | 24 | 20 | |
| Average Riffle Width (ft) | 7 | 4 | 11 | | | | | | 3 | 4 | 3 | 12 | 7 | 12 | |
| Average Riffle Depth (in) | 7 | 5 | 4 | | | | | | 6 | 3 | 3 | 8 | 2 | 6 | |
| Average Riffle Velocity (ft/sec) | 1.2 | 0.63 | 1.6 | | | | | | 0.73 | 0.4 | 0.57 | 0.4 | 0.85 | 1.85 | |
| Flow (cf/sec) | 2.29 | 0.2 | 0.52 | | | | | | 0.55 | 0.08 | 0.05 | 0.21 | 0.65 | 1.81 | |
| Vegetative Canopy Cover (%) | 50 | 10 | 33 | | | | | | 37 | 60 | 60 | 4 | 68 | 18 | |
| Average Substrate Complexity | 18 | 14 | 16 | | | | | | 13 | 7 | 7 | 17 | 17 | 15 | |
| Average Embeddedness | 16 | 14 | 18 | | | | | | 11 | 16 | 17 | 17 | 16 | 17 | |
| Substrate Composition (%) | | | | | | | | | | | | | | | |
| Fines (<0.1 in.) | 5 | 5 | 10 | | | | | | 23 | 5 | 25 | 2 | 2 | 5 | |
| Gravel ((0.1 -2 in.) | 20 | 25 | 10 | | | | | | 23 | 10 | 25 | 0 | 5 | 0 | |
| Cobble (2-10 in) | 57 | 40 | 13 | | | | | | 22 | 80 | 35 | 28 | 42 | 42 | |
| Boulder (>10 in.) | 18 | 30 | 70 | | | | | | 25 | 5 | 15 | 70 | 53 | 53 | |
| Bedrock (solid) | 0 | 0 | 0 | | | | | | 7 | 0 | 0 | 0 | 0 | 0 | |
| Substrate Consolidation | High | Mod | High | | | | | | Mod | High | High | High | High | High | |
| Percent Gradient (%) | 2 | 2 | 2 | | | | | | 2 | 1 | 3 | 3 | 3 | 2 | |
| **Chemical Characteristics** | | | | | | | | | | | | | | | |
| pH | 7.82 | 7.6 | 8.2 | | | | | | 8.16 | 7.4 | 7.5 | 7.9 | 7.7 | 7.6 | |
| D.O (mg/L) | 6.95 | 9.28 | 8.6 | | | | | | 7.86 | 5.83 | 6.67 | 8 | 6.59 | 5.03 | |
| Water Temperature (C°) | 20.3 | 20.0 | 22.5 | | | | | | 20.3 | 18.1 | 18.3 | 20.3 | 18.2 | 18.3 | |
| Specific Conductance (S/cm at 25EC) | 1621 | 1046 | 778 | | | | | | 1425 | 1135 | 575 | 950 | 1014 | 812 | |
| Nitrate Nitrogen (mg/L) | 0.2 | ND | ND | | | | | | ND | 1.1 | 2.5 | ND | ND | ND | |
| Nitrite Nitrogen (mg/L) | ND | ND | ND | | | | | | ND | ND | ND | ND | ND | ND | |
| Phosphate-Phosphorus (mg/L) | 0.9 | ND | ND | | | | | | ND | 0.2 | ND | ND | ND | ND | |
| **Indicator Bacteria** | | | | | | | | | | | | | | | |
| Total Coliforms (MPN/100 mL | 3000 | 2400 | 1600 | | | | | | 3000 | 3500 | 2400 | 3000 | 3000 | 900 | |
| Fecal Coliforms (MPN/100 mL | 50 | 80 | 2 | | | | | | 3000 | 1100 | 2400 | 50 | 5 | 8 | |
| Enterococcus (MPN/100 mL) | 70 | 50 | <2 | | | | | | 50 | 1100 | 500 | 59 | 17 | 110 | |

ND = non-detected, <0.1 mg/L

## BMI Community Structure

The complete taxa list including raw abundances by site and replicate are presented in Appendix A, Table A-1. The ranked abundance of the top 75% of the BMIs identified is illustrated in Table 6. The biological metrics calculated for this survey were grouped into the four categories described in Table 3 and presented in Figures 5 through 8: richness measures, composition measures, tolerance/intolerance measures and functional feeding groups. The So CA IBI scores for each station are shown in Table 7 and illustrated in Figure 9. The biological metrics are presented for each replicate and then averaged by site in Appendix A (Tables A-2 and A-3, respectively).

### *Species Composition*

A combined total of 8,425 BMIs, represented by 102 taxa, were identified from the 27 samples collected at the nine sampling sites during the September 2004 survey (Appendix A, Table A-1). Based on this figure, the projected total abundance for all sites combined would be 87,523 individuals (Figure 5 and Appendix A, Table A-1). Stations 0, 4 and 12, located on the main stem of the Ventura River, shared two relatively abundant species in common, Baetid mayflies (*Baetis sp*.) and chrionomids (Orthocladiinae) (Table 6). Baetid mayflies were either first or second most abundant at these sites and dominated the total abundance at Station 0, contributing 31% of the total population. At Station 4 the trichopteran, *Hydrophyche sp*., was most abundant while the black fly (*Simulium sp*.) was most abundant at Station 12, below the Matilija Dam.

Stations located in the San Antonio Creek system (Stations 15, 8 and 9) shared three relatively abundant species in common: flies of the *Euparyphus/Caloparyphus* complex, which were dominant at Station 15, *Hydropsyche sp*., which was dominant at Station 9 and Orthocladiinid flies. The gastropod, *Physa/Physella sp*. was most abundant at Station 8. The trichopteran, *Micrasema sp*., was second in abundance at both Stations 8 and 9. This species has a tolerance value of 1, indicating that it is very sensitive to disturbances.

The three Stations in the upper watershed on the Matilija Creek system (Stations 10, 11 and 13), shared four species in common: the beetle, *Microcylloepus sp*., which was most abundant at Stations 10 and 13; both Simulium sp. and Orthocladiinid flies, and Baetid mayflies (*Baetis sp*.). Station 13, on Matilija Creek below the human residential community, was almost exclusively comprised of these four species. The trichopteran, *Micrasema sp*., was most abundant at Station 11, located on the North Fork of Matilija Creek.

### *Biological Metrics*

The biological metrics listed in Table 3, above, were calculated for this survey and are presented by group in Figures 5 through 8 and Appendix A, Table A-3.

***Richness Measures*:** Taxa richness is a measure of the total number of species found at a site. This relatively simple index can provide much information about the integrity of the community. Few taxa at a site indicate that some species are being excluded, while a large number of species indicate a more healthy community. Cumulative taxa is a simultaneous count of all of the taxa from each of the three replicate samples taken at a station. Cumulative EPT taxa is the simultaneous count of all of the mayflies (Ephemeroptera), caddisflies (Trichoptera), and stoneflies (Plecoptera) present at a location. These families are generally sensitive to impairment and, when present, are usually indicative of a healthy community. Both Coleopteran and Predator taxa are included since they are used to calculate the So CA IBI.

Taxa richness, both cumulative and individual EPT taxa and Predator taxa each followed a similar trend across sites, with the largest number of taxa found at Station 4 in the lower watershed, Stations 15, 8 and 9 in San Antonio Creek, and Stations 10 and 11 on the North

Fork of Matilija Creek (Figure 5). Lower numbers were found at Station 0 near the ocean, Station 12 below the Matilija Dam and Station 13 below the small human residential community on the upper Matilija Creek. The numbers of Coleopteran taxa were similar across sites and were greatest at Stations 11 and 15, and least at Station 8 on Stewart Creek.

***Composition Measures***: The percent EPT taxa, sensitive EPT, percent non-insects and the Shannon Diversity index are all measures of community composition. Species diversity indices are similar to numbers of species; however they contain an evenness component as well. For example, two samples may have the same numbers of species and the same numbers of individuals. However, one station may have most of its numbers concentrated into only a few species while a second station may have its numbers evenly distributed among its species. The diversity index would be higher for the latter station. Percent EPT taxa are the proportion of the abundance at a site that is comprised of mayflies, stoneflies and caddisflies. Percent Sensitive EPT taxa is similar except it includes only those EPT taxa whose tolerance values range from 0 to 3. These taxa are very sensitive to impairment and, when present, can be indicative of more natural conditions. Percent non-insect taxa are used in the calculation of the So CA IBI.

The percentage of EPT ranged from 40 to 60% at Stations 0, 4 and 12 on the main stem of the Ventura River and from 20 to 40% at Stations 15, 8, 10, 11 and 13 on both San Antonio Creek and Matilija Creek (Figure 6). Station 9, on San Antonio Creek, exceeded 60% EPT taxa and was an exception to this trend. The percentage of Sensitive EPT taxa was lowest in the lower watershed and highest in San Antonio Creek (Stations 8 and 9) and the North Fork of Matilija Creek (Station 11). Therefore, although large numbers of EPT taxa were present at Stations 0, 4 and 12, most were not sensitive species. The same was true for Stations 15, 10 and 13. Shannon Diversity was similar across all stations. Non-insect species composition was elevated at Stations 15 and 8 in San Antonio Creek.

***Tolerance Measures***: The Southern California IBI uses both the percent intolerant and tolerant organisms to evaluate the overall sensitivity of organisms to pollution and habitat impairment. Each species is assigned a tolerance value from 0 (highly intolerant) to 10 (highly tolerant). The percent Intolerance Value for a site is calculated by multiplying the tolerance value of each species with a tolerance value ranging from 0 to 2, by its abundance, then dividing by the total abundance for the site. The percent Tolerant Value is similar except that only species with tolerance values ranging from 8 to 10 are included. A site with many tolerant organisms present is considered to be less pristine or more impacted by human disturbance than one that has few tolerant species. The tolerance values for each species were developed in different parts of the United States and can therefore be region specific. Also, different organisms can be tolerant to one type of disturbance, but highly sensitive to another. For example, an organism that is highly sensitive to sediment deposition may be very insensitive to organic pollution. With these drawbacks in mind, the Tolerance measures generally depict disturbances in a stream that, when coupled with other metrics, can provide good information regarding a stream reach.

Percent dominance reflects the proportion of the total abundance at a site represented by the most abundant species. For example, if 100 organisms are collected at a site and species A is the most abundant with 30 individuals, the percent dominance index score for the site is 30%. The benthic environment tends to be healthier when the dominance index is low, which indicates that more than just a few taxa make up the majority of the community.

The percent Hydropsychidae (caddisflies) and Baetidae (mayflies) present in a stream reach can indicate stressed habitat conditions when they are found in high abundance. They will not be present in highly polluted streams, but can be found in moderately polluted streams, especially when nutrients are high or there is a large amount of sedimentation.

Mean Tolerance Values were similar across sites and ranged from 4.1 at Station 11 to 5.5 at Station 15 (Figure 7). There were low percentages of intolerant organisms present at most sites, except at Stations 8 (23.2%), 9 (18.3%) and 11 (26.1%). The highest percentages of tolerant organisms were found at Stations 15 (24%) and 8 (24%). Percent Dominance exceeded 25% at Stations 0, 12, 9, 11 and 13. Hydropsychid caddisflies were present in large numbers at Station 9 (34%). Baetid mayflies were present in large numbers at Station 0 (37%) and 12 (33%).

***Functional Feeding Groups*****:** These indices provide information regarding the balance of feeding strategies represented in an aquatic assemblage. The combined feeding strategies of the organisms in a reach provide information regarding the form and transfer of energy in the habitat. When the feeding strategy of a stream system is out of balance it can be inferred that the habitat is stressed. For the purposes of this study, species were grouped by feeding strategy as percent collector-gatherers, collector-filterers, grazers, predators and shredders. The Southern California IBI uses the numbers of predators and percent collectors (gatherers + filterers) at a site to calculate the index.

Collecting was the predominant feeding strategy used by organisms in the watershed (Figure 8). Collectors exceeded 75% of the population at Stations 0, 4, 8, 10, 11 and 13. The percentage of filterers ranged from 10.7% at Station 11 to 37.3% at Station 9. Grazers were highest at San Antonio and Matilija Creek Stations 8 (27.3%), 9 (18.6%) and 11 (31.8%). Predators ranged from 4.1% at Station 12 below the Matilija Dam to 18.6% at Station 8 at Stewart Canyon Creek. Shredders were absent or present in low numbers at all sites.

### *IBI Scores*

Work conducted in the 1990's by the San Diego Regional Board and the California Department of Fish and Game, established an Index of Biotic Integrity (IBI) for the San Diego region and its watersheds (Ode and Harrington 2002). The index has recently been expanded to include all of southern California (Ode et. al. 2005) and is used in this section. In previous reports (2001 to 2003), the San Diego IBI was applied to the BMI data collected for the Ventura watershed. A comparison of the So CA IBI and SD IBI scores for each of the four years of survey data is presented in the historical analysis section below.

The IBI is a multi-metric technique that employs seven biological metrics that were each found to respond to a habitat and/or water quality impairment. Each of the seven biological metrics measured at a site are converted to an IBI score then summed. These cumulative scores can then be ranked according to very good (80-100), good (60-79), fair (40-59), poor (20-39) and very poor (0-19) habitat conditions. The threshold limit for this scoring index is 39. Despite the fact that rankings can be identified as "fair", sites with scores above 39 are within two standard deviations of the mean reference site conditions in southern California and are not considered to be impaired. Sites with scores below 39 are considered to have impaired conditions. The metric scoring ranges established for the Southern California IBI survey are listed in Table 3 and were used to classify the Ventura watershed sites for the 2004 survey.

The IBI scores for six of the nine sites were in the fair range and included Stations 4 and 12 in the Ventura River, 15, 8 and 9 in the San Antonio Creek system, and Station 10 in the North Fork of Matilija Creek (Table 7, Figure 9). Two stations scored at or below the impairment threshold of 39 in the poor range: Station 0 at the Main St. Bridge and Station 13 on Matilija Creek below the community. Station 11, on the North Fork of Matilija Creek, scored in the good range.

## Historical Results (2001 to 2004)

Physical habitat and IBI scores for the first four years of the Ventura watershed BMI monitoring program were combined and are presented graphically by site in Figures 10 and 11. Since the San Diego IBI was applied to the BMI data in past reports (2001 to 2003), it was computed for the 2004 survey data, and then combined with the previous three years so that the SD IBI scores could be compared to the So CA IBI (Figure 12).

### Physical Habitat Scores

Most sites varied from optimal to sub-optimal between years, with the majority of the scores for all sites and years in the sub-optimal range (Figure 10). Marginal scores were only reported at Station 1 on the Ventura River below the waste treatment facility in 2001 and Station 2 on Canada Larga Creek. Station 1 improved to sub-optimal in 2002, while Station 2 was dry during the next three years. Station 12 was the only site to score in the optimal range for each of the four years. Differences in physical habitat scores between years for each site were not large, except at Station 15 where the score dropped from the high end of the sub-optimal range in 2001 and 2002, to the low end in 2003 and 2004. This change was not the result of a large decrease in one or two physical habitat parameters in these latter years, but rather an incremental decrease across each of the 10 parameters.

### IBI Scores

#### So CA IBI

There was an upward trend in IBI scores for Stations 0, 12, 15, 8, 9, and 13 during the four year period (Figure 11). There were not large changes between years for any of these sites, but the scores for Stations 15, 8 and 9 on the San Antonio Creek system increased from Poor to Fair ratings during this period. The 2001 IBI score for Station 5, located on San Antonio Creek above its confluence with the Ventura River, was greater than all other upstream sites on the San Antonio during the same year. This indicates that the water quality and/or habitat conditions lowering the IBI scores at the upstream sites were not fully influencing the downstream portions of this Creek system.

Stations 0 and 1, located on the main stem of the Ventura River, had the lowest IBI scores during the four year period. Station 0 is heavily used by a large transient human population. Both sites are also located downstream of a waste treatment facility. Station 12, located below the Matilija Dam, scored in the Poor range for each of the four years. The physical habitat scores for this site were the highest measured in the watershed during the four year period, indicating that the lower IBI scores measured here were probably due to water quality conditions.

Station 11, located above the rock quarry on the North Fork of Matilija Creek, was the only station that scored in the Good range and did so during three of the four years. Station 10 located downstream of Station 11, scored in the poor to fair range during the same time period indicating the possible effects from the quarry. Additionally, Station 10 is heavily used as a swimming hole by Valley residence. Stations 13 and 14 are located downstream and upstream, respectively, of a small human residential community located on the banks of Matilija Creek. Since both sites scored in the Poor range during the years when samples were taken at each, it appears that the water quality impairment found at these sites was due to more widespread sources than just the influence of the residential community.

#### So CA IBI Compared to the SD IBI

The So CA IBI scores for each site across the four sampling years were uniformly lower than the scores computed using the SD IBI (Figure 12). The SD IBI ranked most stations as either Good or Very Good, while the So CA IBI ranked most in the Poor to Fair range. Only

Station 0 during 2003 ranked in the Poor range when using the SD IBI . The general trends between sites were similar between the So CA IBI and the SD IBI with lowest scores measured at Station 0 and highest scores in San Antonio Creek system and Matilija Creek.

Historical Cluster Analysis

The spatial and temporal patterns of the BMI communities in the Ventura River watershed were defined using cluster analyses that were based on Bray-Curtis dissimilarities for pairs of stations. The station and species dendograms summarizing the cluster analyses are presented in Appendix A, Figures A-1 and A-2. A two-way coincidence table that summarizes species abundances in each station and species cluster group is presented in Figure 13. Species with relatively high abundances within a station group characterize the unique species composition of the group. Symbols on the two-way coincidence table indicate relative abundance by the size of the symbol. Cluster analysis considers relative abundance of each tested taxa across the stations it occupies and is not weighted towards dominant species and therefore provides a more complete assessment of community structure. Table 8 presents the ten most common species averaged for each station over time, for each cluster group. A detailed description of the methods used for these analyses are presented in Appendix B.

Seven Station (1 thru 7) and five Species (A thru E) Groups were identified by cluster analysis (Figure 13). The seven Station Groups were delineated more by their location in the watershed, than by survey year. For the five Species Groups, there were no clearly defined distribution patterns across stations and years. Most of the changes were subtle shifts in the relative abundances of a group of species that were common throughout the watershed. These results indicate that water quality in the watershed remained relatively stable during this four year period.

Station Group 1 was comprised of stations on the Ventura River located either at the base of the Matilija Dam (Station 12) or by stations in the lower watershed (Stations 0 and 4). The top ten species common to this group included two Baetid mayflies (*Baetis sp*. and *Fallceon quilleri*), four genera of true flies, two caddisflys (including *Hydropsyche sp*.), a beetle (*Microcylloepus sp.*) and a gastropod mollusk (Table 8).

Station Group 2 was comprised of Stations 0 and 1 in 2002. The most abundant species at these sites included *Microcylloepus sp*., as well as large numbers of non-insects (Planariidae, *Hyalella sp*. and Cyprididae). Station Group 3 included Station 3 in the Upper Canada Larga Creek during 2001 and 2002, the only years when it was flowing. The most common species to this group included *Malenka sp*. (a pollution intolerant stonefly), *Hydropsyche sp*. and the dragonfly, *Argia sp*. Station Group 4 was composed of sites on Matilija Creek (Stations 13 and 14) and the North Fork of the Matilija Creek (Station 10). Among all taxa, *Microcylloepus sp*., *Hydropsyche sp*., five genera of true flies, and three mayflies were most abundant.

Station Groups 5 was comprised of sites on San Antonio Creek (Stations 15 and 7) and the lower Ventura River (Station 4). This group was dominated by the true fly, *Euparyphus/Caloparyphus sp*. Station Group 6 included sites from the 2001 survey in the San Antonio Creek and the lower Ventura River. Species composition for this group was dominated by *Hydropsyche sp*., *Euparyphus/Caloparyphus sp*. and the mayfly, *Tricorythodes sp*. Station Group 7 was composed of Station 11 located on the North Fork of Matilija Creek, Station 8 on Stewart Canyon Creek and Station 9 on San Antonio Creek. The composition of species for this group was similar to other sites except that an extremely intolerant species of caddisfly (*Micrasema sp*.) was relatively abundant through the four year period.

## DISCUSSION

The 2004 So CA IBI results indicated that the aquatic health of the Ventura watershed ranged from poor to good. Stations 0 and 13 each scored in the poor range, indicating that these habitats were impaired. Station 0 is located just upstream of where the Ventura River discharges into the Pacific Ocean. During the previous two years the IBI score for this site has been very poor and poor (based on the So CA IBI). Conversely, the physical habitat score at this site has been either suboptimal or optimal as a result of the good instream cover, vegetative protection, bank stability, and the low amounts sedimentation. The explanation for the low IBI scores could be related to several factors including the reinforced levees present on each bank which protect the City of Ventura from flooding, the large transient human population that use the streambed for shelter and possibly the sites location 2.5 miles downstream of the Ojai Valley Sanitation Plant. This site supported few sensitive BMI species and the greatest number of Baetid mayflies found at any site in the watershed. Baetid mayflies are indicative of moderately disturbed conditions that could be the result of either elevated nutrient loading or sedimentation.

Station 13 is located downstream of a small human residential community on Matilija Creek, which is located in the upper watershed in what appears to be good stream habitat. The physical habitat scores during the past four years were either at the top end of the suboptimal range or optimal and have varied little during that time. The So CA IBI scores for this site during the same four years have been in the poor range. In 2004 the low IBI score was due to the absence of sensitive species and elevated numbers of collector species that included mostly Baetid mayflies and caddisflies, (*Hydropsyche sp*.). During 2004, Station 14 located upstream of Station 13 was dry. However, during 2001 and 2003 when the Creek was flowing at Station 14, its So CA IBI score was in the poor range. This indicates that the low score at Station 13 in 2004 may not have been due to some influence from the residential community.

Station 12 is located below the Matilija Dam at a site that had the highest physical habitat scores (optimal) in the entire watershed during each of the last four years. The So CA IBI scores at this site have been in the poor range during the same time period, except in 2004 when the score improved to fair. From 2001 to 2002 the lower IBI scores were the result of the near absence of sensitive species, large numbers of collector species (*Simulium sp*. and *Baetis sp*.), and few predator species. In 2003 and 2004 the IBI rank increased to fair due to an increase in the numbers of predator taxa which included caddisflies, *Ochrotrichia sp*., dragonflies (*Argia sp*.), gastropods (*Sperchon sp*.), and flatworms (Planariidae).

Station 11 is located on the North Fork of the Matilija at an elevation of just over 1,300 ft and was the only site to score in the good range for the So CA IBI during 2001, 2002 and 2004. In 2003 the score dropped into the fair range. High IBI scores at Station 11 indicate that it is comparable in species composition to reference site locations throughout southern California. The physical habitat score at this site was in the optimal (2001, 2002 and 2004) to suboptimal (2003) range.

Station 10 is located below Station 11 and an active rock quarry. During the past four years the IBI scores for this site have been lower than at Station 11 in the poor to fair range. Two factors that could be influencing the aquatic health at Station 10 are the upstream rock quarry or its use as a swimming hole by local residents. In past years the BMI population at this site has been dominated by black flies (*Simulium sp*.).

IBI scores for each of the three San Antonio Creek system stations (15, 8 and 9) steadily increased from fair to poor since 2001. One would expect these sites to receive low IBI scores since the upper San Antonio drains downtown Ojai and the east end of the Ojai Valley, which is agricultural. Also, the physical habitat scores for these sites were mostly suboptimal during the four years. The reason for the improved BMI communities at these sites is unclear.

The SD IBI scores consistently ranked the aquatic health of the Ventura watershed sites as very good or good at nearly all sites during the 2001 to 2004 survey period. In contrast, the computed So CA IBI scores for the same data sets ranked them as poor to fair, with only one site receiving a rank of good. These results show that the use of IBI scores outside of the region where they were developed can be misleading. Since the development of the So CA IBI included reference sites from throughout the entire southern California area (coastal Monterey to the Mexican boarder), it is a more comparative index for use in the Ventura watershed.

Based on the results of the 2004 bioassessment survey, the sites chosen for BMI analysis in the Ventura watershed can be characterized as providing optimal to suboptimal habitat conditions. The best habitat conditions occurred at sites in the upper watershed and also on the main stem of the Ventura River, where there is high instream cover and complexity, low sedimentation, high bank stability and good vegetative protection. Less optimal habitat conditions exist in San Antonio Creek above its confluence with Lion's Canyon Creek and Stewart Canyon Creek where there was increased evidence of sedimentation.

The data collection technique for physical habitat assessment relies on the subjective opinion of the field crew regarding the habitat conditions found at each site. As a result, the scores for a given site can vary between years as a result of sampling bias. Therefore, minor changes between years at a site do not necessarily imply that a habitat change has occurred. The sampling team strove to eliminate bias by ensuring that staff members were well trained, collaborated on the scoring of each site, and by ensuring that experienced field people were always involved in the collection of these data.

An example of the subjectivity of this sampling technique is provided by the decrease in physical habitat scores at Station 15 in San Antonio Creek between 2002 and 2003. This site is located on private land and is visited by appointment. In the first two years of the program the entire sampling team (four people) participated in the collection of the physical habitat data. Due to the land owner's sensitivity to access, in 2002 and 2003 it was decided that is was more appropriate for only two team members to participate in sampling at this site. Since the habitat at this site did not change dramatically during this time period, it is probable that the decreased physical habitat score was the result of a personnel change.

Results of the historical cluster analysis, which included all the BMI data collected from 2001 through 2004, delineated seven Station and five Species Groups. The station groups were delineated more by their location in the watershed, than by survey year. For the five Species Groups, there were few distribution patterns across stations and years. Most of the changes were subtle shifts in the relative abundances of groups of species that were common throughout the watershed. These results indicated that water quality in the watershed remained relatively stable during this four year period.

**RECOMMENDATIONS**

1. It is recommended that the new Southern California Index of Biological Integrity (So CA IBI) developed by the California Department of Fish and Game be used to assess the aquatic health conditions of the Ventura watershed, since it appears to be more sensitive to benthic macroinvertebrate (BMI) community disturbances than the San Diego Index of Biological Integrity (SD IBI).

2. It is recommended that the BMI sampling and taxonomic procedures for this program be modified to follow the new methods developed by the California Department of Fish and Game. This new protocol specifies that the BMI samples collected at a reach be taken along three transects then composited into a single sample, from which 500 organisms are identified for analysis.

3. It is recommended that the Ventura Watershed Protection District continue to work with the Southern California Coastal Water Research Project (SCCWRP) to assist in the development of improved BMI sampling design, sampling protocols, taxonomic identification and analysis techniques.

Table 6. Ranked % abundance for species comprising the top 75% of organisms at each site in the Ventura watershed, 2004. Hierarchical taxa codes (Grp): E = Ephemeroptera, T = Trichoptera, D = Diptera, NI = non-insects, C = Coleoptera, O = Odonata.

| Station 0 Ventura River Main Street Bridge | Grp | Tol | FFG | % |
|---|---|---|---|---|
| Baetis sp. | E | 5 | cg | 31 |
| Hydropsyche sp. | T | 4 | cf | 14 |
| Chironominae | D | 6 | cg | 13 |
| Simulium sp. | D | 6 | cf | 10 |
| Orthocladiinae | D | 5 | cg | 9 |
| % of Total | | | | 77 |

| Station 4 Ventura River Foster Park | Grp | Tol | FFG | % |
|---|---|---|---|---|
| Hydropsyche sp. | T | 4 | cf | 13 |
| Baetis sp. | E | 5 | cg | 10 |
| Tricorythodes sp. | E | 5 | cg | 10 |
| Chironominae | D | 6 | cg | 10 |
| Ochrotrichia sp. | T | 4 | cg | 8 |
| Tinodes sp. | T | 2 | cg | 6 |
| Euparyphus/Caloparyphus | D | 8 | cg | 6 |
| Oligochaeta | NI | 5 | cg | 5 |
| Orthocladiinae | D | 5 | cg | 5 |
| Fallceon quilleri | E | 4 | cg | 3 |
| % of Total | | | | 75 |

| Station 12 Ventura River below Matilija Dam | Grp | Tol | FFG | % |
|---|---|---|---|---|
| Simulium sp. | D | 6 | cf | 25 |
| Baetis sp. | E | 5 | cg | 18 |
| Fallceon quilleri | E | 4 | cg | 15 |
| Microcylloepus sp. | C | 4 | cg | 12 |
| Orthocladiinae | D | 5 | cg | 7 |
| % of Total | | | | 77 |

| Station 15 San Antonio Creek above Lion Canyon | Grp | Tol | FFG | % |
|---|---|---|---|---|
| Euparyphus/Caloparyphus | D | 8 | cg | 10 |
| Hydropsyche sp. | T | 4 | cf | 9 |
| Fallceon quilleri | E | 4 | cg | 8 |
| Microcylloepus sp. | C | 4 | cg | 8 |
| Cyprididae | NI | 8 | cg | 6 |
| Orthocladiinae | D | 5 | cg | 5 |
| Simulium sp. | D | 6 | cf | 5 |
| Oligochaeta | NI | 5 | cg | 5 |
| Hyalella sp. | NI | 8 | cg | 5 |
| Argia sp. | O | 7 | p | 5 |
| Baetis sp. | E | 5 | cg | 4 |
| Oxyethira sp. | T | 3 | cg | 4 |
| % of Total | | | | 73 |

| Station 8 Stewart Canyon Creek u/s conf. San Antonio Creek | Grp | Tol | FFG | % |
|---|---|---|---|---|
| Physa/Physella sp. | NI | 8 | sc | 14 |
| Micrasema sp. | T | 1 | sc | 12 |
| Hydropsyche sp. | T | 4 | cf | 12 |
| Tinodes sp. | T | 2 | cg | 10 |
| Argia sp. | O | 7 | p | 8 |
| Simulium sp. | D | 6 | cf | 7 |
| Orthocladiinae | D | 5 | cg | 6 |
| Sperchon sp. | NI | 8 | p | 5 |
| Euparyphus/Caloparyphus | D | 8 | cg | 3 |
| % of Total | | | | 78 |

| Station 9 San Antonio Creek near Stewart Canyon Creek | Grp | Tol | FFG | % |
|---|---|---|---|---|
| Hydropsyche sp. | T | 4 | cf | 35 |
| Micrasema sp. | T | 1 | sc | 13 |
| Orthocladiinae | D | 5 | cg | 7 |
| Tricorythodes sp. | E | 5 | cg | 6 |
| Euparyphus/Caloparyphus | D | 8 | cg | 6 |
| Tinodes sp. | T | 2 | cg | 5 |
| Argia sp. | O | 7 | p | 4 |
| % of Total | | | | 76 |

| Station 10 North Fork Matilija Creek u/s conf. Ventura River | Grp | Tol | FFG | % |
|---|---|---|---|---|
| Microcylloepus sp. | C | 4 | cg | 17 |
| Hydropsyche sp. | T | 4 | cf | 13 |
| Dasyhelea sp. | D | 6 | cg | 9 |
| Simulium sp. | D | 6 | cf | 8 |
| Chironominae | D | 6 | cg | 7 |
| Orthocladiinae | D | 5 | cg | 7 |
| Baetis sp. | E | 5 | cg | 5 |
| Ochrotrichia sp. | T | 4 | cg | 5 |
| Tinodes sp. | T | 2 | cg | 4 |
| % of Total | | | | 76 |

| Station 11 North Fork Matilija Creek at gauging station | Grp | Tol | FFG | % |
|---|---|---|---|---|
| Micrasema sp. | T | 1 | sc | 22 |
| Orthocladiinae | D | 5 | cg | 21 |
| Microcylloepus sp. | C | 4 | cg | 9 |
| Hydropsyche sp. | T | 4 | cf | 7 |
| Chironominae | D | 6 | cg | 5 |
| Simulium sp. | D | 6 | cf | 4 |
| Baetis sp. | E | 5 | cg | 4 |
| Euparyphus/Caloparyphus | D | 8 | cg | 4 |
| Maruina lanceolata | D | 2 | sc | 2 |
| % of Total | | | | 77 |

| Station 13 Matilija Creek below community | Grp | Tol | FFG | % |
|---|---|---|---|---|
| Microcylloepus sp. | C | 4 | cg | 30 |
| Simulium sp. | D | 6 | cf | 23 |
| Orthocladiinae | D | 5 | cg | 14 |
| Baetis sp. | E | 5 | cg | 7 |
| Fallceon quilleri | E | 4 | cg | 6 |
| % of Total | | | | 80 |

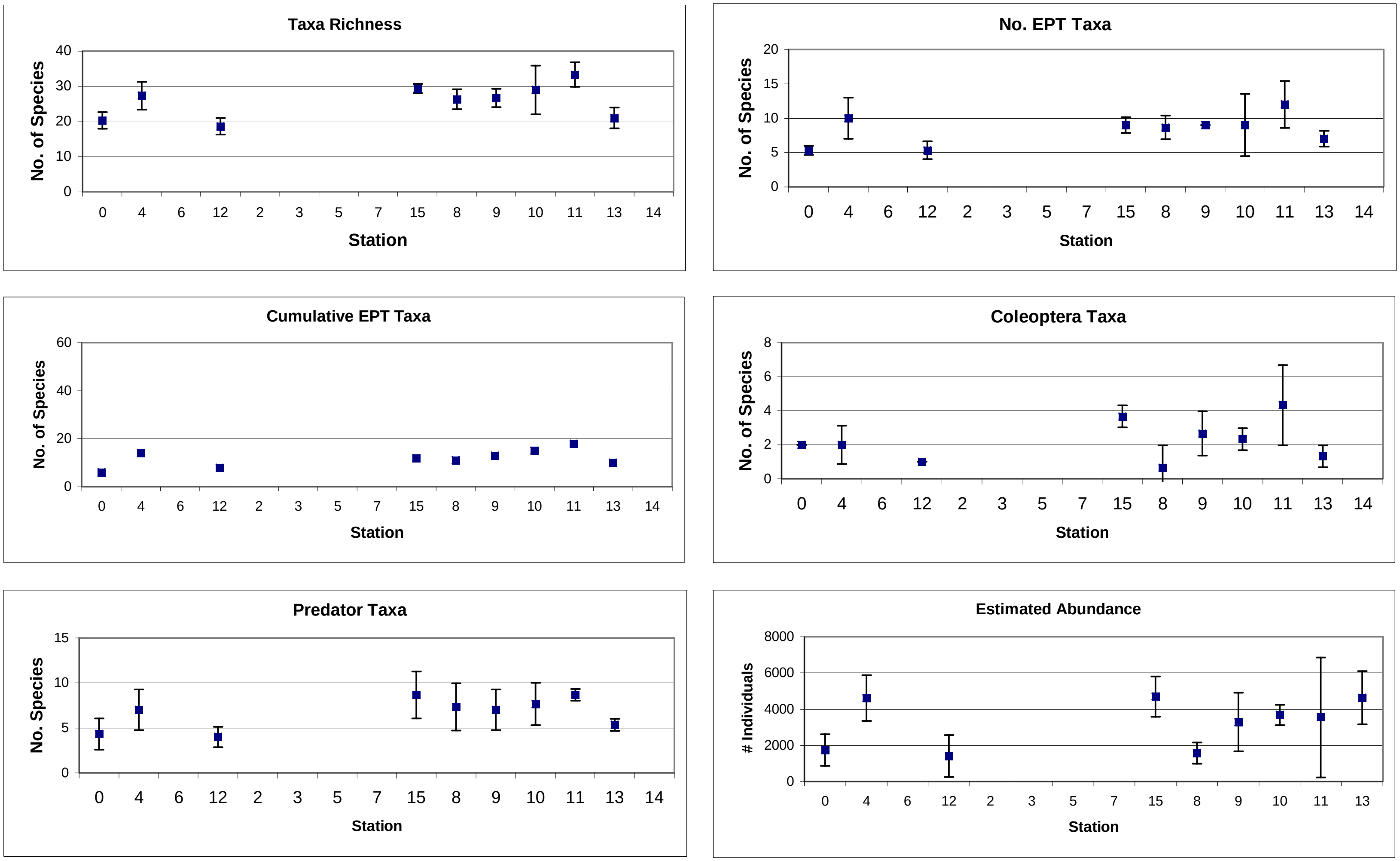


Figure 5. Richness measures: average (n=3) for each biological metric (± 95% CI) by site in the Ventura watershed, 2004.

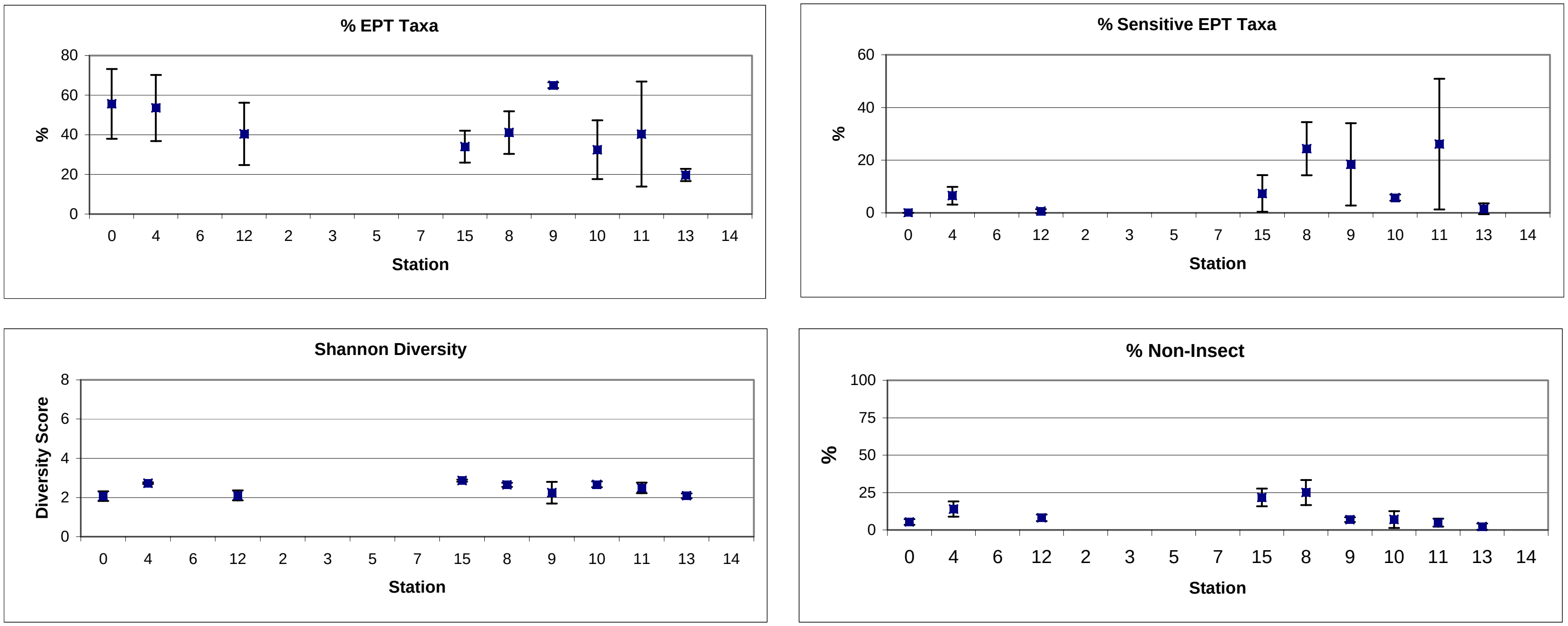


Figure 6. Composition measures: average (n=3) for each biological metric (± 95% CI) by site in the Ventura watershed, 2004.

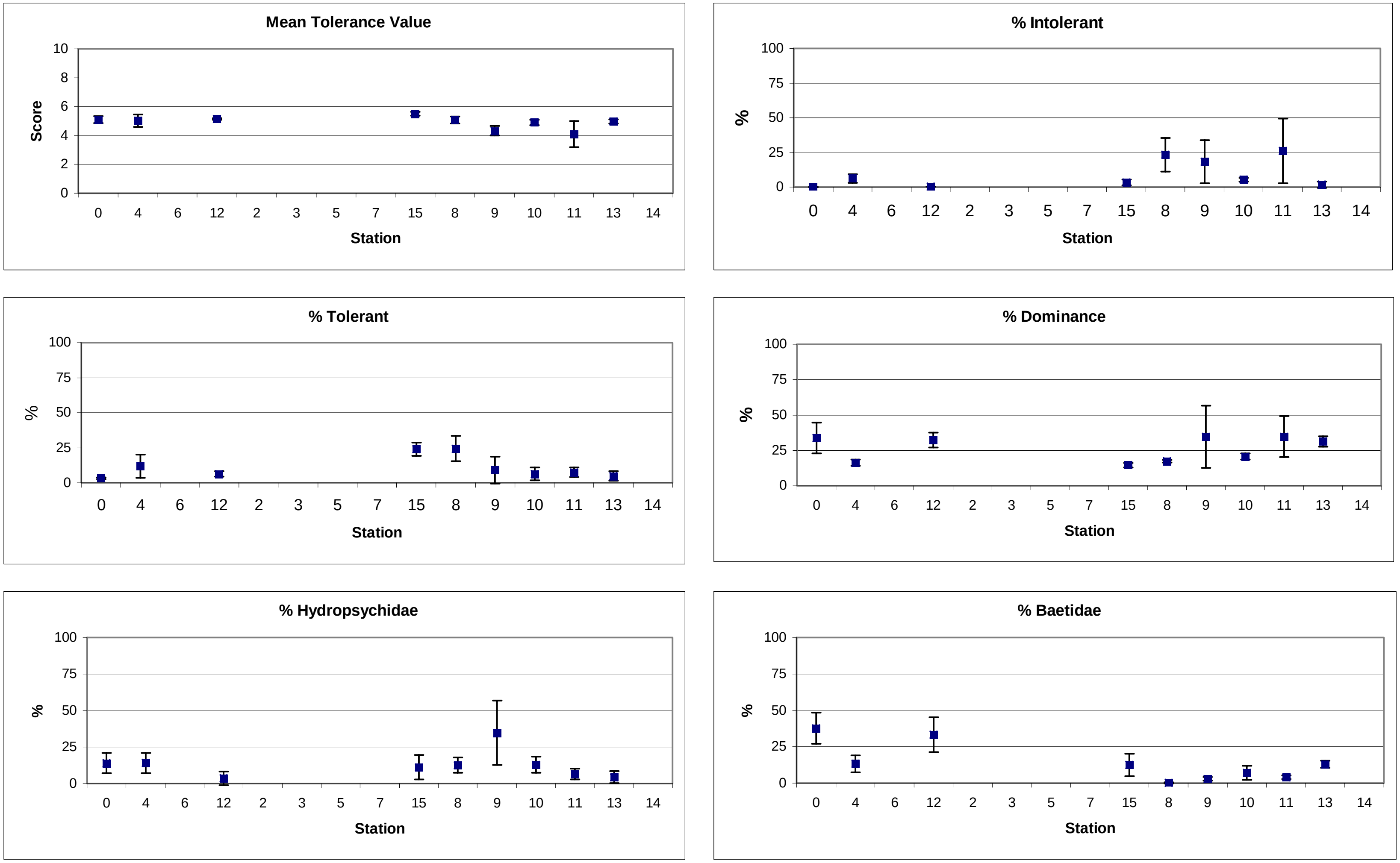


Figure 7. Tolerance/Intolerance measures: average (n=3) for each biological metric (± 95% CI) by site in the Ventura watershed, 2004.

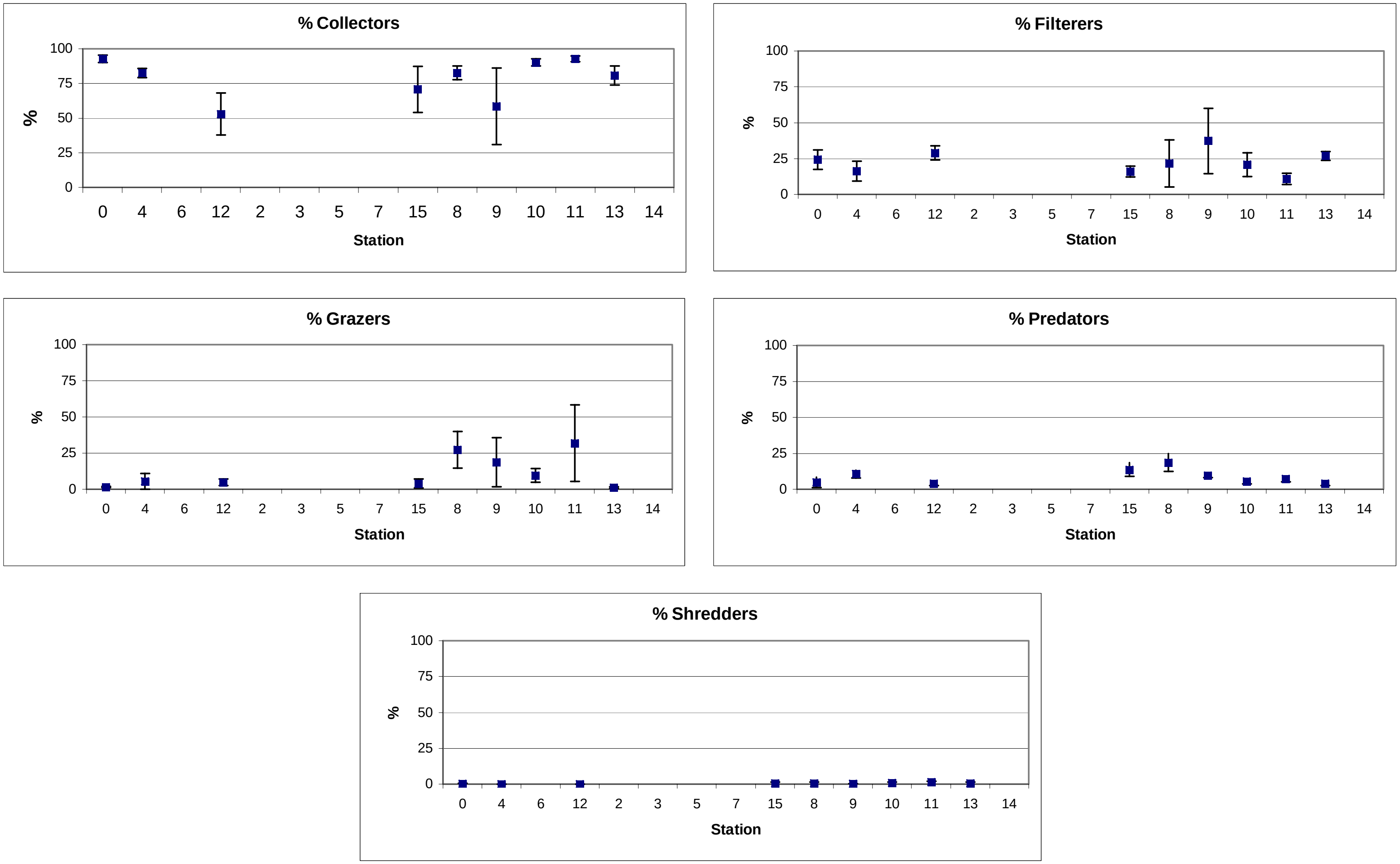


Figure 8. Functional Feeding Group measures: average (n=3) for each biological metric (± 95% CI) by site in the Ventura watershed, 2004.

Table 7. Southern California IBI scores and ratings for sites sampled in the Ventura watershed.

| River/Stream System | Ventura River | | | | Canada Larga | | San Antonio Creek | | | | | North Fork Matilija Creek | | Matilija Creek | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Station Description | Main Street Bridge | Foster Park | Below Matilija Dam | @Santa Ana Rd. | Below Grazing | Above Grazing | u/s Ventura River Confluence | Lion Canyon u/s San Antonio | u/s Lion Canyon | Stewart Canyon u/s San Antonio | u/s Stewart Canyon Creek | u/s Ventura River Confluence | At gauging station | Below community | Above Community |
| Biological Metric | 0 | 4 | 12 | 6 | 2 | 3 | 5 | 7 | 15 | 8 | 9 | 10 | 11 | 13 | 14 |
| Coleopteran Taxa | 4 | 7 | 5 | | | | | | 10 | 5 | 7 | 8 | 10 | 5 | |
| EPT Taxa | 3 | 7 | 5 | | | | | | 6 | 6 | 5 | 7 | 6 | 5 | |
| Predator Taxa | 3 | 9 | 8 | | | | | | 10 | 10 | 8 | 10 | 9 | 6 | |
| % Collectors (cg + cf) | 1 | 4 | 3 | | | | | | 5 | 10 | 7 | 4 | 10 | 2 | |
| % Intolerant | 0 | 2 | 0 | | | | | | 1 | 9 | 7 | 2 | 10 | 1 | |
| % Non-Insect Taxa | 10 | 10 | 10 | | | | | | 8 | 10 | 10 | 10 | 10 | 10 | |
| % Tolerant | 10 | 8 | 9 | | | | | | 5 | 4 | 9 | 9 | 9 | 10 | |
| Total<br>So. Cal. IBI Rating | 31<br>Poor | 47<br>Fair | 40<br>Fair | Dry | Dry | Dry | Dry | Dry | 45<br>Fair | 54<br>Fair | 53<br>Fair | 50<br>Fair | 64<br>Good | 39<br>Poor | Dry |

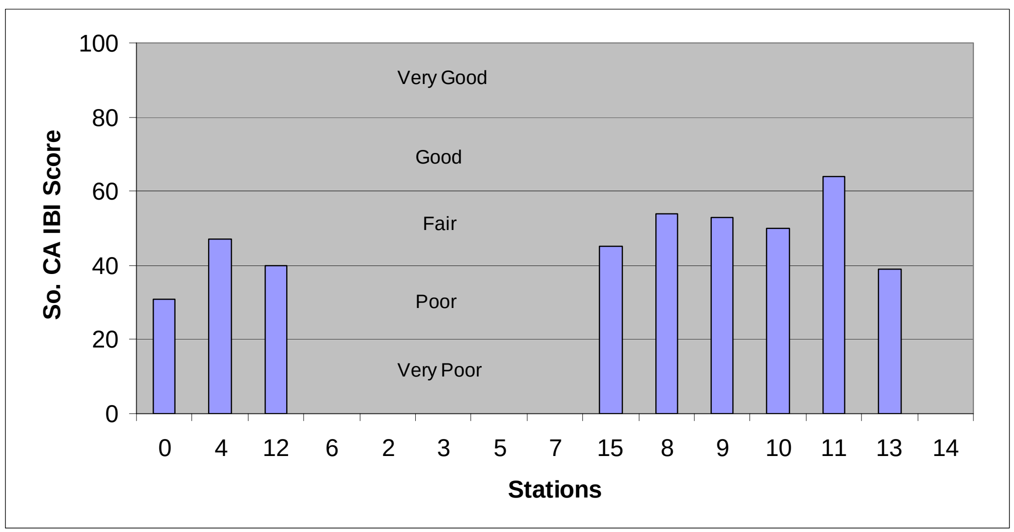


Figure 9. Southern California IBI Scores for sites in the Ventura watershed, 2004.

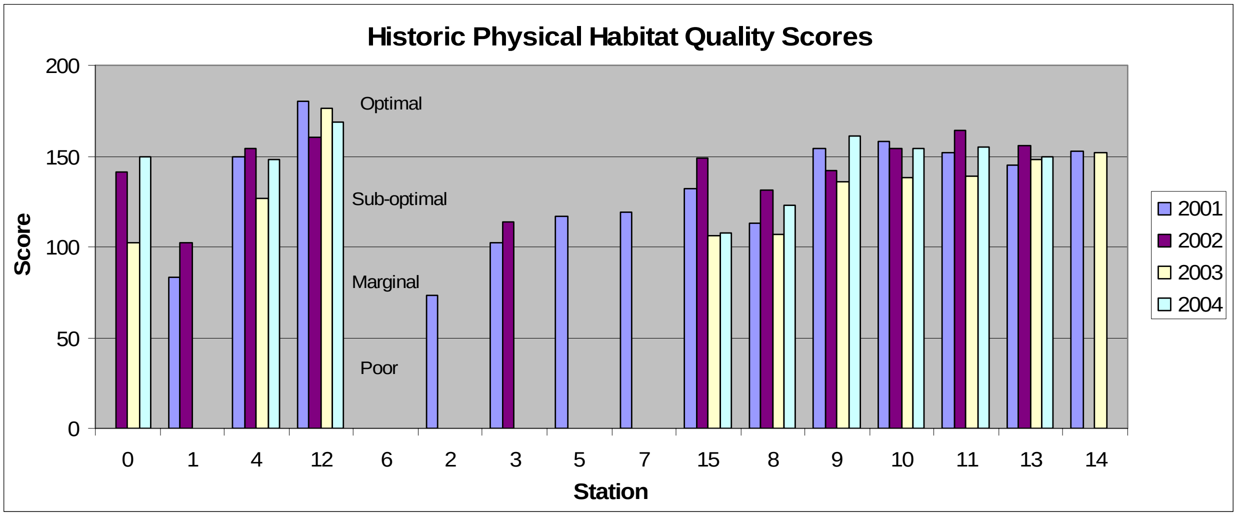


Figure 10. Physical habitat scores for sites in the Ventura watershed, 2001 to 2004.

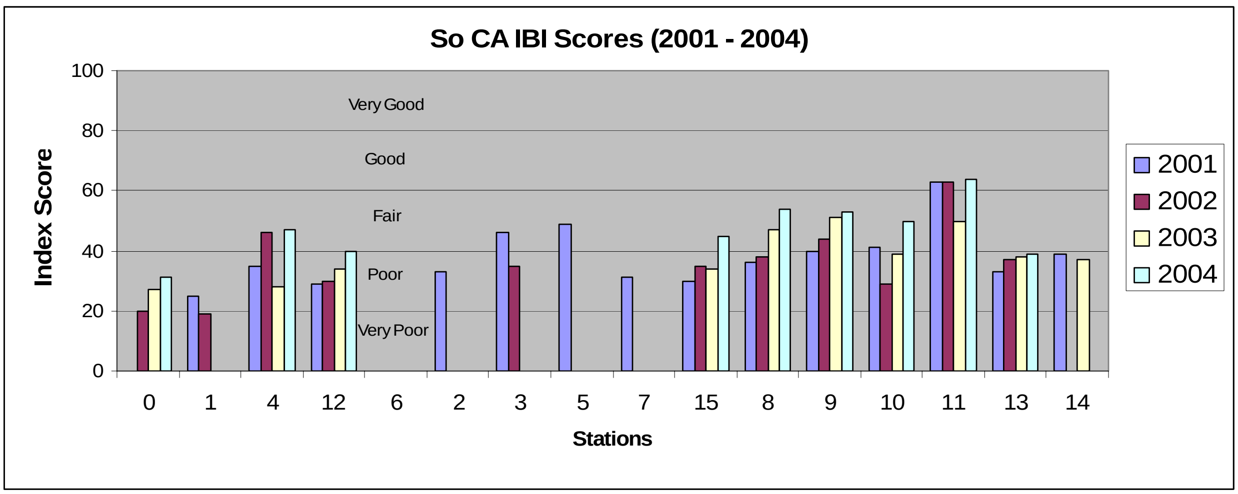


Figure 11. So CA IBI scores for sites in the Ventura watershed, 2001 to 2004.

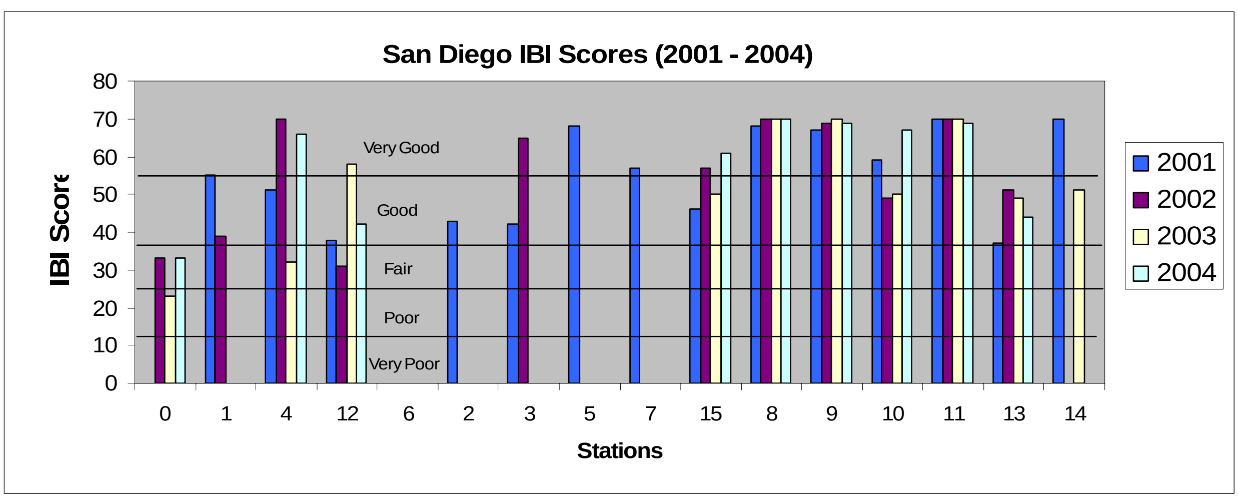


Figure 12. SD IBI scores for sites in the Ventura watershed, 2001 to 2004.

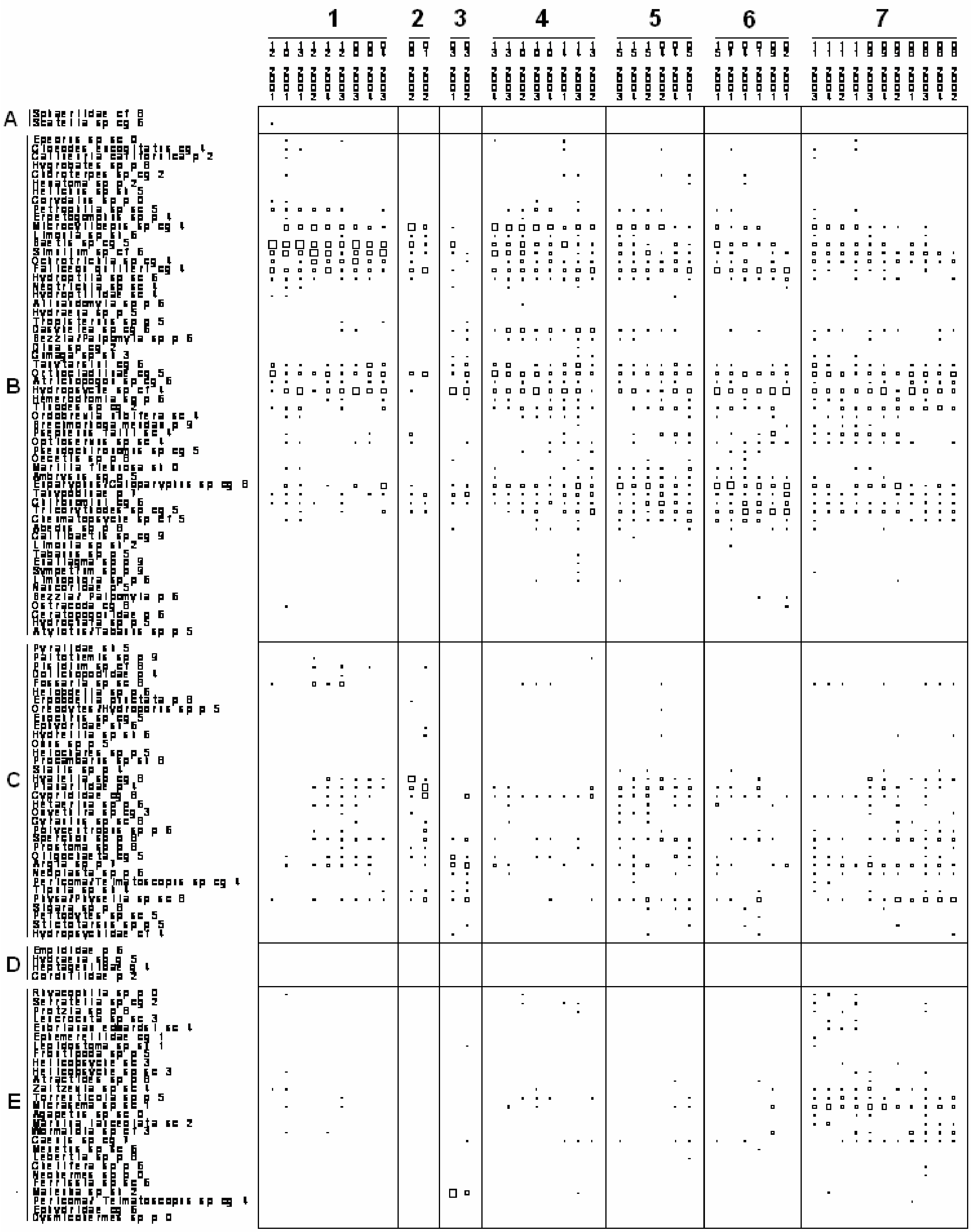

Figure 13. Two-way coincidence table of historical species groups (left) vs. stations (top) as resolved by cluster analysis using the Bray-Curtis dissimilarity metric. Data were square root transformed. Symbols represent the relative abundance of each species at a station.

Table 8. Top 10 species averaged across each station by species cluster group (2001-2004). Grp = taxa groups: E = Ephemeroptera; D = Dipterans; T = Trichopterans; C = Coleopterans; M = Mollusks; NI = non-insects; P = Plecopterans; O = Odonata. Tol = tolerance groups. FFG = feeding groups: cg = collector gatherers; cf = collector filterers; p = predators; sc = scrapers.

**Cluster Grp 1 — Ventura River / Matilija Dam**

| | Grp | Tol | FFG | Avg |
|---|---|---|---|---|
| Baetis sp | E | 5 | cg | 280 |
| Simulium sp | D | 6 | cf | 153 |
| Hydropsyche sp | T | 4 | cf | 89 |
| Microcylloepus sp | C | 4 | cg | 59 |
| Orthocladiinae | D | 5 | cg | 51 |
| Fallceon quilleri | E | 4 | cg | 49 |
| Ochrotrichia sp | T | 4 | cg | 40 |
| Fossaria sp | M | 8 | sc | 25 |
| Tanytarsini | D | 6 | cg | 23 |
| Euparyphus/Caloparyphus sp | D | 8 | cg | 19 |

**Cluster Grp 2 — Lower Watershed 2002**

| | Grp | Tol | FFG | Avg |
|---|---|---|---|---|
| Microcylloepus sp | C | 4 | cg | 174 |
| Planariidae | NI | 4 | p | 137 |
| Hyalella sp | NI | 8 | cg | 114 |
| Cyprididae | NI | 8 | cg | 103 |
| Fallceon quilleri | E | 4 | cg | 94 |
| Baetis sp | E | 5 | cg | 75 |
| Orthocladiinae | D | 5 | cg | 58 |
| Physa/Physella sp | M | 8 | sc | 26 |
| Tanypodinae | D | 7 | p | 15 |
| Simulium sp | D | 6 | cf | 12 |

**Cluster Grp 3 — Canada Larga Creek**

| | Grp | Tol | FFG | Avg |
|---|---|---|---|---|
| Malenka sp | P | 2 | sh | 246 |
| Hydropsyche sp | T | 4 | cf | 217 |
| Argia sp | O | 7 | p | 107 |
| Physa/Physella sp | M | 8 | sc | 76 |
| Baetis sp | E | 5 | cg | 41 |
| Orthocladiinae | D | 5 | cg | 40 |
| Tanypodinae | D | 7 | p | 37 |
| Cyprididae | NI | 8 | cg | 31 |
| Oligochaeta | NI | 5 | cg | 24 |
| Tanytarsini | D | 6 | cg | 19 |

**Cluster Grp 4 — Matilija Creek**

| | Grp | Tol | FFG | Avg |
|---|---|---|---|---|
| Microcylloepus sp | C | 4 | cg | 169 |
| Hydropsyche sp | T | 4 | cf | 96 |
| Orthocladiinae | D | 5 | cg | 81 |
| Baetis sp | E | 5 | cg | 75 |
| Simulium sp | D | 6 | cf | 62 |
| Dasyhelea sp | D | 6 | cg | 59 |
| Fallceon quilleri | E | 4 | cg | 56 |
| Euparyphus/Caloparyphus sp | D | 8 | cg | 54 |
| Tricorythodes sp | E | 5 | cg | 32 |
| Tanytarsini | D | 6 | cg | 29 |

**Cluster Grp 5 — San Antonio Creek**

| | Grp | Tol | FFG | Avg |
|---|---|---|---|---|
| Euparyphus/Caloparyphus sp | D | 8 | cg | 105 |
| Fallceon quilleri | E | 4 | cg | 82 |
| Microcylloepus sp | C | 4 | cg | 75 |
| Hydropsyche sp | T | 4 | cf | 67 |
| Orthocladiinae | D | 5 | cg | 52 |
| Chironomini | D | 6 | cg | 46 |
| Simulium sp | D | 6 | cf | 42 |
| Planariidae | NI | 4 | p | 39 |
| Tricorythodes sp | E | 5 | cg | 35 |
| Tinodes sp | T | 2 | cg | 29 |

**Cluster Grp 6 — San Antonio Creek / Ventura River**

| | Grp | Tol | FFG | Avg |
|---|---|---|---|---|
| Hydropsyche sp | T | 4 | cf | 195 |
| Euparyphus/Caloparyphus sp | D | 8 | cg | 150 |
| Tricorythodes sp | E | 5 | cg | 106 |
| Fallceon quilleri | E | 4 | cg | 85 |
| Orthocladiinae | D | 5 | cg | 45 |
| Chironomini | D | 6 | cg | 45 |
| Baetis sp | E | 5 | cg | 44 |
| Tanypodinae | D | 7 | p | 23 |
| Cheumatopsyche sp | T | 5 | cf | 19 |
| Microcylloepus sp | C | 4 | cg | 18 |

**Cluster Grp 7 — North Fork Matilija Creek / Upper San Antonio Creek**

| | Grp | Tol | FFG | Avg |
|---|---|---|---|---|
| Hydropsyche sp | T | 4 | cf | 140 |
| Orthocladiinae | D | 5 | cg | 96 |
| Micrasema sp | T | 1 | sc | 84 |
| Physa/Physella sp | M | 8 | sc | 52 |
| Euparyphus/Caloparyphus sp | D | 8 | cg | 46 |
| Simulium sp | D | 6 | cf | 44 |
| Tinodes sp | T | 2 | cg | 42 |
| Microcylloepus sp | C | 4 | cg | 34 |
| Argia sp | O | 7 | p | 33 |
| Ochrotrichia sp | T | 4 | cg | 30 |

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## Appendix A – BMI Taxa Lists, Metric Tables & Cluster Analysis

Table A-1. September 2004 BMI raw taxa list for all sites in the Ventura watershed.

| | | Stations | 0 | | | 4 | | | 8 | | | 9 | | | 10 | | | 11 | | | 12 | | | 13 | | | 15 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TV | FFG | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| ***Identified Taxa*** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Non-Insects** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ***Procambarus sp.*** | 8 | sh | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| ***Planariidae*** | 4 | p | 4 | 1 | 9 | 19 | 1 | 7 | 0 | 0 | 7 | 2 | 13 | 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 5 | 2 | 2 | 1 | 6 | 22 |
| ***Physa/Physella sp.*** | 8 | sc | 0 | 3 | 0 | 3 | 0 | 1 | 54 | 53 | 18 | 6 | 3 | 0 | 0 | 6 | 14 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 8 |
| ***Ferrissia sp.*** | 6 | sc | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Fossaria sp.*** | 8 | sc | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 1 | 0 | 0 | 0 | 0 | 4 | 3 | 11 | 0 | 2 | 8 | 16 | 0 | 0 | 0 | 0 | 1 | 0 |
| ***Gyraulus sp.*** | 8 | sc | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Menetus sp.*** | 6 | sc | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Pisidium sp.*** | 8 | cf | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Oligochaeta*** | 5 | cg | 7 | 0 | 0 | 4 | 38 | 3 | 3 | 6 | 7 | 0 | 0 | 2 | 0 | 6 | 6 | 1 | 2 | 2 | 3 | 12 | 0 | 4 | 0 | 0 | 17 | 18 | 8 |
| ***Atractides sp.*** | 8 | p | 0 | 0 | 1 | 0 | 4 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Sperchon sp.*** | 8 | p | 5 | 3 | 1 | 5 | 4 | 14 | 26 | 14 | 7 | 3 | 1 | 0 | 2 | 2 | 2 | 7 | 7 | 1 | 5 | 0 | 0 | 1 | 1 | 0 | 1 | 11 | 3 |
| ***Torrenticola sp.*** | 5 | p | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 6 | 1 | 3 | 1 | 0 | 0 | 7 | 6 | 2 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Hyalella sp.*** | 8 | cg | 4 | 1 | 4 | 4 | 2 | 0 | 3 | 5 | 6 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 0 | 1 | 0 | 0 | 0 | 5 | 30 | 8 |
| ***Cyprididae*** | 8 | cg | 0 | 2 | 1 | 7 | 4 | 3 | 0 | 0 | 0 | 1 | 3 | 0 | 2 | 9 | 0 | 2 | 0 | 1 | 6 | 2 | 2 | 2 | 1 | 1 | 26 | 4 | 29 |
| **Ephemeroptera** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ***Baetis sp.*** | 5 | cg | 137 | 89 | 53 | 28 | 15 | 46 | 2 | 0 | 0 | 10 | 11 | 3 | 26 | 6 | 20 | 12 | 13 | 10 | 14 | 34 | 120 | 18 | 17 | 22 | 6 | 29 | 1 |
| ***Callibaetis sp.*** | 9 | cg | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| ***Fallceon quilleri*** | 4 | cg | 9 | 21 | 31 | 10 | 10 | 9 | 0 | 0 | 0 | 0 | 1 | 2 | 9 | 4 | 2 | 1 | 5 | 0 | 94 | 29 | 18 | 12 | 19 | 24 | 47 | 18 | 13 |
| ***Caenis sp.*** | 7 | cg | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 3 | 5 | 3 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Serratella sp.*** | 2 | cg | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Epeorus sp.*** | 0 | sc | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| ***Leucrocuta sp.*** | 3 | sc | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Tricorythodes sp.*** | 5 | cg | 0 | 1 | 2 | 22 | 27 | 36 | 21 | 2 | 1 | 31 | 19 | 7 | 2 | 0 | 2 | 2 | 0 | 8 | 0 | 0 | 0 | 0 | 2 | 1 | 12 | 1 | 2 |
| **Odonata** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ***Hetaerina sp.*** | 6 | p | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 5 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| ***Argia sp.*** | 7 | p | 0 | 3 | 6 | 1 | 0 | 0 | 7 | 41 | 29 | 18 | 10 | 10 | 1 | 0 | 2 | 0 | 1 | 4 | 6 | 6 | 3 | 5 | 3 | 4 | 12 | 20 | 10 |
| ***Erpetogomphus sp.*** | 4 | p | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Brechmorhoga mendax*** | 9 | p | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| **Plecoptera** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ***Malenka sp.*** | 2 | sh | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Hemiptera** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ***Abedus sp.*** | 8 | p | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Sigara sp.*** | 8 | p | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Ambrysus sp.*** | 5 | p | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 4 |
| **Megaloptera** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ***Corydalus sp.*** | 0 | p | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Sialis sp.*** | 4 | p | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| **Trichoptera** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ***Micrasema sp.*** | 1 | sc | 0 | 0 | 0 | 3 | 1 | 1 | 51 | 41 | 22 | 50 | 71 | 5 | 0 | 0 | 3 | 152 | 51 | 13 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| ***Helicopsyche*** | 3 | sc | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Cheumatopsyche sp.*** | 5 | cf | 0 | 0 | 0 | 3 | 0 | 7 | 4 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 3 | 16 |
| ***Hydropsyche sp.*** | 4 | cf | 63 | 25 | 38 | 55 | 21 | 39 | 29 | 27 | 52 | 72 | 75 | 179 | 56 | 35 | 30 | 18 | 35 | 13 | 2 | 5 | 27 | 6 | 24 | 7 | 16 | 23 | 41 |
| ***Hydroptilidae (imm.)*** | 4 | sc | 0 | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Hydroptila sp.*** | 6 | sc | 3 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 0 | 4 | 0 | 2 | 2 | 1 | 0 | 0 | 0 | 0 | 2 | 1 | 1 | 0 | 0 | 4 |
| ***Neotrichia sp.*** | 4 | sc | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| ***Ochrotrichia sp.*** | 4 | cg | 12 | 14 | 3 | 39 | 10 | 25 | 0 | 5 | 0 | 8 | 1 | 0 | 25 | 13 | 13 | 13 | 1 | 5 | 1 | 11 | 14 | 0 | 0 | 0 | 5 | 2 | 0 |
| ***Oxyethira sp.*** | 3 | cg | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 35 |
| ***Oecetis sp.*** | 8 | p | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| ***Marilia flexuosa*** | 0 | sh | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 1 | 2 | 2 | 0 |
| ***Wormaldia sp.*** | 3 | cf | 0 | 0 | 0 | 1 | 0 | 0 | 3 | 2 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Polycentropus sp.*** | 6 | p | 0 | 0 | 0 | 1 | 0 | 2 | 1 | 2 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Tinodes sp. (L)*** | 2 | cg | 0 | 0 | 0 | 19 | 23 | 8 | 43 | 42 | 9 | 19 | 22 | 4 | 18 | 15 | 8 | 2 | 1 | 0 | 0 | 1 | 0 | 5 | 1 | 0 | 5 | 17 | 6 |
| ***Rhyacophila sp. (L)*** | 0 | p | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 2 | 5 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Gumaga sp.*** | 3 | sh | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 7 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Lepidoptera** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ***Petrophila sp.*** | 5 | sc | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 6 | 5 | 2 | 0 | 1 | 5 | 7 | 6 | 0 | 1 | 0 | 0 | 12 | 0 |
| **Coleoptera** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ***Microcylloepus sp.*** | 4 | cg | 4 | 6 | 14 | 1 | 0 | 9 | 0 | 1 | 0 | 1 | 3 | 4 | 26 | 69 | 71 | 15 | 36 | 43 | 45 | 38 | 26 | 91 | 93 | 77 | 21 | 46 | 5 |
| ***Optioservus sp.*** | 4 | sc | 0 | 0 | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 4 | 10 | 3 | 8 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 2 |
| ***Ordobrevia sp.*** | 4 | sc | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 6 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Zaitzevia sp.*** | 4 | sc | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Peltodytes sp.*** | 5 | sc | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |

Table A-1. Continued.

| | TV | *FFG* | 0 | | | 4 | | | 8 | | | 9 | | | 10 | | | 11 | | | 12 | | | 13 | | | 15 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| *Tropisternus sp.* | 5 | p | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Helochares sp.* | 5 | p | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hydraena sp.* | 5 | p | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Eubrianax edwardsi* | 4 | sc | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Psephenus falli* | 4 | sc | 3 | 1 | 0 | 6 | 2 | 17 | 0 | 0 | 0 | 10 | 21 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 |
| Diptera | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Bezzia/Palpomyia sp.* | 6 | p | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 2 |
| *Dasyhelea sp.* | 6 | cg | 0 | 0 | 0 | 1 | 4 | 1 | 6 | 0 | 4 | 3 | 5 | 0 | 13 | 50 | 18 | 5 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 11 | 12 | 2 |
| *Atrichopogon sp.* | 6 | cg | 4 | 1 | 1 | 4 | 5 | 0 | 3 | 11 | 3 | 4 | 4 | 2 | 12 | 1 | 3 | 1 | 0 | 0 | 0 | 6 | 1 | 2 | 1 | 0 | 0 | 1 | 0 |
| **Chironominae** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Chironomini** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Apedilum sp.* | 6 | cg | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Dicrotendipes sp.* | 8 | cg | 0 | 0 | 0 | 2 | 9 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 18 | 20 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| *Microtendipes sp.* | 6 | cf | 0 | 0 | 0 | 3 | 4 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 4 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 |
| *Paracladopelma sp.* | 7 | cg | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| *Paratendipes sp.* | 8 | cg | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polypedilum sp.* | 6 | sc | 0 | 0 | 0 | 2 | 14 | 3 | 0 | 2 | 0 | 0 | 0 | 0 | 4 | 1 | 0 | 3 | 4 | 12 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 0 | 0 |
| *Stenochironomus sp.* | 5 | cg | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 9 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 0 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Pseudochironomini** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Pseudochironomus sp.* | 5 | cg | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 3 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Tanytarsini** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Rheotanytarsus sp.* | 6 | cf | 1 | 42 | 78 | 29 | 11 | 3 | 0 | 5 | 1 | 0 | 1 | 0 | 0 | 6 | 1 | 0 | 12 | 11 | 0 | 3 | 6 | 1 | 15 | 7 | 4 | 5 | 1 |
| *Tanytarsus sp.* | 6 | cf | | | | | | | | | | | | | | | | | | | 0 | 0 | 0 | 0 | 3 | 0 | 2 | 1 | 0 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Orthocladiinae** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Brillia sp.* | 5 | sh | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cardiocladius sp.* | 5 | p | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Corynoneura sp.* | 7 | cg | 1 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 4 | 26 | 0 | 2 | 4 | 1 | 8 | 15 | 0 | 1 | 1 | 9 | 6 | 10 | 3 | 1 | 3 |
| *Cricotopus sp.* | 7 | cg | 17 | 12 | 14 | 1 | 10 | 4 | 7 | 1 | 4 | 0 | 0 | 0 | 4 | 10 | 8 | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 1 | 1 | 6 | 0 | 0 |
| *Eukiefferiella sp.* | 8 | cg | 8 | 2 | 1 | 2 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 5 | 2 | 4 | 5 | 5 | 8 | 5 | 6 | 6 | 6 | 5 | 20 | 0 | 9 | 2 |
| *Parametriocnemus sp.* | 5 | cg | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 5 | 17 | 2 | 2 | 5 | 0 | 0 | 1 | 0 | 36 | 35 | 0 | 2 | 7 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Paraphaenocladius sp.* | 4 | cg | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| *Rheocricotopus sp.* | 6 | cg | 7 | 2 | 6 | 0 | 1 | 4 | 0 | 1 | 8 | 1 | 1 | 19 | 0 | 3 | 3 | 4 | 19 | 51 | 2 | 12 | 12 | 7 | 30 | 23 | 6 | 5 | 2 |
| *Thienemanniella sp.* | 6 | cg | 3 | 1 | 2 | 1 | 4 | 10 | 2 | 1 | 2 | 8 | 0 | 2 | 11 | 1 | 2 | 7 | 2 | 11 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 5 | 3 |
| **Tanypodinae** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Labrundinia sp.* | 6 | p | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 3 |
| *Nilotanypus sp.* | 6 | p | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Pentaneura sp.* | 6 | p | 0 | 1 | 7 | 4 | 6 | 4 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 7 | 3 | 6 |
| *Thienemannimyia Gr.* | 6 | p | 0 | 0 | 0 | 2 | 6 | 0 | 0 | 4 | 6 | 0 | 0 | 1 | 4 | 1 | 0 | 5 | 10 | 4 | 0 | 1 | 0 | 3 | 0 | 2 | 1 | 1 | 0 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Dolichopodidae (L)* | 4 | p | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hemerodromia sp. (L)* | 6 | p | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 3 | 1 | 3 | 2 | 0 | 2 | 2 | 2 | 1 | 0 | 0 | 0 | 0 |
| *Neoplasta sp. (L)* | 6 | p | 0 | 0 | 1 | 2 | 0 | 1 | 0 | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Ephydridae (L)* | 6 | sh | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Maruina lanceolata (L)* | 2 | sc | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 7 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pericoma/Telmatoscopus sp.* | 4 | cg | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| *Dixa sp.* | 2 | cg | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Simulium sp. (L)* | 6 | cf | 11 | 64 | 14 | 1 | 6 | 12 | 7 | 9 | 48 | 2 | 12 | 10 | 13 | 4 | 61 | 5 | 11 | 24 | 95 | 81 | 51 | 65 | 46 | 84 | 21 | 25 | 0 |
| *Euparyphus/Caloparyphus sp.* | 8 | cg | 1 | 1 | 0 | 4 | 43 | 3 | 10 | 9 | 12 | 33 | 20 | 1 | 1 | 9 | 4 | 18 | 4 | 13 | 0 | 3 | 0 | 20 | 6 | 8 | 34 | 22 | 32 |
| *Limonia sp. (L)* | 6 | sh | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 2 | 0 | 0 |
| *Tipula sp. (L)* | 4 | sh | 0 | 1 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Sum** | | | 307 | 302 | 295 | 305 | 295 | 296 | 311 | 324 | 298 | 317 | 320 | 316 | 314 | 310 | 342 | 344 | 346 | 321 | 319 | 289 | 325 | 293 | 283 | 307 | 309 | 346 | 291 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **No. Caton Grids picked** | | | 10 | 4 | 5 | 2 | 4 | 2 | 5 | 10 | 5 | 5 | 3 | 2 | 3 | 3 | 3 | 2 | 23 | 3 | 4 | 10 | 14 | 2 | 2 | 3 | 2 | 3 | 2 |
| **Residual BMIs** | | | 7 | 31 | 11 | 23 | 159 | 80 | 0 | 7 | 24 | 11 | 0 | 5 | 78 | 6 | 70 | 86 | 2 | 75 | 37 | 32 | 3 | 0 | 125 | 58 | 33 | 19 | 82 |
| **Total Estimated BMIs/sample** | | | 939 | 2483 | 1818 | 4845 | 3390 | 5595 | 1812 | 987 | 1914 | 1908 | 3180 | 4770 | 3810 | 3140 | 4090 | 6270 | 451 | 3930 | 2573 | 957 | 696 | 4185 | 6090 | 3620 | 4890 | 3630 | 5550 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **No. Ephemeroptera Taxa** | | | 2 | 3 | 3 | 3 | 3 | 4 | 3 | 2 | 2 | 3 | 4 | 4 | 3 | 2 | 5 | 5 | 4 | 3 | 2 | 2 | 2 | 3 | 3 | 3 | 4 | 3 | 4 |
| **No. Plecoptera Taxa** | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **No. Trichoptera Taxa** | | | 3 | 3 | 2 | 8 | 4 | 8 | 7 | 7 | 5 | 6 | 5 | 5 | 6 | 3 | 8 | 7 | 10 | 5 | 4 | 4 | 2 | 5 | 3 | 4 | 5 | 5 | 6 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **No. Epemeroptera individuals** | | | 146 | 111 | 86 | 60 | 52 | 92 | 24 | 3 | 2 | 44 | 36 | 15 | 37 | 10 | 27 | 17 | 34 | 19 | 108 | 63 | 138 | 32 | 38 | 47 | 66 | 48 | 17 |
| **No. Plecoptera individuals** | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **No. Trichoptera individuals** | | | 78 | 40 | 41 | 123 | 55 | 93 | 132 | 121 | 96 | 151 | 173 | 191 | 107 | 63 | 62 | 196 | 99 | 35 | 7 | 18 | 41 | 17 | 26 | 10 | 30 | 47 | 103 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **No. Sensitive E ind.** | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 16 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| **No. Sensitive P ind.** | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **No. Sensitive T ind.** | | | 0 | 0 | 0 | 25 | 24 | 9 | 97 | 85 | 43 | 71 | 93 | 9 | 21 | 15 | 16 | 163 | 60 | 17 | 4 | 2 | 0 | 8 | 1 | 2 | 7 | 19 | 41 |

Table A-2. Spring 2004 BMI metrics by replicate for each of the three sample locations in the Ventura Watershed.

| | Ventura River Main Street Bridge | | | Ventura River Foster Park | | | Ventura River below Matilija Dam | | |
|---|---|---|---|---|---|---|---|---|---|
| Station | 0 | | | 4 | | | 12 | | |
| Replicate | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| Taxonomic richness | 18 | 22 | 21 | 31 | 24 | 27 | 17 | 21 | 18 |
| % dominant taxa | 44.8 | 29.7 | 26.7 | 18.3 | 14.7 | 15.7 | 31.0 | 28.2 | 37.3 |
| Cumulative taxa | | 32 | | | 48 | | | 34 | |
| EPT taxa | 5 | 6 | 5 | 11 | 7 | 12 | 6 | 6 | 4 |
| EPT Index (%) | 73.2 | 50.3 | 43.5 | 61.0 | 36.5 | 63.1 | 37.6 | 28.2 | 55.6 |
| Sensitive EPT Index (%) | 0.0 | 0.0 | 0.0 | 8.3 | 8.2 | 3.1 | 1.3 | 0.7 | 0.0 |
| Percent Chironomidae | 12.1 | 20.3 | 37.0 | 15.7 | 22.9 | 12.3 | 2.3 | 12.5 | 9.9 |
| Shannon Diversity | 1.83 | 2.11 | 2.26 | 2.75 | 2.69 | 2.75 | 1.91 | 2.34 | 2.07 |
| Tolerance Value | 4.9 | 5.3 | 5.2 | 4.8 | 5.5 | 4.8 | 5.1 | 5.2 | 5.1 |
| Percent Intolerance Value (0-2) | 0.0 | 0.0 | 0.0 | 7.3 | 8.2 | 3.1 | 0.3 | 0.3 | 0.3 |
| Percent Tolerance Value (8-10) | 3.6 | 3.7 | 2.7 | 8.0 | 20.1 | 7.2 | 8.2 | 4.9 | 5.9 |
| Percent Collectors | 94.8 | 93.5 | 90.1 | 82.0 | 85.7 | 79.9 | 49.7 | 41.4 | 67.8 |
| Percent Filterers | 24.5 | 30.0 | 18.2 | 20.0 | 9.2 | 19.8 | 32.7 | 30.3 | 24.2 |
| Percent Grazers | 2.0 | 1.7 | 1.0 | 4.7 | 1.0 | 10.6 | 2.6 | 5.2 | 6.8 |
| Percent Predators | 3.3 | 2.7 | 8.6 | 13.3 | 8.9 | 9.6 | 5.2 | 4.5 | 2.5 |
| Percent Shredders | 0.0 | 0.3 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Percent Hydropsychidae | 20.6 | 8.3 | 13.0 | 19.3 | 7.2 | 15.7 | 0.7 | 1.7 | 8.4 |
| Percent Baetidae | 47.7 | 36.7 | 28.8 | 12.7 | 8.5 | 18.8 | 35.3 | 22.0 | 42.9 |
| Predator Taxa | 3 | 4 | 6 | 9 | 7 | 5 | 3 | 4 | 5 |
| Coleoptera Taxa | 2 | 2 | 2 | 2 | 1 | 3 | 1 | 1 | 1 |
| Percent Non-Insect | 6.9 | 3.7 | 5.8 | 14.0 | 18.4 | 9.6 | 9.2 | 9.4 | 5.9 |

| | San Antonio Creek above Lion Canyon | | | Stewart Canyon Creek /s conf. San Antonio Cree | | | San Antonio Creek ear Stewart Canyon Cree | | |
|---|---|---|---|---|---|---|---|---|---|
| Station | 15 | | | 8 | | | 9 | | |
| Replicate | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| Taxonomic richness | 28 | 30 | 30 | 26 | 29 | 24 | 28 | 28 | 24 |
| % dominant taxa | 16.2 | 13.5 | 14.2 | 17.9 | 16.5 | 17.6 | 23.5 | 23.6 | 57.2 |
| Cumulative taxa | | 56 | | | 48 | | | 49 | |
| EPT taxa | 9 | 8 | 10 | 10 | 9 | 7 | 9 | 9 | 9 |
| EPT Index (%) | 32.8 | 27.6 | 41.7 | 51.7 | 38.5 | 33.2 | 63.5 | 65.7 | 65.8 |
| Sensitive EPT Index (%) | 2.4 | 5.5 | 14.2 | 32.1 | 26.4 | 14.6 | 23.1 | 29.2 | 2.9 |
| Percent Chironomidae | 13.1 | 8.5 | 10.1 | 5.0 | 7.5 | 16.6 | 3.9 | 2.5 | 17.9 |
| Shannon Diversity | 2.82 | 2.91 | 2.85 | 2.55 | 2.74 | 2.63 | 2.54 | 2.50 | 1.68 |
| Tolerance Value | 5.6 | 5.4 | 5.5 | 4.8 | 5.1 | 5.2 | 4.5 | 4.0 | 4.4 |
| Percent Intolerance Value (0-2) | 2.4 | 5.6 | 2.1 | 31.1 | 27.6 | 10.8 | 22.5 | 29.6 | 2.9 |
| Percent Tolerance Value (8-10) | 23.0 | 20.5 | 28.5 | 31.5 | 26.1 | 15.6 | 17.6 | 9.1 | 0.6 |
| Percent Collectors | 68.4 | 57.4 | 86.6 | 85.1 | 85.1 | 77.6 | 35.2 | 56.6 | 84.0 |
| Percent Filterers | 13.4 | 14.9 | 19.8 | 14.2 | 12.4 | 38.3 | 24.1 | 27.4 | 60.4 |
| Percent Grazers | 0.7 | 5.8 | 5.2 | 35.4 | 32.0 | 14.6 | 22.8 | 31.1 | 1.9 |
| Percent Predators | 10.3 | 12.3 | 18.4 | 13.6 | 24.5 | 17.6 | 8.8 | 8.8 | 11.2 |
| Percent Shredders | 1.4 | 0.6 | 0.0 | 1.3 | 0.0 | 0.0 | 0.0 | 0.3 | 0.3 |
| Percent Hydropsychidae | 6.2 | 7.6 | 19.8 | 10.9 | 9.0 | 18.0 | 23.5 | 23.6 | 57.2 |
| Percent Baetidae | 18.6 | 13.7 | 5.2 | 0.7 | 0.0 | 0.0 | 3.3 | 3.8 | 1.6 |
| Predator Taxa | 10 | 6 | 10 | 6 | 10 | 6 | 5 | 7 | 9 |
| Coleoptera Taxa | 3 | 4 | 4 | 0 | 2 | 0 | 4 | 2 | 2 |
| Percent Non-Insect | 17.1 | 20.9 | 27.4 | 30.8 | 27.6 | 16.6 | 8.5 | 6.6 | 5.8 |

| | North Fork Matilija Creek u/s conf. Ventura River | | | North Fork Matilija Creek at gauging station | | | Matilija Creek below community | | |
|---|---|---|---|---|---|---|---|---|---|
| Station | 10 | | | 11 | | | 13 | | |
| Replicate | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| Taxonomic richness | 26 | 25 | 36 | 36 | 34 | 30 | 24 | 20 | 19 |
| % dominant taxa | 18.5 | 22.4 | 20.9 | 45.8 | 20.6 | 37.7 | 32.6 | 33.5 | 27.6 |
| Cumulative taxa | | 55 | | | 57 | | | 36 | |
| EPT taxa | 9 | 5 | 13 | 12 | 15 | 9 | 8 | 6 | 7 |
| EPT Index (%) | 47.5 | 23.7 | 26.3 | 64.2 | 39.5 | 17.3 | 17.6 | 22.8 | 18.8 |
| Sensitive EPT Index (%) | 6.9 | 4.9 | 5.6 | 49.4 | 23.0 | 6.0 | 3.6 | 0.4 | 0.7 |
| Percent Chironomidae | 18.5 | 17.9 | 7.4 | 7.5 | 29.1 | 46.9 | 10.0 | 20.5 | 22.0 |
| Shannon Diversity | 2.69 | 2.54 | 2.79 | 2.38 | 2.77 | 2.33 | 2.21 | 2.05 | 2.00 |
| Tolerance Value | 4.7 | 5.0 | 5.0 | 3.2 | 4.2 | 4.8 | 5.0 | 4.8 | 5.1 |
| Percent Intolerance Value (0-2) | 6.6 | 4.9 | 4.4 | 49.1 | 20.1 | 9.1 | 3.9 | 0.4 | 0.7 |
| Percent Tolerance Value (8-10) | 1.7 | 8.8 | 8.6 | 10.8 | 6.7 | 5.0 | 8.2 | 3.2 | 3.0 |
| Percent Collectors | 92.2 | 87.8 | 90.7 | 91.0 | 92.8 | 94.7 | 87.7 | 78.7 | 76.0 |
| Percent Filterers | 22.8 | 12.7 | 26.8 | 6.9 | 13.7 | 11.6 | 25.4 | 25.2 | 29.9 |
| Percent Grazers | 9.9 | 5.2 | 13.6 | 56.0 | 29.9 | 9.4 | 1.8 | 1.1 | 0.7 |
| Percent Predators | 4.3 | 4.9 | 7.4 | 6.6 | 9.0 | 5.7 | 5.7 | 2.9 | 3.9 |
| Percent Shredders | 0.7 | 0.6 | 1.5 | 2.1 | 1.5 | 0.9 | 1.4 | 0.0 | 0.7 |
| Percent Hydropsychidae | 18.5 | 11.4 | 8.8 | 5.4 | 10.2 | 4.1 | 2.2 | 8.6 | 2.3 |
| Percent Baetidae | 11.6 | 3.2 | 6.5 | 3.9 | 5.2 | 3.1 | 10.8 | 12.9 | 15.1 |
| Predator Taxa | 7 | 6 | 10 | 8 | 9 | 9 | 5 | 5 | 6 |
| Coleoptera Taxa | 2 | 2 | 3 | 6 | 5 | 2 | 1 | 2 | 1 |
| Percent Non-Insect | 1.3 | 9.7 | 10.0 | 6.0 | 6.4 | 2.2 | 4.3 | 1.4 | 1.0 |

Table A-3. Averaged biological metrics for each station in the Ventura watershed with standard deviations, coefficients of variation and 95% confidence intervals. Grayed area denotes stations that were dry.

| | River/Stream System | Ventura River | | | | Canada Larga | | San Antonio Creek | | | | | North Fork Matilija Creek | | Matilija Creek | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Station Description | Main Street Bridge | Foster Park | Below Matilija Dam | @Santa Ana Rd. | Below Grazing | Above Grazing | u/s Ventura River Confluence | Lion Canyon u/s San Antonio | u/s Lion Canyon | Stewart Canyon u/s San Antonio | u/s Stewart Canyon Creek | u/s Ventura River Confluence | At gauging station | Below community | Above Community |
| Biological Metric | Station | 0 | 4 | 12 | 6 | 2 | 3 | 5 | 7 | 15 | 8 | 9 | 10 | 11 | 13 | 14 |
| Taxonomic richness | mean | 20.3 | 27.3 | 18.7 | | | | | | 29.3 | 26.3 | 26.7 | 29.0 | 33.3 | 21.0 | |
| | st. dev. | 2.1 | 3.5 | 2.1 | | | | | | 1.2 | 2.5 | 2.3 | 6.1 | 3.1 | 2.6 | |
| | cv | 10 | 13 | 11 | | | | | | 4 | 10 | 9 | 21 | 9 | 13 | |
| | 95% CI | 2.4 | 4.0 | 2.4 | | | | | | 1.3 | 2.8 | 2.6 | 6.9 | 3.5 | 3.0 | |
| % dominant taxa | mean | 33.7 | 16.2 | 32.2 | | | | | | 14.6 | 17.3 | 34.7 | 20.6 | 34.7 | 31.2 | |
| | st. dev. | 9.7 | 1.9 | 4.6 | | | | | | 1.4 | 0.8 | 19.4 | 2.0 | 12.8 | 3.1 | |
| | cv | 29 | 12 | 14 | | | | | | 10 | 4 | 56 | 10 | 37 | 10 | |
| | 95% CI | 11.0 | 2.1 | 5.2 | | | | | | 1.6 | 0.9 | 22.0 | 2.2 | 14.5 | 3.6 | |
| Cumulative Taxa | | 32 | 48 | 34 | | | | | | 56 | 48 | 49 | 55 | 57 | 36 | |
| EPT taxa | mean | 5.3 | 10.0 | 5.3 | | | | | | 9.0 | 8.7 | 9.0 | 9.0 | 12.0 | 7.0 | |
| | st. dev. | 0.6 | 2.6 | 1.2 | | | | | | 1.0 | 1.5 | 0.0 | 4.0 | 3.0 | 1.0 | |
| | cv | 11 | 26 | 22 | | | | | | 11 | 18 | 0.0 | 44 | 25 | 14 | |
| | 95% CI | 0.7 | 3.0 | 1.3 | | | | | | 1.1 | 1.7 | 0.0 | 4.5 | 3.4 | 1.1 | |
| EPT Index (%) | mean | 55.7 | 53.6 | 40.5 | | | | | | 34.0 | 41.1 | 65.0 | 32.5 | 40.3 | 19.7 | |
| | st. dev. | 15.6 | 14.8 | 13.9 | | | | | | 7.1 | 9.5 | 1.3 | 13.1 | 23.4 | 2.7 | |
| | cv | 28 | 28 | 34 | | | | | | 21 | 23 | 2 | 40 | 58 | 14 | |
| | 95% CI | 17.6 | 16.7 | 15.7 | | | | | | 8.0 | 10.7 | 1.5 | 14.8 | 26.5 | 3.1 | |
| Sensitive EPT Index (%) | mean | 0.0 | 6.5 | 0.7 | | | | | | 7.4 | 24.4 | 18.4 | 5.8 | 26.1 | 1.5 | |
| | st. dev. | 0.0 | 3.0 | 0.7 | | | | | | 6.1 | 8.9 | 13.8 | 1.0 | 21.9 | 1.8 | |
| | cv | . | 46 | 98 | | | | | | 83 | 37 | 75 | 18 | 84 | 116 | |
| | 95% CI | . | 3.4 | 0.7 | | | | | | 6.9 | 10.1 | 15.6 | 1.2 | 24.8 | 2.0 | |
| Cumulative EPT Taxa | mean | 6 | 14 | 8 | | | | | | 12 | 11 | 13 | 15 | 18 | 10 | |
| | st. dev. | | | | | | | | | | | | | | | |
| | cv | | | | | | | | | | | | | | | |
| Percent Chironomidae | mean | 23.1 | 16.9 | 8.3 | | | | | | 10.5 | 9.7 | 8.1 | 14.6 | 27.8 | 17.5 | |
| | st. dev. | 12.7 | 5.4 | 5.3 | | | | | | 2.3 | 6.1 | 8.5 | 6.2 | 19.7 | 6.5 | |
| | cv | 55 | 32 | 65 | | | | | | 22 | 63 | 105 | 43 | 71 | 37 | |
| | 95% CI | 14.4 | 6.1 | 6.0 | | | | | | 2.6 | 6.9 | 9.6 | 7.1 | 22.3 | 7.4 | |
| Predator Taxa | mean | 4 | 7 | 4 | | | | | | 9 | 7 | 7 | 8 | 9 | 5 | |
| | st. dev. | 2 | 2 | 1 | | | | | | 2 | 2 | 2 | 2 | 1 | 1 | |
| | cv | 35 | 29 | 25 | | | | | | 27 | 31 | 29 | 27 | 7 | 11 | |
| | 95% CI | 1.7 | 2.3 | 1.1 | | | | | | 2.6 | 2.6 | 2.3 | 2.4 | 0.7 | 0.7 | |
| Coleoptera Taxa | mean | 2 | 2 | 1 | | | | | | 4 | 1 | 3 | 2 | 4 | 1 | |
| | st. dev. | 0 | 1 | 0 | | | | | | 1 | 1 | 1 | 1 | 2 | 1 | |
| | cv | . | 50 | . | | | | | | 16 | 173 | 43 | 25 | 48 | 43 | |
| | 95% CI | . | 1 | . | | | | | | 0.7 | 1.3 | 1.3 | 0.7 | 2.4 | 0.7 | |
| Shannon Diversity | mean | 2.1 | 2.7 | 2.1 | | | | | | 2.9 | 2.6 | 2.2 | 2.7 | 2.5 | 2.1 | |
| | st. dev. | 0.2 | 0.0 | 0.2 | | | | | | 0.0 | 0.1 | 0.5 | 0.1 | 0.2 | 0.1 | |
| | cv | 10 | 1 | 10 | | | | | | 2 | 3 | 22 | 5 | 10 | 5 | |
| | 95% CI | 0.2 | 0.0 | 0.2 | | | | | | 0.1 | 0.1 | 0.6 | 0.1 | 0.3 | 0.1 | |
| Tolerance Value | mean | 5.1 | 5.0 | 5.1 | | | | | | 5.5 | 5.1 | 4.3 | 4.9 | 4.1 | 5.0 | |
| | st. dev. | 0.2 | 0.4 | 0.1 | | | | | | 0.1 | 0.2 | 0.3 | 0.2 | 0.8 | 0.1 | |
| | cv | 4 | 8 | 1 | | | | | | 2 | 4 | 7 | 3 | 20 | 2 | |
| | 95% CI | 0.2 | 0.4 | 0.1 | | | | | | 0.1 | 0.2 | 0.3 | 0.2 | 0.9 | 0.1 | |
| Percent Intolerance Value (0-2) | mean | 0.0 | 6.2 | 0.3 | | | | | | 3.3 | 23.2 | 18.3 | 5.3 | 26.1 | 1.7 | |
| | st. dev. | 0.0 | 2.7 | 0.0 | | | | | | 1.9 | 10.8 | 13.8 | 1.1 | 20.7 | 2.0 | |
| | cv | . | 44 | 6 | | | | | | 57 | 47 | 76 | 22 | 79 | 120 | |
| | 95% CI | . | 3.1 | 0.0 | | | | | | 2.2 | 12.3 | 15.6 | 1.3 | 23.4 | 2.2 | |
| Percent Tolerance Value (8-10) | mean | 3.3 | 11.8 | 6.3 | | | | | | 24.0 | 24.4 | 9.1 | 6.3 | 7.5 | 4.8 | |
| | st. dev. | 0.5 | 7.3 | 1.7 | | | | | | 4.1 | 8.1 | 8.5 | 4.0 | 3.0 | 3.0 | |
| | cv | 15 | 62 | 27 | | | | | | 17 | 33 | 93 | 64 | 40 | 62 | |
| | 95% CI | 0.6 | 8.2 | 1.9 | | | | | | 4.6 | 9.1 | 9.6 | 4.6 | 3.4 | 3.4 | |
| Percent Collectors | mean | 92.8 | 82.5 | 53.0 | | | | | | 70.8 | 82.6 | 58.6 | 90.2 | 92.9 | 80.8 | |
| | st. dev. | 2.4 | 2.9 | 13.5 | | | | | | 14.7 | 4.4 | 24.4 | 2.2 | 1.8 | 6.1 | |
| | cv | 2.6 | 3.6 | 25.5 | | | | | | 20.8 | 5.3 | 41.7 | 2.5 | 2.0 | 7.6 | |
| | 95% CI | 2.7 | 3.3 | 15.3 | | | | | | 16.7 | 4.9 | 27.6 | 2.5 | 2.1 | 6.9 | |
| Percent Filterers | mean | 24.2 | 16.3 | 29.1 | | | | | | 16.0 | 21.7 | 37.3 | 20.8 | 10.7 | 26.9 | |
| | st. dev. | 5.9 | 6.2 | 4.4 | | | | | | 3.3 | 14.4 | 20.1 | 7.3 | 3.5 | 2.7 | |
| | cv | 24.5 | 37.8 | 15.0 | | | | | | 20.8 | 66.7 | 53.8 | 35.2 | 32.2 | 9.9 | |
| | 95% CI | 6.7 | 7.0 | 4.9 | | | | | | 3.8 | 16.3 | 22.7 | 8.3 | 3.9 | 3.0 | |
| Percent Grazers | mean | 1.6 | 5.4 | 4.9 | | | | | | 3.9 | 27.3 | 18.6 | 9.6 | 31.8 | 1.2 | |
| | st. dev. | 0.5 | 4.8 | 2.1 | | | | | | 2.8 | 11.2 | 15.1 | 4.2 | 23.4 | 0.6 | |
| | cv | 31 | 89 | 44 | | | | | | 72 | 41 | 81 | 44 | 73 | 49 | |
| | 95% CI | 0.5 | 5.5 | 2.4 | | | | | | 3.2 | 12.7 | 17.0 | 4.8 | 26.4 | 0.6 | |
| Percent Predators | mean | 4.8 | 10.6 | 4.1 | | | | | | 13.7 | 18.6 | 9.6 | 5.5 | 7.1 | 4.2 | |
| | st. dev. | 3.2 | 2.4 | 1.4 | | | | | | 4.2 | 5.5 | 1.4 | 1.6 | 1.7 | 1.4 | |
| | cv | 67 | 23 | 35 | | | | | | 31 | 30 | 14 | 30 | 24 | 34 | |
| | 95% CI | 3.7 | 2.7 | 1.6 | | | | | | 4.8 | 6.3 | 1.6 | 1.9 | 2.0 | 1.6 | |
| Percent Shredders | mean | 0.2 | 0.0 | 0.0 | | | | | | 0.7 | 0.4 | 0.2 | 0.9 | 1.5 | 0.7 | |
| | st. dev. | 0.2 | 0.0 | 0.0 | | | | | | 0.7 | 0.8 | 0.2 | 0.5 | 0.6 | 0.7 | |
| | cv | 87 | . | . | | | | | | 106 | 173 | 87 | 51 | 39 | 103 | |
| | 95% CI | 0.2 | . | . | | | | | | 0.8 | 0.9 | 0.2 | 0.5 | 0.7 | 0.8 | |
| Percent Hydropsychidae | mean | 14.0 | 14.1 | 3.6 | | | | | | 11.2 | 12.6 | 34.7 | 12.9 | 6.6 | 4.4 | |
| | st. dev. | 6.2 | 6.2 | 4.2 | | | | | | 7.5 | 4.7 | 19.4 | 5.0 | 3.2 | 3.7 | |
| | cv | 44 | 44 | 116 | | | | | | 67 | 37 | 56 | 39 | 49 | 85 | |
| | 95% CI | 7.0 | 7.1 | 4.7 | | | | | | 8.5 | 5.3 | 22.0 | 5.7 | 3.6 | 4.2 | |
| Percent Baetidae | mean | 37.7 | 13.3 | 33.4 | | | | | | 12.5 | 0.2 | 2.9 | 7.1 | 4.1 | 12.9 | |
| | st. dev. | 9.5 | 5.2 | 10.6 | | | | | | 6.8 | 0.4 | 1.1 | 4.2 | 1.1 | 2.2 | |
| | cv | 25 | 39 | 32 | | | | | | 54 | 173 | 40 | 59 | 26 | 17 | |
| | 95% CI | 10.8 | 5.8 | 12.0 | | | | | | 7.6 | 0.4 | 1.3 | 4.7 | 1.2 | 2.5 | |
| Percent Non-Insect | mean | 5.5 | 14.0 | 8.2 | | | | | | 21.8 | 25.0 | 6.9 | 7.0 | 4.9 | 2.2 | |
| | st. dev. | 1.6 | 4.4 | 2.0 | | | | | | 5.2 | 7.4 | 1.4 | 4.9 | 2.3 | 1.8 | |
| | cv | 29.9 | 31.7 | 24.0 | | | | | | 24.0 | 29.8 | 20.0 | 70.4 | 47.6 | 80.5 | |
| | 95% CI | 1.8 | 5.0 | 2.2 | | | | | | 5.9 | 8.4 | 1.6 | 5.6 | 2.6 | 2.0 | |
| Estimated Abundance | mean | 1747 | 4610 | 1409 | | | | | | 4690 | 1571 | 3286 | 3680 | 3550 | 4632 | |
| | st. dev. | 774 | 1121 | 1016 | | | | | | 975 | 508 | 1434 | 488 | 2928 | 1294 | |
| | 95% CI | 876 | 1269 | 1150 | | | | | | 1104 | 575 | 1623 | 552 | 3313 | 1464 | |

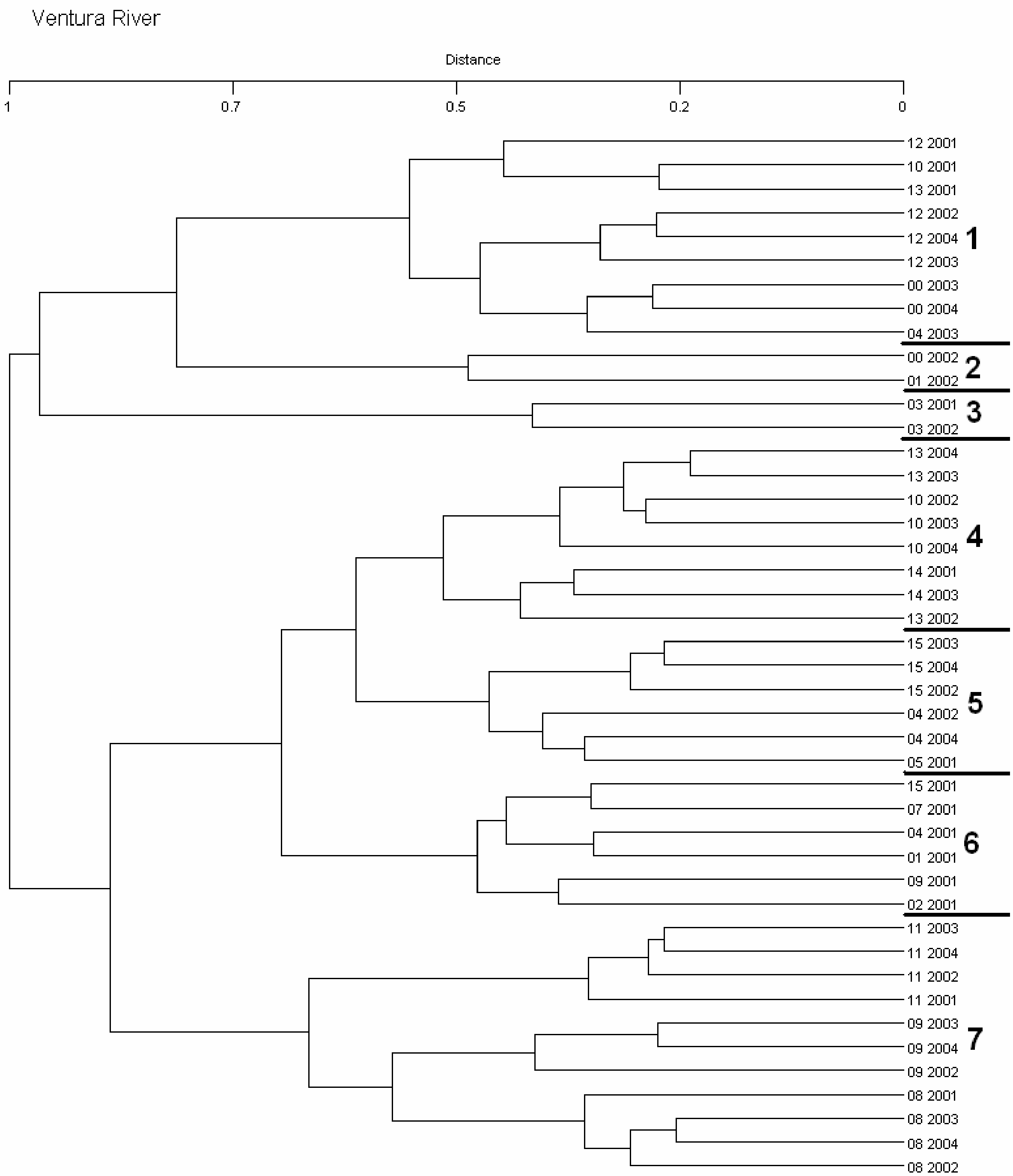


Figure A-1. Station dendogram for historic Ventura watershed BMI data (2001-2004) based on Bray-Curtis dissimilarity. Station groups are listed on right.

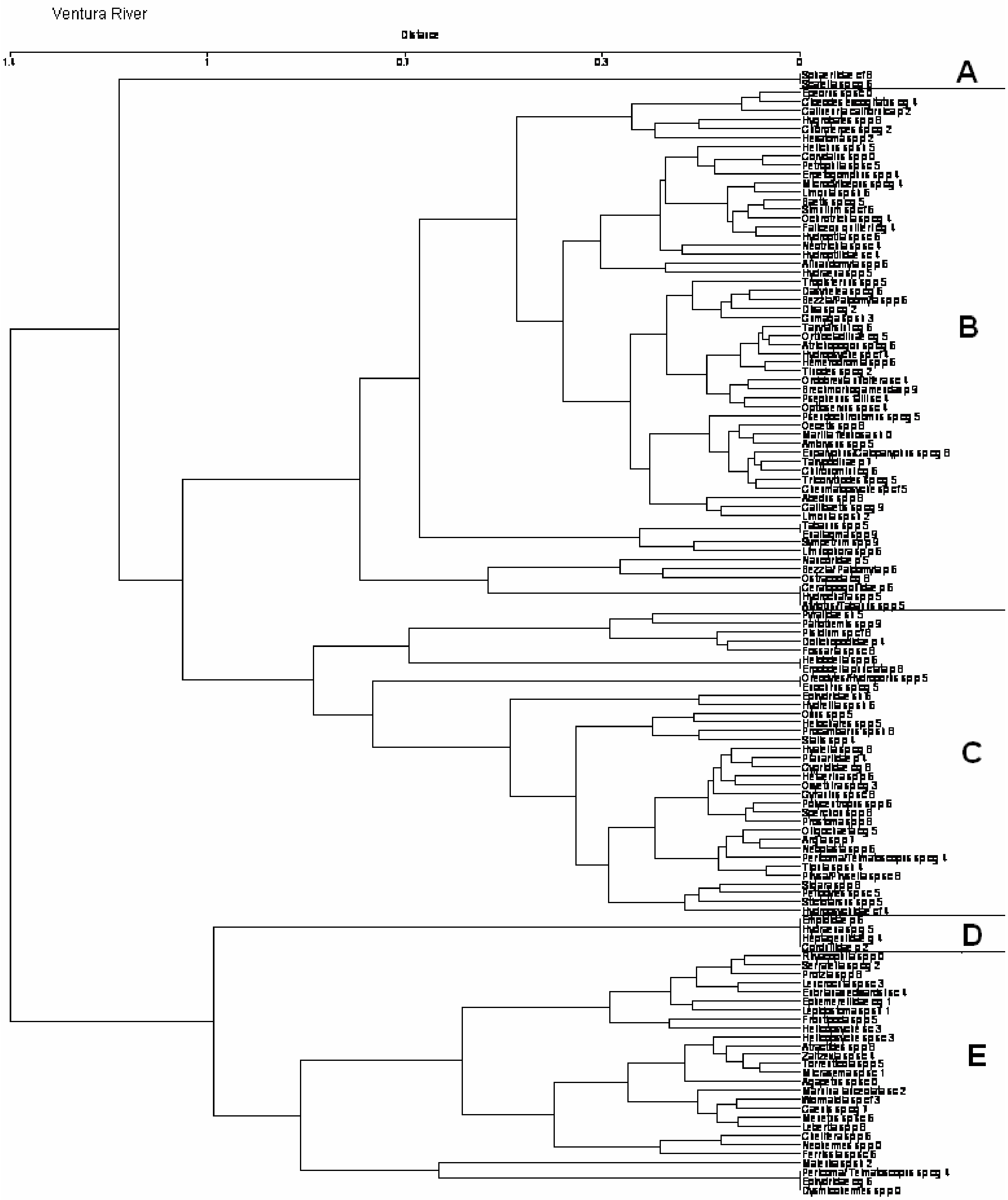


Figure A-2. Species dendogram for historic Ventura watershed BMI data (2001-2004) based on Bray-Curtis dissimilarity. Species groups listed on right.

# Appendix B – Multivariate Statistical Methods

Cluster Analysis

Cluster analysis defines groups of stations with similar community composition. The results are displayed in a hierarchical tree-like structure called a dendrogram. On the dendrogram, two groups are first defined, and within these groups subgroups are defined. Subsequently, subgroups within the subgroups are defined. This process is continued until all stations are a separate subgroup. The hierarchical nature of the dendrogram allows the analyst to choose groups of stations that represent a scale of community differences relevant to the present project.

Cluster analysis is also be used to define groups of species that tend to have similar distributional patterns among the stations.

Dissimilarity Index

Both the ordination and cluster analyses require the imput of a dissimilarity matrix, which quantifies the (biological community) dissimilarity between all pairs of stations. We used the Bray-Curtis dissimilarity index (Bray and Curtis 1957) with the stepacross procedure (Williamson 1978, Bradfield and Kenkel 1987). Before computation of the dissimilarity index, the species abundance data were transformed by a square root and standardized by a species mean of abundance values greater than zero. The square root transformation tends to dampen some of the noise often found positively skewed species abundance data. The Bray-Curtis index has been shown to perform well when used with a species standardization (Faith et al. 1987, Smith 1976). Smith (1976) demonstrates how the species mean standardization in particular should best emphasize species abundance counts that change commensurate to changes along community gradients.

All dissimilarity indices are incapable of properly measuring community change for highly dissimilar stations (Swan 1970, Beals 1973). This is because once two stations have no species in common, the dissimilarity index values cannot continue to increase in value as stations become more dissimilar in community composition. The non-monotonic pattern of species abundance values along community gradients also contributes to this lack of index sensitivity for relatively large amounts of community change. The stepacross procedure applied to the computed dissimilarity matrix corrects for this deficiency of the dissimilarity index. Here the larger dissimilarity values (>.8 on a scale of 0 to 1) are reestimated from the shorter dissimilarity values, resulting in larger dissimilarity values that are more commensurate with the degree of actual community changes.

Two-way Coincidence Table

A two-way coincidence table is the station-species abundance data matrix displayed as a table of symbols indicating the relative abundances of the species at the stations. The rows and columns of the table are arranged to correspond to the order of stations and species along the respective station and species dendrograms. Since similar entities (stations or species) will tend to be closer together along a dendrogram, the row and column orders will efficiently show the pattern of species over the stations and station groups.

Since the rows and columns of the two-way coincidence table are ordered according to the dendrograms, the two-way coincidence table is also used to help delimit the station and species groups defined by the cluster analyses. At each potential separation of subgroups defined by the dendrogram, the two way coincidence table is examined to see the corresponding group differences in terms of species presences and abundances. This allows the analyst to choose groups with a level of community differences consistent with the goals of the project.

Calculation of Symbols in the Two-Way Coincidence Table

The symbols are based on square-root transformed, species maximum standardized data values. For example, a raw data matrix:

| | species | | |
|---|---|---|---|
| station | A | B | C |
| 1 | 0 | 4 | 9 |
| 2 | 1 | 5 | 7 |
| 3 | 7 | 2 | 12 |
| 4 | 4 | 0 | 0 |

Data transformed by square root:

| | species | | |
|---|---|---|---|
| station | A | B | C |
| 1 | 0 | 2 | 3 |
| 2 | 1 | 2.2 | 2.6 |
| 3 | 2.6 | 1.4 | 3.5 |
| 4 | 2 | 0 | 0 |

species maximum 2.6 2.2 3.5

Data standardized by species maximum:

| station | species A | B | C |
|---|---|---|---|
| 1 | 0 | .91 | .86 |
| 2 | .38 | 1 | .74 |
| 3 | 1 | .64 | 1 |
| 4 | .77 | 0 | 0 |

Transformed and standardized data as symbols:

| station | species A | B | C |
|---|---|---|---|
| 1 | | * | * |
| 2 | - | * | + |
| 3 | * | + | * |
| 4 | * | | |

| | | |
|---|---|---|
| where 0 | = | blank |
| >0 - .25 | = | . |
| >.25 - .50 | = | - |
| >.50 - .75 | = | + |
| >.75 | = | * |

Thus, the symbols represent the (square-root transformed) abundance of the species relative to the (square-root transformed) maximum species abundance. The standardized values will range between 0 and 1. We need to put all species on a common scale so we can use a single set of symbols for all species.