Biological and Physical/Habitat Assessment of Selected Sites Within the Santa Rosa Watershed

Sustainable Land Stewardship Institute

INTRODUCTION

Urban streams and rivers throughout the world face a number of problems, primarily associated with modification of in-stream and riparian structure, inputs of contaminated water and increases in the size and frequency of floods due to the increase in impervious surfaces. There have been many studies and reports showing the deleterious effects of urbanization to macroinvertebrate and fish communities (Jones and Clark 1987; Lenat and Crawford 1994; Weaver and Garman 1994; Karr 1998). Preventing some of these problems and restoring urban streams to a healthier condition is being attempted throughout the world (Karr et al. 2000).

Direct measurements of ambient biological communities including plants, invertebrates, fish, and microbial life have been used for the past 150 years as indicators of sanitation, potable water supplies and the health of water for fisheries and recreation. In addition to these water quality implications, 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 condition (Davis and Simons 1995).

Biological assessments of water resources integrate the effects of water quality over time, 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, sedimentation and habitat destruction).

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 evolutionary, ecological and biogeographical information (Erman 1996).

While there are many potential methods for evaluating biotic condition from community data, most approaches in the United States use a combination of multimetric and multivariate techniques. In multimetric 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 Simons 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 (Harrington 1999).

In 1998, the City of Santa Rosa initiated a biological and physical/habitat assessment program as part of their Stormwater Monitoring Program. In 1998 and 1999, the assessments were based on a family level taxonomic effort recommended for citizen monitors. Since 2000, the assessments have been based on the state standard recommended by the California Department of Fish and Game and described in the California Stream Bioassessment Procedure (Harrington 1996). The data described in this report will include only those generated since 2000 when the program used a genera/species level of taxonomy. Six sampling stations were established on tributary streams within the Santa Rosa Creek Watershed. The goal of the program was to:

1) Provide base line information on the macroinvertebrate assemblages within the Santa Rosa watershed;
2) Evaluate the biological and physical/habitat condition at six sampling sites located on Matanzas, Colgan, Piner, Paulin, Brush and Peterson Creeks using the Russian River IBI.
3) Provide recommendations and strategies for continued monitoring.

MATERIALS AND METHODS

Sampling Site Descriptions{tc "Monitoring Reach Descriptions"}
{tc "Monitoring Reach Descriptions"}

Stream & site #	**Description/Directions**	**GIS info**	**Sampled**
Brush Creek	*Impacts upstream:* Within the urban boundary, the watershed upstream of the Brush Creek sampling reach consists of 2,012 acres of residential property, 761 acres of vacant land, 183 acres of open space, 83 acres of recreational land, 81 acres of commercial property, and 450 acres of roadways. The Brush Creek channel covers a total of 55 acres. The watershed covers a total of 3,625 acres within the urban boundary and 3,021 acres outside of the urban boundary. From HWY. 12 heading east from Santa Rosa, turn left immediately after Brush Creek Rd. onto Sonoma County Water Agency access road adjacent to the creek. The reach extends to the confluence of Austin Creek.	*Reach length: 3,910'* *Stream order: 3*	Sp 98 Sp 99 Sp 00 Sp 01 Sp 02
Colgan Creek	*Impacts upstream:* Within the urban boundary, the watershed upstream of the Colgan Creek sampling reach consists of 655 acres of residential property, 561 acres of vacant land, 30 acres of recreational land, 474 acres of commercial property, and 517 acres of roadways. The Colgan Creek channel covers a total of 23 acres. The watershed covers a total of 2,260 acres within the urban boundary and 2,729 acres outside of the urban boundary. Heading south on Stony Point road from Santa Rosa, turn left on Bellevue Avenue. Enter Colgan Creek from the Sonoma County Water Agency access road on the right, across from the high school. The reach extends to Stony Point Road.	*Reach length: 5,360'* *Stream order: 1*	Sp 98 Sp 99 Sp 00 Sp 01 Sp 02
Matanzas Creek	*Impacts upstream:* Within the urban boundary, the watershed upstream of the Matanzas Creek sampling reach consists of 1,854 acres of residential property, 207 acres of vacant land, 393 acres of recreational land, 141 acres of open space, 209 acres of commercial property, and 633 acres of roadways. The Matanzas Creek channel covers a total of 17 acres. The watershed contains a total of 3,454 acres within the urban boundary and 10,504 acres outside of the urban boundary. Take Hwy. 12 east from Santa Rosa and turn left onto Farmers Lane. Turn right on Hoen Ave. and pull off to the right to enter the creek. The reach extends from Farmers Lane to Hoen Frontage Road.	*Reach length: 1,557'* *Stream order: 2*	Sp 98 Sp 99 Sp 00 Sp 01 Sp 02

Paulin Creek	*Upstream impacts:* Within the urban boundary, the watershed upstream of the Paulin Creek sampling reach consists of 1,667 acres of residential property, 397 acres of vacant land, 66 acres of recreational land, 101 acres of open space, 621 acres of commercial property, and 483 acres of roadways. The Paulin Creek channel covers a total of 17 acres. The watershed covers a total of 3,352 acres within the urban boundary and 13 acres outside of the urban boundary. Heading north on Mendocino Avenue, turn left on Administration Drive. Paulin Creek is on the left. The reach extends from Mendocino Ave. to approximately Paulin Drive.	*Reach length: 954'* *Stream order: 1*	Sp 98 Sp 99 Sp 00 Sp 01 Sp 02
Piner Creek	*Upstream impacts:* Within the urban boundary, the watershed upstream of the Piner Creek sampling reach consists of 1,383 acres of residential property, 392 acres of vacant land, 225 acres of recreational land, 34 acres of open space, 459 acres of commercial property, and 546 acres of roadways. The Piner Creek channel covers a total of 59 acres. The watershed covers a total of 3,098 acres within the urban boundary and 950 acres outside of the urban boundary. Heading south on Marlow Rd. from Piner Rd., turn right onto the Sonoma County Water Agency access road immediately after Beth Ct.. The reach extends from Marlow Rd. to Valdez Dr.	*N38° 27' 40.3"* *W122° 45'05.3"* *Reach length: 1,515'* *Stream order: 2*	Sp 98 Sp 99 Sp 00 Sp 01 Sp 02
Peterson Creek	*Upstream impacts:* Within the urban boundary, the watershed upstream of the Peterson Creek sampling reach consists of 375 acres of residential property, 190 acres of vacant land, 29 acres of recreational land, 17 acres of commercial property, and 114 acres of roadways. The Peterson Creek channel covers a total of 4 acres. The watershed covers a total of 729 acres within the urban boundary and 638 acres outside of the urban boundary. Heading north on Fulton Rd., turn left into Youth Community Park across from Piner High School. The creek borders the north end of the park. The reach extends from Fulton Rd. west to the end of the park where the creek becomes grouted rip rap.	*Reach length: 1,300'* *Stream order: 1*	Sp 98 Sp 99 Sp 00 Sp 01 Sp 02

BMI Sampling

The technique used to describe the BMI community and the biotic condition of the six sampling sites was the California Stream Bioassessment Procedure (CSBP). The California Department of Fish and Game (Harrington 1996) developed the CSBP as standardized and cost-effective sampling, laboratory and quality assurance procedures for the State's bioassessment programs. 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 was conducted by the City of Santa Rosa staff in May of 2000, 2001 and 2002. Riffle length was measured for each of three riffles at each monitoring reach. Using a random number table, a transect was established perpendicular to stream flow along the upstream third of each riffle. Starting at 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 representing any habitat diversity along each transect were sampled and combined into a composite sample, representing a 6 ft^2 area for each transect and 18 ft^2 for the entire reach. Each composite sample was transferred into a 500 ml wide-mouth plastic jar containing approximately 200 ml of 95% ethanol. This technique was repeated for each of three riffles in each reach.

BMI Laboratory Analysis

The BMI samples collected in 2000 and 2001 were processed at the EcoAnalysists Laboratory in Moscow Idaho and the 2002 samples were processed by SLSI in Chico California. At both laboratories, each sample was rinsed through a No. 35 standard testing sieve (0.5 mm brass mesh) and transferred into a tray marked with twenty, 25 cm^2 grids. All sample material was removed from one randomly selected grid at a time and placed in a petri dish for inspection under a stereomicroscope. All invertebrates from the grid were separated from the surrounding detritus and transferred to vials containing 70% ethanol and 5% glycerol. This process was continued until 300 organisms were removed from each sample. The material left from the processed grids was transferred into a jar with 70% ethanol and labeled as "remnant" material. Any remaining unprocessed sample from the tray was transferred back to the original sample container with 70% ethanol and archived. BMIs were then identified to a standard taxonomic level using appropriate taxonomic keys (Brown 1972, Edmunds et al. 1976, Klemm 1985, Merritt and Cummins 1995, Pennak 1989, Stewart and Stark 1993, Surdick 1985, Thorp and Covich 1991, Usinger 1963, Wiederholm 1983, 1986, Wiggins 1996, Wold 1974).

Data Analysis

A taxonomic list of all aquatic macroinvertebrates identified from the samples was entered into a Microsoft Excel7 spreadsheet program. Excel7 is used to generate a stand alone taxonomic list, and to calculate and summarize the aquatic macroinvertebrate community based metric values. The biological metrics are listed in Table 2 and have been categorized into the following types:

Richness Measures - These metrics reflect the diversity of the aquatic assemblage where increasing diversity correlates with increasing health of the assemblage and suggests that niche space, habitat and food sources are adequate to support survival and propagation of a variety of species.

Table 2. Bioassessment metrics used to describe characteristics of the benthic macroinvertebrate (BMI) community in the Santa Rosa Watershed.

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
Abundance		
Estimated Abundance	Estimated number of BMIs in sample calculated by extrapolating from the proportion of organisms counted in the subsample	variable

Composition Measures - These metrics reflect the relative contribution of the population of individual taxa to the total fauna. Choice of a relevant taxon is based on knowledge of the individual taxa and their associated ecological patterns and environmental requirements such as those that are environmentally sensitive or a nuisance species.

Tolerance/intolerance Measures - These metrics reflect the relative sensitivity of the community to aquatic perturbations. The taxa used are usually pollution tolerant and intolerant, but are generally nonspecific to the type of stressors. The metric values usually increase as the effects of pollution in the form of organics and sedimentation increases.

Functional Feeding Groups - These metrics provide information on the balance of feeding strategies in the aquatic assemblage. The functional feeding group composition is a surrogate for complex processes of trophic interaction, production and food source availability. An imbalance of the functional feeding groups reflects unstable food dynamics and indicates a stressed condition.

Index of Biological Integrity (IBI)

The IBIs used to evaluate the six Santa Rosa monitoring sites was developed from data collected on Russian River tributary streams in 1995-1997 (Harrington 1999). The scoring values used for the Russian River IBI are listed in Table 3. Streams in excellent condition have a total score of 30 to 24, in good condition 23 to 18, in fair condition 17 to 12 and in poor condition 11 to 6.

Table 3. Scores for the six biological metrics used to develop the Russsin~~a~~ River IBI.

Biological Metrics	Russian River IBI Scores		
	5	3	1
Mean Taxonomic Richness	>36	35-26	<26
Mean Modified EPT Index	>54	53-17	<17
Mean Shannon Diversity	>3.0	2.9-2.3	<2.3
Mean Tolerance Value	<3.0	3.1-4.6	>4.6
Mean Percent Dominant Taxon	<14	15-39	>39

Total Score	30-24	23-18	17-12	11-6
Integrity Scale	Excellent	Good	Fair	Poor

Physical Habitat Quality

Physical habitat quality was assessed for the monitoring reaches using U.S. Environmental Protection Agency (EPA) Rapid Bioassessment Protocols (RBPs) (Barbour et al. 1999). Habitat quality assessments were recorded for each monitoring reach during each macroinvertebrate sampling events within riffle/ run habitats.

RESULTS

Excel Spreadsheets containing lists of BMI's identified from the samples collected in May 2000, 2001, and 2002, and the means and coefficients of variation (CV) for biological metrics calculated from BMI samples are on file at the City of Santa Rosa office. Forms containing chemical and physical/habitat characteristic scores and field notes are also on file at the City of Santa Rosa office.

BMI Community Structure

Analysis of the benthic macroinvertebrates inhabiting the Santa Rosa watersheds showed that all six sampling stations had uniformly low faunal diversity. Those organisms present in the streams tended to be tolerant forms, with near complete absence of more sensitive taxa. Two groups dominated the fauna, chironomid midge larvae (especially orthoclads and tanytarsids) and oligochaete worms (especially naidids and tubificids) accounting for up to 67% and 25% of the entire fauna in 2002 (Table 4). Simulid blackfly larvae were abundant at a few of the sites accounting for up to 22 % of the entire fauna. Baetid mayflies were abundant at only the Matanzas and Paulin Creek sites.

Table 4. Percent Chironomidae and Tubificida for the six sampling reaches in the Santa Rosa watershed, May 2002.

Site #	Bush	Colgan	Matanzas	Paulin	Peterson	Piner
% Chironomidae	77	44	51	52	50	47
% Tubificida	3	25	6	4	10	18

A total of 69, 58 and 48 macroinvertebrate taxa were identified from all 6 Santa Rosa sites in 2000, 2001 and 2002, respectively. There is a noted and consistent decrease in total taxa over the three years. Such low taxonomic diversity, especially in 2002, is apparent when compared with that in other small streams of coastal California, which often contain twice as many taxa.

Biotic Condition of the Six Urban Reaches for 2001 and 2002

Richness Measures: For the six reaches, mean taxonomic richness ranged from 13 to 24 taxa in 2000, 15 to 24 in 2001 and 14 to 17 in 2002 (Figure 1). One of the most obvious features of the Santa Rosa reaches was the low numbers of mayflies, stoneflies, and caddisflies (EPT), taxa which are normally abundant in high quality small streams. Likewise, sensitive forms were generally absent from the Santa Rosa reaches. Thus, EPT Taxa averaged only 0 to 5 in both 2000 and 2001 and 1 to 3 in 2002 at all six reaches (Figure 2). The only mayfly found in the monitoring reaches was the relatively tolerant *Baetis*. However, there was one sensitive mayfly taxa (Ephemerellidae) collected at Brush and Matanzas Creeks sites in 2001 and 2002 and two sensitive caddisfly taxa (Lepidostomatidae and Psychomyiidae) collected at Matanzas and Paulin Creek sites in 2002 . Significantly, no stoneflies, a group requiring cool, clean, flowing waters for survival, were collected at any sites during both years.

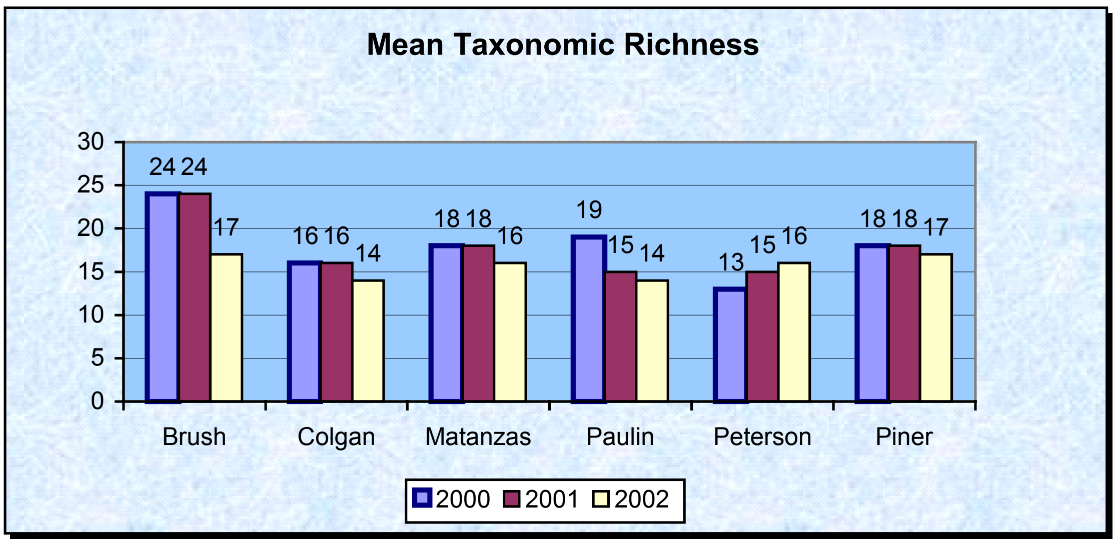

Figure 1. Mean Taxonomic Richness for benthic macroinvertebrates collected in May 2000, 2001 and 2002 in six tributary streams in the Santa Rosa Creek watershed, California.

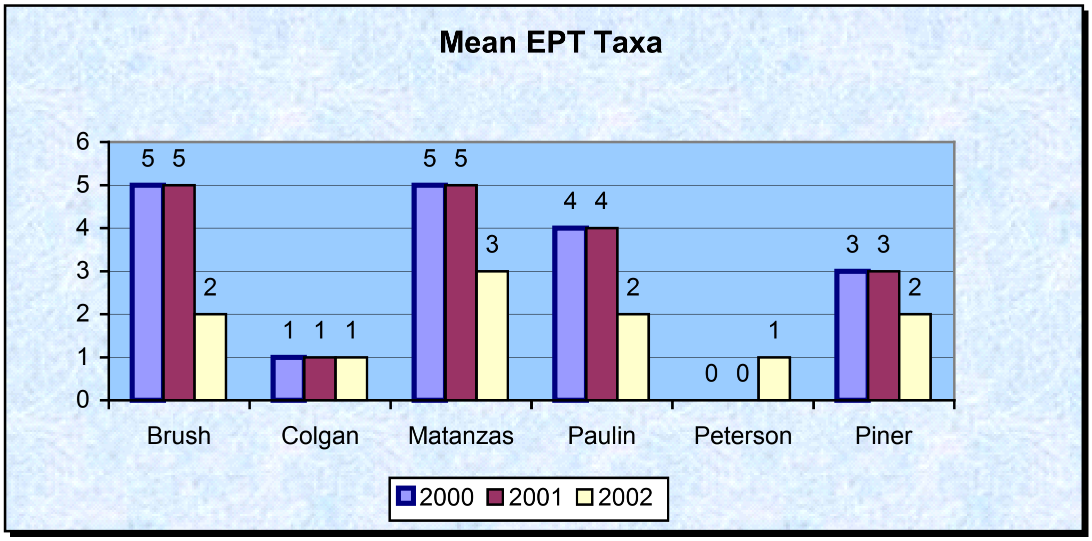

Figure 2. Mean EPT Taxa for benthic macroinvertebrates collected in May 2000, 2001 and 2002 in six tributary streams in the Santa Rosa Creek watershed, California.

Composition Measures: For the six reaches, mean EPT Index ranged from 0% to 16% in both 2000 and 2001 and 1% to 22% in 2002 (Figure 3). The Sensitive EPT Index and Percent Intolerant Organisms metric values for all six reaches in all three years were less than one (see list of metrics in spreadsheets). Shannon Diversity values were consistently low at all sites ranging from 1.6 to 2.2 in 2000, 1.7 to 2.2 in 2001 and 1.6 to 1.9 in 2002 (Figure 4).

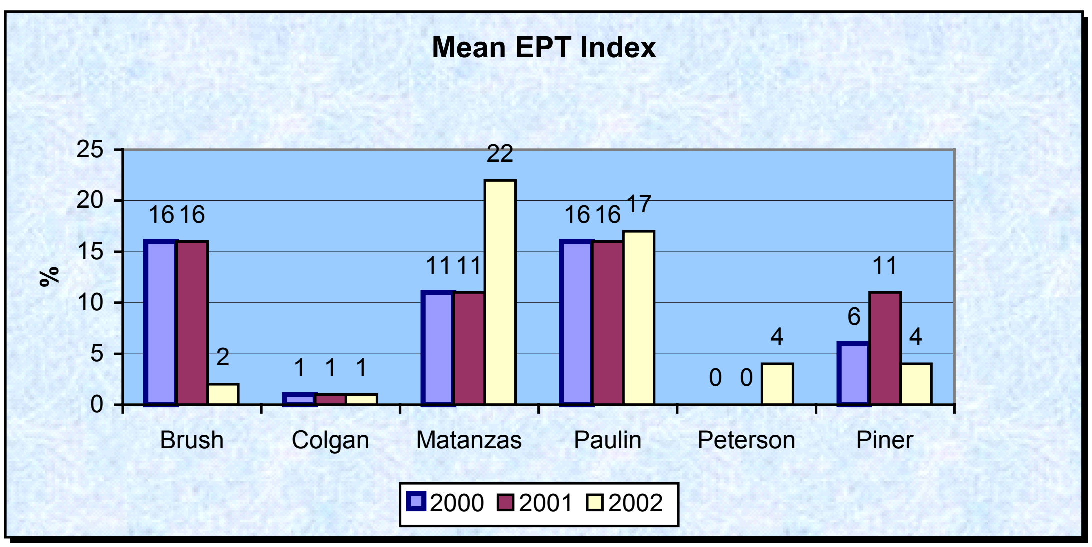

Figure 3. Mean EPT Index for benthic macroinvertebrates collected in May 2000, 2001 and 2002 in six tributary streams in the Santa Rosa Creek watershed, California.

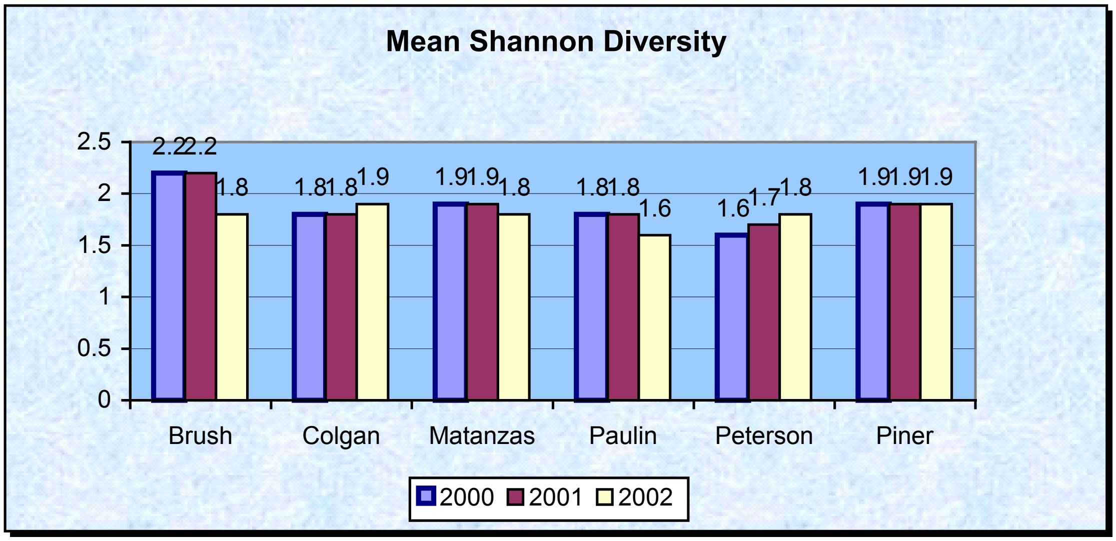

Figure 4. Mean Shannon Diversity for benthic macroinvertebrates collected in May 2000, 2001 and 2002 in six tributary streams in the Santa Rosa Creek watershed, Ca.

Tolerance Measures: For the six reaches, mean Tolerance Values ranged from 5.4 to 4.6 in 2000, 5.4 to 5.0 in 2001 and 5.7 to 6.7 in 2002 (Figure 5). Percent Dominant Taxon, for the six reaches ranged from 32% to 50% in 2000, 32% to 45 % in 2001 and 31% to 43% in 2002 (Figure 6). Both these biological metrics demonstrated that BMI diversity was low in the Santa Rosa reaches, and those taxa present were abundant, more tolerant forms such as the chironimids, simulids and oligochaetes, as previously mentioned.

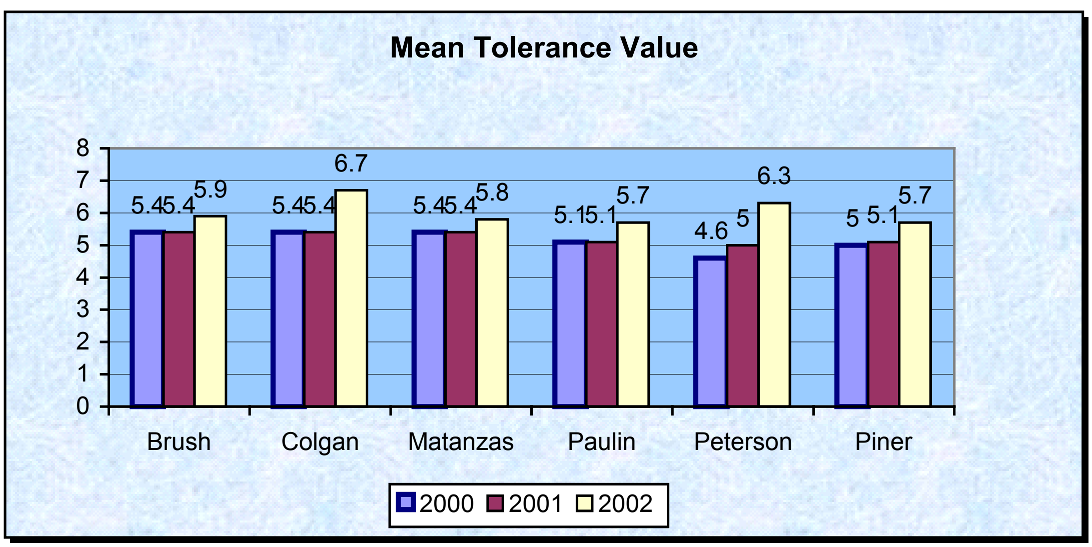

Figure 5. Mean Tolerance Value for benthic macroinvertebrates collected in May 2000, 2001 and 2002 in six tributary streams in the Santa Rosa Creek watershed, California.

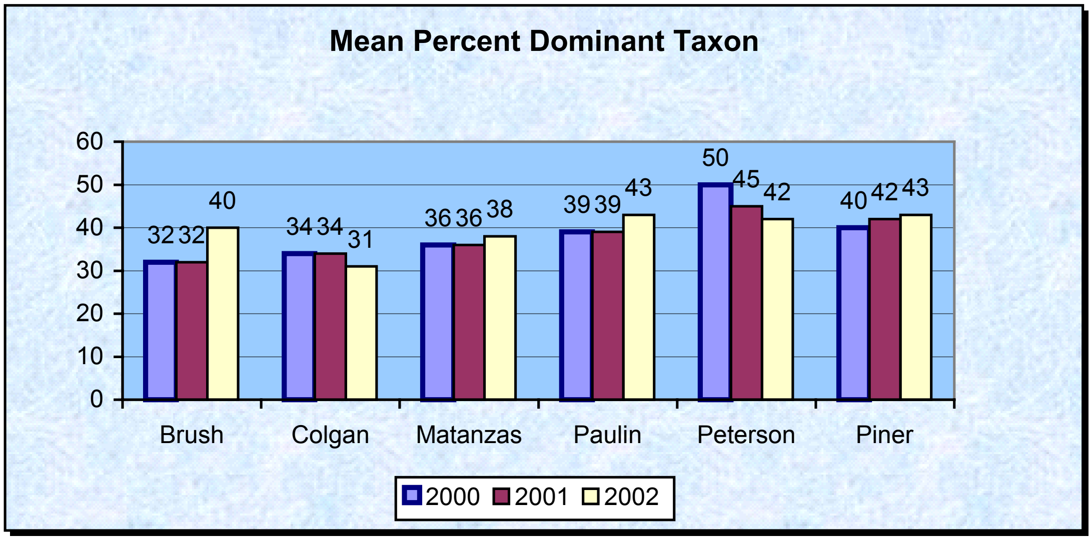

Figure 6. Mean Percent Dominant Taxon for benthic macroinvertebrates collected in May 2000, 2001 and 2002 in six tributary streams in the Santa Rosa Creek watershed, California.

Functional Feed Groups: Collectors and Filterers were the dominant functional feeding group averaging 36% to 75% and 11% to 57%, respectively in 2000, 49% to 73 % and 17% to 22%, respectively in 2001 and 23% to 54 % and 21% to 48%, respectively in 2002. In contrast to the Collectors and Filterers, the other four functional feeding groups were highly variable and usually a relatively small part of the fauna in the Santa Rosa reaches with Grazers, Predators, and Shredders averaging 0-12%, <1-30% and 0-4% in 2000, 7-12%, 7-9% and <1%, respectively in 2001 and 2-11%, 1-31% and <1%, respectively in 2002.

Macroinvertebrate abundance's averaged from 9,696 to 2,700 in 2000, 11,814 to 4,402 in 2001 and 11,630 to 790 in 2002 organisms per reach. The excessive range in the abundance values is typical for urban watershed dominated by tolerant organisms.

IBI Scoring

The IBI scores for the six Santa Rosa reaches using the Russian River IBI were no higher than 7 for all three years which makes them all rank as poor in biological condition.

Physical Habitat Quality

Physical/habitat quality scores are listed in Table 5 for 2000, Table 6 for 2001 and Table 7 for 2002. There was some inconsistency in scoring each site throughout the three years, but all sites are in the fair to good range with no poor or excellent rating at any site.

Table 5. Habitat scores determined during May 2000 biological monitoring event in six tributary streams in the Santa Rosa Creek watershed, California.

Habitat	Matanzas	Colgan	Piner	Paulin	Brush	Peterson
Epifaunal Cover	15	3	3	18	13	11
Embeddedness	19	2	5	12	6	7
Velocity/Depth	14	9	9	15	15	10
Sediment Deposition	18	3	13	16	6	15
Channel Flow	9	14	15	17	8	15
Channel Alteration	17	7	5	13	14	16
Riffle Frequency	6	2	15	9	18	11
Bank Stability – Left	8	8	9	8	3	6
Bank Stability – Right	7	6	9	2	8	8
Vegetative Protection - Left	9	4	6	8	8	7
Vegetative Protection - Right	9	4	6	2	9	8
Riparian Zone Width - Left	4	1	1	3	4	4
Riparian Zone Width - Right	5	1	1	2	3	9
Total Habitat Score	**140**	**64**	**97**	**125**	**115**	**127**
Physical Condition Rating	**Good**	**Fair**	**Fair**	**Good**	**Good**	**Good**

Table 6. Habitat scores determined during May 2001 biological monitoring event in six tributary streams in the Santa Rosa Creek watershed, California.

	Matanzas	Colgan	Piner	Paulin	Brush	Peterson
Epifaunal Cover	4	4	4	3	8	6
Embeddedness	12	6	8	12	12	7
Velocity/Depth	10	9	10	13	12	13
Sediment Deposition	13	0	10	8	8	8
Channel Flow	6	4	9	7	4	3
Channel Alteration	17	6	6	8	6	15
Riffle Frequency	5	1	7	7	6	2
Bank Stability – Left	7	10	7	7	9	8
Bank Stability – Right	6	10	7	8	9	9
Veg. Protection – Left	5	2	7	4	5	6
Veg. Protection – Right	5	2	7	2	5	5
Riparian Width – Left	7	4	3	1	5	5
Riparian Width – Right	7	4	3	1	5	10
Total Habitat Score	**104**	**62**	**88**	**81**	**94**	**97**
Physical Condition Rating	**Good**	**Fair**	**Fair**	**Fair**	**Fair**	**Fair**

Table 7. Habitat scores determined during May 2002 biological monitoring event in six tributary streams in the Santa Rosa Creek watershed, California.

Habitat	Matanzas	Colgan	Piner	Paulin	Brush	Peterson
Epifaunal Cover	13	4	13	8	9	9
Embeddedness	12	6	12	12	11	12
Velocity/Depth	15	12	13	13	7	13
Sediment Deposition	9	4	11	7	4	6
Channel Flow	10	8	16	13	6	8
Channel Alteration	9	6	9	5	4	12
Riffle Frequency	13	3	13	5	2	5
Bank Stability – Left	8	7	7	8	8	7
Bank Stability – Right	9	6	7	3	8	7
Vegetative Protection - Left	7	3	6	5	3	6
Vegetative Protection - Right	6	3	6	2	4	6
Riparian Zone Width - Left	5	3	3	2	4	4
Riparian Zone Width - Right	2	3	3	1	4	9
Total Habitat Score	**118**	**68**	**119**	**84**	**74**	**104**
Physical Condition Rating	**Good**	**Fair**	**Good**	**Fair**	**Fair**	**Good**

DISCUSSION

The structure of the invertebrate community, the individual biological metric values and the IBI scores all indicate that each of the six Santa Rosa monitoring reaches are impaired by land use practices throughout the watershed. Although the sampling design can not determine what is causing the impairment, the biological signals lead to water quality affected by sedimentation, organic enrichment (high level of nutrients such as nitrogen and phosphorous) and inadequate flow.

Most of the invertebrates collected at the monitoring reaches are able to tolerate sediment. Chironomids, Tubifica and even the Baetid mayfly have a preference for sedimented stream beds and have no need for complex habitat with high volume of interstitial areas. Aquatic organisms can respond as negatively to inorganic sediment as they do to other environmental contaminants (Newcombe and MacDonald 1991). Fish can sometimes avoid sediment discharge events by relocating, but deposition of fine sediment can fill pools used as habitat by fish and interstitial areas of riffle gravels used for spawning. Healthy communities of benthic macroinvertebrates that depend on a diverse substrate particle size, available interstitial spaces and a complex habitat can be significantly affected or eliminated by sediment deposition (Waters 1995). Benthic macroinvertebrates can be killed directly by suffocation or affected indirectly through loss of food sources and habitat (Johnson et al. 1993). Eventually, fish, amphibians and many terrestrial animals will be affected when macroinvertebrate abundance decreases. There is considerable evidence supporting aquatic invertebrates as a major food source of other aquatic organisms and terrestrial animals (Erman 1996; Waters 1995).

The strongest signals of organic enrichness in the six Santa Rosa sites were indicated by the high percentage of collector and filterers and the presence of tubificids. According to (Welch and Lindell (2000), tubificid worms dominate running water environments that are grossly polluted with organic waste. Tubificid worms can be abundant in aquatic environments with heavy loads of organic detritus because they can tolerate low levels of dissolved oxygen, reproduce throughout the year and even recycle their own feces (Welch and Lindell 2000). The sites on Colgan, Peterson and Piner Creeks had the most severe signals of organic enrichment.

Lack of adequate flows can cause a variety of poor water quality conditions for aquatic invertebrate communities including low dissolved oxygen, high water temperatures, lack of mobility for downstream drift of organisms and decrease in food supply. Although tolerant of sedimentation, baetid mayflies do require adequate flow to maintain their life history requirements. However, it is hard to say whether baetids were absent due to low flow conditions, poor water quality or lack of habitat.

All sites were scored poor using the Russian River IBI. The results of the IBI scoring were predictable given the composition of the invertebrate community. Although the Russian River IBI was developed as a demonstration project, it is derived from northern California streams which make it appropriate for evaluating the biological integrity of Santa Rosa streams. Physical/habitat scores were somewhat inconsistent, but all scores were in the fair to good range. These ranges of scores are quite acceptable for urban streams which make the lack of biological integrity problematic. On the other hand, it also suggests that improving water column chemistry could have a promising affects to the biotic community since the habitat seems to be available for colonization.

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