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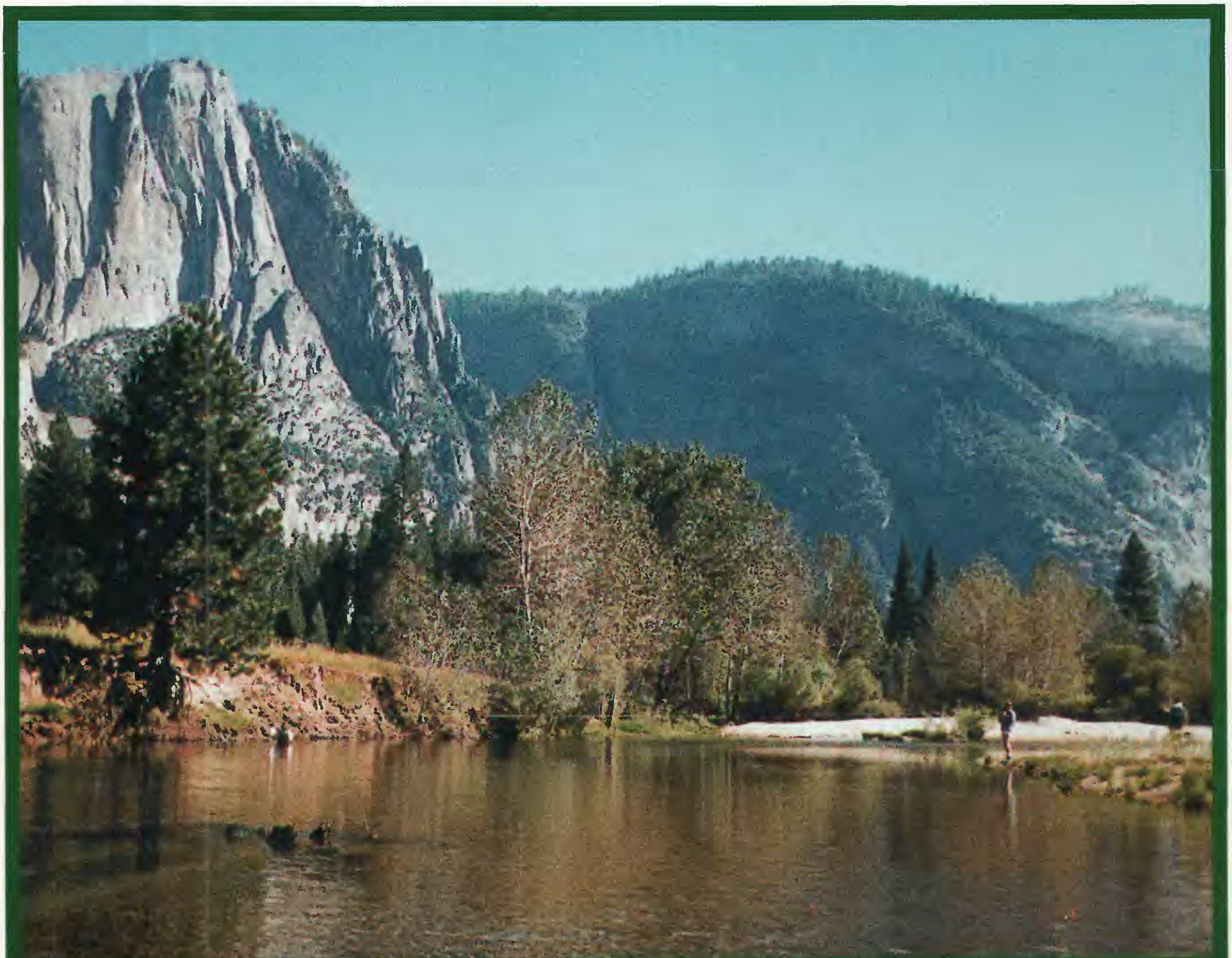
Biological, Habitat, and Water Quality Conditions in the Upper Merced River Drainage, Yosemite National Park, California, 1993–1996

Vater-Resources Investigations Report 99-4088



S. DEPARTMENT OF THE INTERIOR
S. GEOLOGICAL SURVEY

Biological, Habitat, and Water Quality Conditions in the Upper Merced River Drainage, Yosemite National Park, California, 1993–1996

By Larry R. Brown *and* Terry M. Short

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Water-Resources Investigations Report 99-4088

In cooperation with the National Park Service Water Resources Division and
Yosemite National Park

Sacramento, California
1999

U.S. DEPARTMENT OF THE INTERIOR
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FOREWORD

The mission of the U.S. Geological Survey (USGS) is to assess the quantity and quality of the earth resources of the Nation and to provide information that will assist resource managers and policymakers at Federal, State, and local levels in making sound decisions. Assessment of water-quality conditions and trends is an important part of this overall mission.

One of the greatest challenges faced by water-resources scientists is acquiring reliable information that will guide the use and protection of the Nation's water resources. That challenge is being addressed by Federal, State, interstate, and local water-resource agencies and by many academic institutions. These organizations are collecting water-quality data for a host of purposes that include: compliance with permits and water-supply standards; development of remediation plans for specific contamination problems; operational decisions on industrial, wastewater, or water-supply facilities; and research on factors that affect water quality. An additional need for water-quality information is to provide a basis on which regional- and national-level policy decisions can be based. Wise decisions must be based on sound information. As a society we need to know whether certain types of water-quality problems are isolated or ubiquitous, whether there are significant differences in conditions among regions, whether the conditions are changing over time, and why these conditions change from place to place and over time. The information can be used to help determine the efficacy of existing water-quality policies and to help analysts determine the need for and likely consequences of new policies.

To address these needs, the U.S. Congress appropriated funds in 1986 for the USGS to begin a pilot program in seven project areas to develop and refine the National Water-Quality Assessment (NAWQA) Program. In 1991, the USGS began full implementation of the program. The NAWQA Program builds upon an existing base of water-quality studies of the USGS, as well as those of other Federal, State, and local agencies. The objectives of the NAWQA Program are to:

- Describe current water-quality conditions for a large part of the Nation's freshwater streams, rivers, and aquifers.
- Describe how water quality is changing over time.
- Improve understanding of the primary natural and human factors that affect water-quality conditions.

This information will help support the development and evaluation of management, regulatory, and monitoring decisions by other Federal, State, and local agencies to protect, use, and enhance water resources.

The goals of the NAWQA Program are being achieved through ongoing and proposed investigations of 59 of the Nation's most important river basins and aquifer systems, which are referred to as study units. These study units are distributed throughout the Nation and cover a diversity of hydrogeologic settings. More than two-thirds of the Nation's freshwater use occurs within the 59 study units and more than two-thirds of the people served by public water-supply systems live within their boundaries.

National synthesis of data analysis, based on aggregation of comparable information obtained from the study units, is a major component of the program. This effort focuses on selected water-quality topics using nationally consistent information. Comparative studies will explain differences and similarities in observed water-quality conditions among study areas and will identify changes and trends and their causes. The first topics addressed by the national synthesis are pesticides, nutrients, volatile organic compounds, and aquatic biology. Discussions on these and other water-quality topics will be published in periodic summaries of the quality of the Nation's ground and surface water as the information becomes available.

This report is an element of the comprehensive body of information developed as part of the NAWQA Program. The program depends heavily on the advice, cooperation, and information from many Federal, State, interstate, Tribal, and local agencies and the public. The assistance and suggestions of all are greatly appreciated.

Robert M. Hirsch

Robert M. Hirsch
Chief Hydrologist

CONTENTS

FIGURES

TABLES

CONVERSION FACTORS, VERTICAL DATUM, WATER QUALITY UNITS, WATER YEAR, AND ABBREVIATIONS AND ACRONYMS

Conversion Factors

Multiply	By	To obtain
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)

Temperature is given in degrees Celsius (°C), which can be converted to degrees Fahrenheit (°F) by the following equation:

$$°F=1.8(°C)+32.$$

Vertical Datum

Sea level: In this paper, "sea level" refers to the National Geodetic Vertical Datum of 1929—a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

Water Quality Units

Concentrations of constituents in water samples are given in either milligrams per liter (mg/L) or micrograms per liter (µg/L). Milligrams per liter is equivalent to "parts per million" and micrograms per liter is equivalent to "parts per billion."

Abbreviations and Acronyms

(Additional information noted in parenthesis)

cm, centimeter
cm^2, square centimeter
ft^3/s, cubic feet per second
g/kg, gram per kilogram
g/m^2, gram per square meter
km^2, square kilometer
m, meter
m^2, square meter
m^3, cubic meter
m^3/s, cubic meter per second
$MJ/m^2/d$, megajoules per square meter per day
µg/kg, microgram per kilogram
µg/L, microgram per liter
µm, micrometer
µS/cm, microsiemens per centimeter at 25 degrees Celsius
mg $CaCO_3/L$, milligram of calcium carbonate per liter
mg/L, milligram per liter
mg/m^2, milligram per square meter
mL, milliliter
mm, millimeter
m/s, meter per second
organisms/m^2, organisms per square meter

AFDM, ash-free-dry mass
ANOVA, analysis of variance

BQAU, Biological Quality Assurance Unit
CCA, canonical correlation analysis
DTH, depositional targeted habitat
MDL, method detection limit
NASQAN, National Stream Quality Assessment Network
NAWQA, National Water-Quality Assessment (Program)
NWQL, National Water Quality Laboratory
PC, principal component
PCA, principal component analysis
QMH, qualitative multiple habitat
RATIO, optical density ratios
RTH, richest targeted habitat
USGS, U.S. Geological Survey

Biological, Habitat, and Water Quality Conditions in the Upper Merced River Drainage, Yosemite National Park, California, 1993–1996

By Larry R. Brown *and* Terry M. Short

Abstract

Four studies were done in the upper Merced River drainage in Yosemite National Park and nearby areas from 1993 to 1996. First, monitoring studies of benthic algae, benthic invertebrates, fish, and habitat were undertaken at sites near Happy Isles and Pohono bridges from 1993 to 1995 as part of the National Water-Quality Assessment Program of the U.S. Geological Survey. Second, an ecological survey of benthic algae, benthic invertebrates, fish, and habitat was done in the upper Merced River drainage in 1994. Third, a special study of benthic algae, habitat, and water quality was done in the reach of the Merced River within Yosemite Valley to determine whether human activities were having measurable effects on the ecosystem. Fourth, baseline data on benthic algae, benthic invertebrates, and habitat were collected in 1996 at four sites, two of which were undergoing extensive streambank restoration activities. Comparisons of the baseline data with future collections could be used to assess the effects of streambank restoration on aquatic biota.

The general conclusion from these studies is that water quality in the upper Merced River was very good from 1993–1996, despite high levels of human activities in some areas. Fish communities did not appear to be a useful indicator of habitat and water quality because of low species richness and the apparent importance of physical barriers in determining species distributions. Measurements of fish densities and size-distributions might be useful, but would be logistically difficult. Benthic algae and benthic invertebrates do appear to be useful in monitoring environmental conditions. Benthic algae may be more sensitive than benthic invertebrates to small environmental differences within years. Benthic algae were also more responsive than benthic invertebrates to differences in discharge between years. Thus, benthic invertebrates may be more useful in comparing environmental conditions between years, independent of discharge conditions.

INTRODUCTION

The National Water-Quality Assessment (NAWQA) Program of the U.S. Geological Survey (USGS) includes bioassessments as part of a multidisciplinary approach to the assessment of the current conditions and long-term trends in water quality of the nations surface- and ground-water resources (Gilliom and others, 1995). The San Joaquin–Tulare Basins study area, which includes Yosemite National Park (hereinafter referred to simply as "the Park"), and the Merced River, was one of the first 20 study areas included in the full implementation of the NAWQA Program. Because the focus of the surface water part of the NAWQA Program in the study area was on the effects of agricultural activities on water quality, most sampling effort occurred on the floor of the San Joaquin Valley. However, the National Hydrologic Benchmark site on the Merced River at the Happy Isles Bridge at the head of Yosemite Valley (fig. 1), hereinafter referred to simply as "Happy Isles" (site

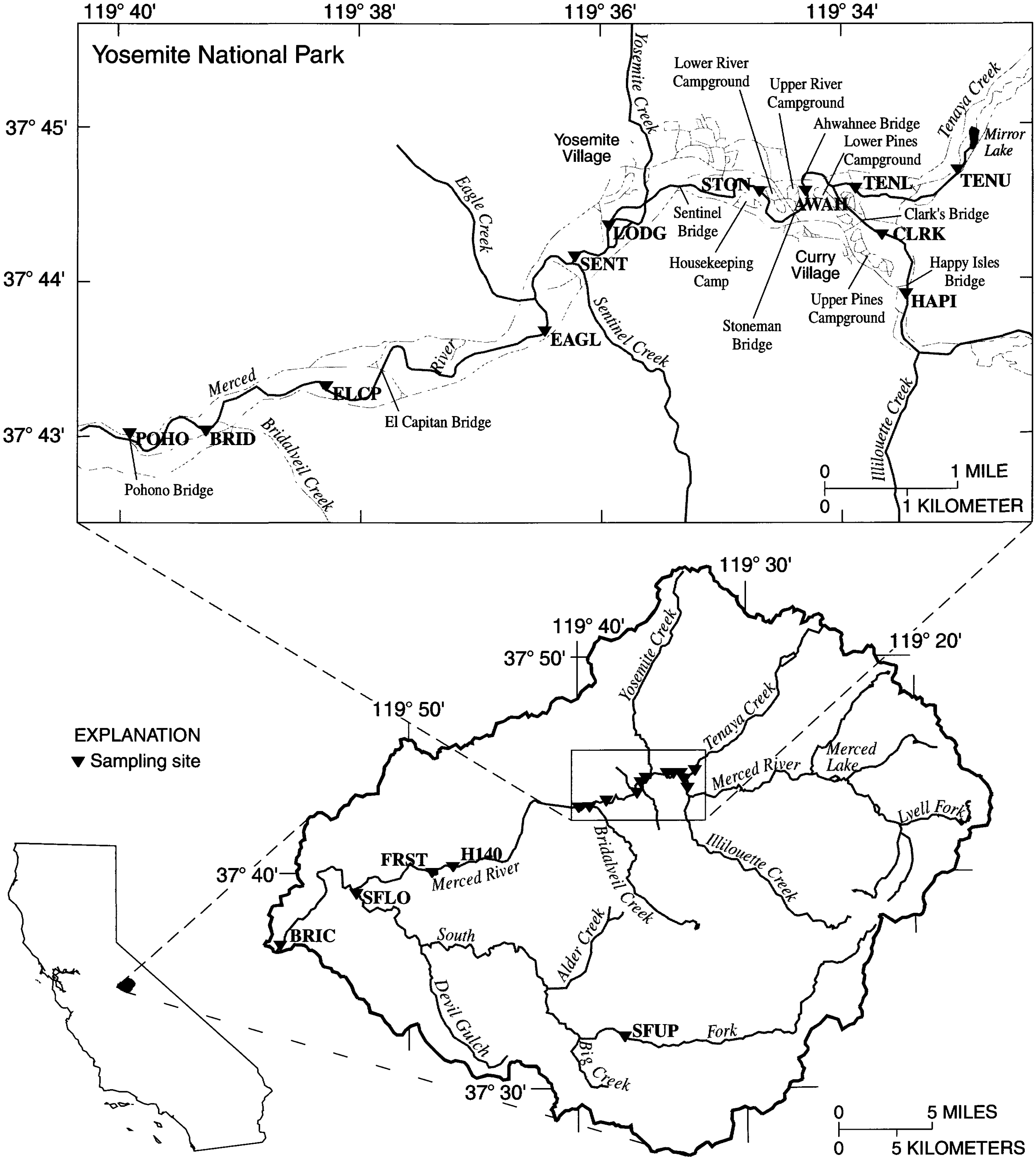

Figure 1. Site locations in the upper Merced River drainage and Yosemite National Park, California. Refer to table 1 for the full site names associated with the site codes.

code used in table 1 is HAPI), was chosen as a multiple year-sampling site for the long-term assessment of natural variability of aquatic communities (algae, invertebrates, and fish) and aquatic habitat in the study area.

As the result of a Memorandum of Understanding between the USGS and the National Park Service, funds became available for the development of cooperative projects in the Park in 1995 and 1996. The goal of the cooperative projects was to provide data to build a long-term baseline data set for the Happy Isles site and to support the goals of Merced River restoration work in the Park.

Purpose and Scope

This report summarizes results of the following studies that were conducted in the Park from 1993 to 1996. First, NAWQA sampling at Happy Isles and at the Merced River at Pohono Bridge, hereinafter referred to simply as "Pohono" (site code used in table 1 is POHO), was undertaken to monitor long-term trends in the fish community, benthic invertebrate community, benthic algae community, and stream habitat. Second, a survey of algae, invertebrates, fish, habitat, and water quality of the upper Merced River drainage (above McClure Reservoir) was done in 1994. Third, a special study of benthic algae, habitat, and water quality of the Merced River within Yosemite Valley in 1995 was carried out to determine whether there were any effects of human activities on the ecosystem. Fourth, a special study of algae, invertebrates, and habitat was done in 1996 in Yosemite Valley to provide baseline data for assessment of the effects of stream bank improvements on aquatic biota.

Study Area

The upper Merced River drainage is the least modified of the major river drainages, including the upper San Joaquin River, that are confluent with the mainstem San Joaquin River on the valley floor. All of these rivers have major storage reservoirs near the transition from the Sierra Nevada foothills to the valleyfloor, but only the upper Merced River drainage has not been extensively developed for hydroelectric or water supply purposes.

The upper Merced River, above the lowermost site sampled in this study, drains 1,814 km^2, of which 96 percent is in the Sierra Nevada ecoregion and 4 percent is in the Foothills ecoregion (Omernik, 1987). The drainage area is primarily forest with less than 0.2 percent of the basin devoted to agricultural and urban land uses (U.S. Geological Survey, 1986). There is a major change in elevation between Pohono bridge and El Portal, where the Merced River runs through a steep-sided, high gradient gorge.

Despite the small amount of developed land in the basin, most of the development has occurred within Yosemite Valley of the Park, one of the most well known and most frequently visited national parks in the United States. Most visitor use affecting the Merced River occurs in the upstream section of Yosemite Valley, primarily between Clarks Bridge and Sentinel Bridge (Madej and others, 1994). Visitor use in this reach is associated with six major campgrounds and six bridges. Visitor use in other areas is locally heavy but associated with a limited number of day-use areas. Despite the natural appearance of undeveloped areas in Yosemite Valley, historical land uses within Yosemite Valley have varied since the arrival of Euroamericans in 1851 (Madej and others, 1994). Human activities have included grazing, row crops, planted pastures, haymaking, construction of corrals, roads, campgrounds, garbage dumps, sewage treatment plants, slaughterhouse, powerhouse, barrow pits, drainage tiles, buildings, water development, utility lines and pipes, removal of trees and smaller vegetation, and fire suppression. From 1877 to 1977, more than 15,000 m^3 of sand and gravel were removed from the Merced River (Milestone, 1978). In 1879, a moraine across the Merced River between Pohono and El Capitan bridges was blasted to drain the floodplain of the lower valley, resulting in localized downstream downcutting (lowering) of the streambed of up to 1.2 m (Milestone, 1978).

Bank erosion has been perceived as a major problem in the Park since the turn of the century. Significant bank erosion and channel widening has been documented in the most heavily used reach of the river and has been attributed primarily to destruction of riparian vegetation by human trampling and effects of bridge constriction on high flow, and secondarily to poorly installed channel revetments (Madej and others, 1994). Present day efforts in the Park are focused on restoring natural fluvial processes by removing channel revetments, relocating campgrounds and other development, bridge modifications, permitting natural recruitment of large woody debris to the

Table 1. Site name, site code, year(s) sampled, and activities conducted at each site

[Sites are listed from most upstream to most downstream. Elevation is in meters above sea level. m, meters. x, indicates site activity; —, not sampled]

Site Name	Site Code	Year Sampled	Elevation (m)	Ecological Survey				Water Quality		
				Algae	Invertebrates	Fish	Habitat	Basic	Major Ions	Nutrients
Merced River at Happy Isles Bridge	HAPI	1993	1,225	x	x	x	x	x	—	—
		1994		x	x	x	x	x	—	x
		1995		x	x	x	x	x	x	x
		1996		x	x	—	x	x	—	—
Merced River near Clarks Bridge	CLRK	1995		x	—	—	x	x	x	x
		1996		x	x	—	x	x	—	—
Merced River below Awahnee Bridge	AWAH	1996	1,204	x	x	—	x	x	—	—
Merced River below Stoneman Bridge	STON	1996	1,204	x	x	—	x	x	—	—
Merced River near Yosemite Lodge	LODG	1995		x	—	—	x	x	x	x
		1996		x	x	—	x	x	—	—
Merced River above Sentinel Creek	SENT	1995		x	—	—	x	x	x	x
Merced River below Eagle Creek	EAGL	1995		x	—	—	x	x	x	x
Merced River below El Capitan Bridge	ELCP	1995		x	—	—	x	x	x	x
Merced River at Bridalveil Morraine	BRID	1995		x	—	—	x	x	x	x
Merced River at Pohono Bridge[1]	POHO	1994	1,177	x	x	x	x	x	—	x
		1995		x	x	x	x	x	x	x
		1996		x	x	—	x	x	—	—
Merced River at Highway 140 bridge	H140	1994	556	x	x	x	x	x	—	x
Merced River near Foresta Road bridge	FRST	1994	511	x	x	x	x	x	—	x
Merced River near Briceburg	BRIC	1994	343	x	x	x	x	x	—	x
Tenaya Creek below Mirror Lake	TENU	1994	1,225	x	x	x	x	x	—	x
Tenaya Creek near Group Camp	TENL	1994	1,213	x	x	x	x	x	—	x
South Fork Merced River near Wawona	SFUP	1994	1,268	x	x	x	x	x	—	x
South Fork Merced River near mouth	SFLO	1994	434	x	x	x	x	x	—	x

[1] In 1995, this site was also sampled for trace elements, suspended sediment, and organic contaminants in tissue and sediment.

river, and restoring riparian vegetation through planting and redirection of recreational activities.

Design of Component Studies

The design of each of the four component studies is discussed separately. Site locations and activities conducted at each site are given in figure 1 and table 1, respectively. The specific methods used in each study are discussed in the Methods sections of this report.

Monitoring Sites

Happy Isles site was sampled every year from 1993 to 1995 as a long-term trend ecology site for the San Joaquin–Tulare Basins study unit of the NAWQA Program. Sampling consisted of a comprehensive assessment of physical habitat, algae, invertebrate, and fish communities. In addition, Pohono was sampled with full ecological protocols in 1995 (table 1). Concentrations of organic contaminants were measured in bed sediment and tissues of Sacramento sucker (*Catostomus occidentalis*) at Pohono in 1995. Nutrients, major ions, trace elements, and suspended sediment in water were monitored monthly at Pohono from April through September 1995. Comparative water quality data for Happy Isles were obtained from the USGS National Stream Quality Accounting Network Program. Field parameters, including discharge, water temperature, specific conductance, pH, dissolved oxygen, and alkalinity, were measured at each site during each sampling visit.

Ecological Survey

As part of a 1994 ecological survey to characterize the range of ecological conditions in the San Joaquin River drainage, nine stations in the upper Merced River Basin were sampled (table 1). Of these stations, four were not actually in the Park, but the data are included to provide a better characterization of conditions in the Park in comparison to nearby, downstream areas. Three of the four stations were on the Merced River, with one at the Highway 140 bridge, hereinafter referred to simply as "Highway 140" (site code used in table 1 is H140), located immediately above the Yosemite National Park wastewater treatment plant; and the other two at Foresta Road Bridge and just upstream of Briceburg, hereinafter referred to simply as "Foresta" and "Briceburg" (site codes used in table 1 are FRST and BRIC, respectively), located below the plant (fig. 1), to assess impacts of the plant on water quality. The other site was located on the South Fork Merced River, just above the confluence with the Merced River, hereinafter referred to simply as "lower South Fork" (site code used in table 1 is SFLO).

Physical habitat and fish community structure were assessed at these sites. In addition, qualitative multiple habitat (QMH) assessments of algae and invertebrates and a richest targeted habitat (RTH) assessment of invertebrates were done at each site. Water samples were collected concurrently for nutrient analyses. Fish were sampled in August 1994 when only discharge and basic water-quality measurements were taken. Invertebrate, algae, habitat, and nutrient sampling were done during September 1994.

Algae Study

In 1995, an algae study was done to determine if there were differences in standing crop or species composition of benthic algae among eight locations on the Merced River in Yosemite Valley, which could be associated with differences in water quality or habitat quality (table 1). Site locations and reach boundaries were chosen to correspond to reaches sampled for invertebrates by Jim Carter and Steven Fend (U.S. Geological Survey, oral commun., 1995).

Algae standing crop was assessed as chlorophyll-*a* content and ash-free-dry mass (AFDM). Determinations of pheophytin-*a* (a degradation product of chlorophyll-*a*) measurements also were made at each site. Five replicate samples were taken at each site, each a composite of a number of individual samples (see Methods section). A measured aliquot was removed from each sample for assessment of chlorophyll-*a* and AFDM.

The optical density ratios (RATIO) of chlorophyll-*a* and pheophytin-*a* were determined, which provided an estimate of the physiological health of the periphytic algae. Ratios generally range from 1.0 to 1.7, with higher values indicative of improved physiological condition.

For community analyses, standard RTH algae samples were collected from natural substrates at each site, with five replicate samples (assigned numbers 1 through 5) taken at Happy Isles, Pohono, and a site near Yosemite Lodge, hereinafter referred to simply as "Lodge" (site code used in table 1 is LODG). Water samples were collected for analyses of nutrients and major ions at each site. Field parameters also were measured. Measurements of physical habitat were modified to account for the short reach lengths used, and included more detailed assessments of flow conditions near the streambed.

Algae and Invertebrate Baseline Study

In 1996, algae and invertebrate community studies were done at Happy Isles and Pohono to provide an additional year of trend data. In addition, invertebrate and algae communities were surveyed at the Merced River near Clarks Bridge, hereinafter referred to simply as "Clarks" (site code used in table 1 is CLRK), and Lodge to augment biological information collected as part of the 1995 algae study. Physical habitat, algae, and invertebrates were assessed at the Merced River below Awahnee Bridge and at the Merced River below Stoneman Bridge sites, hereinafter referred to as "Awahnee" and "Stoneman" (site codes used in table 1 are AWAH and STON, respectively), to provide a measure of baseline biological conditions with which to evaluate habitat restoration activities at those locations (table 1). Sampling reach lengths were increased at Clarks and Lodge to include more habitat types and to more closely correspond to a standard NAWQA sampling reach (minimum recommended length of 150 m). QMH and RTH samples of algae and invertebrates were collected at all sites. A full NAWQA habitat protocol was also done at each site.

COLLECTION METHODS

In general, samples were collected according to standard NAWQA protocols for algae (Porter and others, 1993), invertebrates (Cuffney and others, 1993), fish (Meador and others, 1993a), and habitat (Meador and others 1993b). Deviations from standard protocols are described in the following section.

Full ecological protocols include multiple approaches for the assessment of algae and invertebrate communities. The RTH sample is taken from the habitat expected to support the highest species diversity. Riffle habitats were selected for RTH samples at all sites. The depositional targeted habitat (DTH) sample is taken from the habitat where water velocities are reduced and the substrate consists of fine-grained sediment. The depositional habitat was stream-edge backwaters in all cases. The QMH algae and invertebrate collections are based on sampling effort in all available habitat types. The sample is intended to provide a complete species list for all habitat types in the reach.

Algae RTH samples were collected with a standard (samples collected in 1993) or modified (all other samples) SG-92 sampler. The sampler consists of the barrel of a plastic syringe (20 mL and 30 mL, respectively) fitted with a rubber gasket. A rock is selected for sampling and gently removed from the stream. The sampler is then pressed against the upward-facing surface (referring to its original orientation on the streambed) of the rock, a small volume of water added, and the enclosed area brushed thoroughly. The detached algae is removed with a pipette. A single sample consists of a composite of five SG-92 collections from each of five locations within the sampling reach. The single composited RTH sample comprises a surface area of about 95 cm^2. Algae DTH samples were collected by pressing a 47-mm-diameter petri dish (open end down) gently into the sediment of a depositional area, then sliding a broad-bladed spatula under the dish. The trapped sediment was then removed from the stream and washed with deionized water into a container. A sample consisted of one petri dish collection from each of five locations within the sampling reach. A single composited DTH sample comprises a surface area of about 85 cm^2. Algae QMH samples were collected in a variety of habitat types using a variety of methods. During the 1995 algae study, the modified SG-92 sampler (30 mL-syringe barrel) was used to collect algae from large gravel and cobble-sized stones. For smaller-sized substrate, a 47-mm-diameter petri dish was used as a template to collect mineral particles (usually small gravel) that were then scrubbed with a toothbrush. These collections (either 25 SG-92 or 5 petri dish samples) were composited into a single container that constituted the sample.

Invertebrate RTH samples were collected with a rectangular kick net (0.5-m wide by 0.25-m high) with 425 μm mesh. The net frame was firmly placed against the substrate, and then all large rocks within a 0.5- by 0.5-m square (0.25 m^2) in front of the net were gently brushed to dislodge attached organisms. After all the large rocks were brushed and removed, the smaller substrates were disturbed to a depth of 10 cm by using a metal rod or by kicking for 30 seconds. A sample consisted of a composite of collections from each of five locations within the sampling reach. A RTH sample composited invertebrates from about 1.25 m^2. Invertebrate DTH samples were collected with a 7.6-cm-diameter coring tube. The tube was inserted approximately 10 cm into the substrate of a depositional area, and then the bottom opening was sealed by sliding a large trowel under the coring tube. The trapped sediments were then placed in a bucket, and the sample was sieved through a 425 μm mesh sieve. A sample consisted of a composite of two cores from each of five locations within the sampling reach. The surface area sampled was approximately 120 cm^2. The invertebrate QMH sample was collected with a D-frame kick net with 210-μm mesh. All habitat types were sampled using a variety of methods to dislodge organisms, including brushing, kicking, scraping, and hand picking.

Fish communities were sampled at each site using a combination of snorkeling and electrofishing. Several morphometric measures were recorded for all fish taxa collected by electrofishing, including total length, standard length, and wet weight. In addition, the presences and types of physical abnormalities or parasites were noted. Estimates of standard length were made of fish observed by snorkeling.

Stream and riparian habitat were measured at six transects within each sampling reach. At each of the six transects, water depth, mean water column velocity, and dominant substrate type were measured at three points at intervals approximately at 1/4, 1/2, and 3/4 of the stream width. Additional measurements were sometimes taken to characterize unusual stream morphology (for example, instream bars) or if the three assessment points along the transect did not include the stream thalweg. Dominant substrate was classified as, (1) detritus, (2) silt, (3) mud, (4) sand, (5) gravel, (6) cobble, (7) boulder, or (8) bedrock. Embededness, the degree to which gravel or coarser substrate particles are buried in finer substrates, was classified as, (1) 75 percent or greater, (2) 50 to 75 percent, (3) 25 to 50 percent, (4) 5 to 25 percent, or (5) less than 5 percent. Stream width was measured as the width of the wetted channel. Open canopy angle was measured at the center of the channel using a clinometer. The open canopy angle is based on measurements taken from mid-channel to the tallest objects in the direction of both the left and right banks. The left and right angles are summed and subtracted from 180 degrees to produce the open canopy angle. Percent canopy density was measured at each transect with a spherical densiometer at mid-channel in all four directions (upstream, downstream, left, and right), and near the edge of water while facing the bank (both the left and right banks). Instream cover was estimated as the percentage of area in a band 2–m wide on each side of the transect that offered cover to fish. Because of the relatively short reach lengths (less than 100 m) sampled during the 1995 algae study, the number of transects was reduced to four. Six transects were surveyed at Lodge and Clarks in 1996 because those sites were included as monitoring sites for long-term trends. Summer (June through August) and annual inputs of surface solar radiation (megajoules/m^2/d) were measured in 1995 using a solar pathfinder. Measurements were taken at mid-channel at each of three locations along the reach, and the values were averaged.

Water samples collected during water-quality monitoring at Pohono and Happy Isles and during the 1995 algae study were depth- and width-integrated samples as described in NAWQA guidelines (Shelton, 1994). Water samples for dissolved nutrients collected during 1994 were midstream grab samples. Water samples collected for onsite measurements of specific conductance, pH, and alkalinity were also midstream grab samples. Dissolved oxygen and water temperature were measured in the stream at each site. Stream discharge was obtained from gaging station records or was measured at ungaged sites.

Bed sediment and fish tissue samples for organic contaminants were collected using NAWQA protocols (Crawford and Luoma, 1993; Shelton and Capel, 1994). Sacramento suckers (*Catostomus occidentalis*) were collected by spearfishing and targeted for contaminant analysis. Standard and total lengths, wet weight, and sex were recorded for each fish. A whole fish composite of six to eight fish is required for determining the presence of synthetic organic compounds in fish tissues. Fish collected were wrapped in aluminum foil and frozen on dry ice. Fine-grained sediments for determination of synthetic organic compounds were collected from low velocity stream edge areas using Teflon scoops. Collected sediments were composited in a cleaned glass bowl. Approximately 400 mL of sediment then were wet seived through a 2-mm stainless steel sieve into a precleaned glass jar. The bed sediment sample then was stored on ice.

SAMPLE ANALYSIS

Analytical Methods

All algae, invertebrate, and chemical samples were submitted to the USGS National Water Quality Laboratory (NWQL), Arvada, Colo., for analyses. Algae samples first were sent to the Biological Quality Assurance Unit (BQAU) of the NWQL for initial processing and then to contract laboratories for identification and counting of algae taxa. Data for RTH and DTH samples consisted of densities and biovolume (total summed cell volume). Biovolumes were only calculated for the most common taxa (greater than 5 percent of abundance in at least one sample). Data for QMH samples consisted of a species list for each sample. Quality assurance checks of species identifications, abundances, and biovolumes were done by the BQAU before release of the data. Analysis of algae samples for chlorophyll and AFDM were done at the USGS, California District Laboratory, Sacramento, California, using standard methods (American Public Health Association, 1992). Taxonomic changes occurred for ten algae taxa (see appendix). The original name assigned to each taxon was used in this report.

Taxonomic identifications of benthic invertebrates were done at the BQAU of the NWQL. Verification of problematical taxa and routine quality assurance checks on taxonomic identifications were done by nationally recognized experts on invertebrate taxonomy. Data reported for RTH and DTH samples consisted of species occurrence and density. In contrast, QMH invertebrate samples were analyzed for species occurrence only.

Water samples collected for analysis of nutrients, major ions, and trace elements were packaged on ice and sent to the laboratory for analysis by standard USGS analytical methods (Fishman and Friedman, 1970; Patton and Truitt, 1992; Fishman, 1993). Field measurements of specific conductance, pH, water temperature, and dissolved oxygen were made with electronic meters. Alkalinity was determined by titration.

The sediment sample for organic contaminants analysis was packed in ice and shipped to the NWQL. The sediment sample was analyzed using the methods of Foreman and others (1995). A composite sample of seven Sacramento suckers for organic contaminants analysis was shipped to the NWQL on dry ice. The fish sample was processed and analyzed using the methods of Leiker and others (1995).

Data Analysis

Monitoring Sites

The long-term trend data for RTH and DTH algae and RTH invertebrate samples collected at Happy Isles and Pohono are presented and discussed; however, because only 3 years of annual trend data were available, quantitative analyses of these data were not performed. In addition, results of the DTH and QMH invertebrate samples were unavailable for analysis. The QMH algae data and RTH invertebrate data were included in the analysis of the 1994 ecological survey data as described below. Habitat and water-quality data from all the studies were combined to better characterize trends within and between the years when work was done in the Park.

Ecological Survey

Principal component analysis (PCA) was used to explore environmental differences among sites. Fish data were discussed qualitatively because the low species richness made multivariate analyses unnecessary. Associations between algae communities (QMH presence/absence data), physical variables, and habitat variables were assessed with canonical correlation analysis (CCA) (ter Braak, 1986, 1987; Jongman and others, 1995). Associations between invertebrate communities (RTH density data), physical variables, and habitat variables also were assessed with CCA.

Algae Study

Data for chlorophyll-*a*, pheophytin-*a*, AFDM, and RATIO were examined for normality using normal probability plots. Variables were transformed to improve normality. Chlorophyll-*a* and absorbance ratio were $\log_{10}(x+1)$ transformed, and the other two variables were square root transformed ($X^{0.5}$ + $(X+1)^{0.5}$) for analyses. Differences among sites for these variables were assessed with one-way analysis of variance (ANOVA) followed by the Newman-Keul's Studentized Range Test. Correlations among chlorophyll-*a*, pheophytin-*a*, AFDM, and RATIO were explored with Pearson-product moment correlations. Correlations among mean values of these variables, total biovolume and environmental variables were explored with Spearman rank correlations. Patterns in species densities, percentage abundances and biovolumes were explored with correspondence analysis (Hill and Gauch 1980).

Algae and Invertebrate Baseline Study

Because the data in this study were collected to establish a baseline, no data analyses were conducted. Data were tabulated for comparison with data from future studies.

RESULTS AND DISCUSSION

Monitoring Sites

Water quality and habitat varied among and within the years of monitoring. Multiyear comparisons were based on data collected during September at Happy Isles and Pohono. Highest discharge in the period from 1993 to 1996 occurred in 1995. In contrast, specific conductance was lowest in 1995, but during September the range in specific conductance values was small at both Happy Isles (12–21 µS/cm) and Pohono (18–46 µS/cm) (table 2). Nutrient concentrations were always low at both stations, with concentrations near or below the analytical limit of detection (table 3). Stream width was greatest in 1995 because of high stream discharge (table 4). This was especially evident at Happy Isles because side channels that were dry in other years were flowing in 1995. The instream cover rating at POHO also was higher in 1995. The greater instream cover rating at Pohono was likely due in part to greater depths and velocities in 1995; however, there was an indication that some fine substrate may have been transported out of the system because the mean dominant substrate changed from gravel to cobble (table 5). Larger diameter particles in deeper, faster water would provide more cover for fish.

Within-year comparisons of physical and chemical conditions at Happy Isles and Pohono were based on samples collected semimonthly to monthly in 1995. Specific conductance, total dissolved solids (table 2) and major ions (table 6) seem to be inversely proportional to discharge (table 2), likely because of dilution of baseflow with water derived from snow-melt. Minimum values occurred in July at the peak of 1995 discharge. Trace element concentrations were variable and consistently low (table 7).

Water quality changed little as the river flowed through Yosemite Valley. Though specific conductance, total dissolved solids, and major ions generally were higher at Pohono, concentrations of all constituents were consistently low (tables 2, 3, and 6).

Contaminant samples collected at Pohono contained few compounds (table 8). Of 27 organochlorine compounds analyzed in Sacramento sucker tissue, only *p,p′*-DDE was detected at a low concentration (24 µg/kg tissue wet weight). Lipid content of the composite fish sample was 4.6 percent. Of 31 organochlorine compounds analyzed in sediment, none were detected. Total organic carbon was 4 g/kg sediment dry weight and inorganic carbon was only 0.3 g/kg sediment dry weight, indicating that most of the fine sediment probably was organic detritus.

Of 62 other semivolatile organic compounds analyzed in sediment (table 8), only 5 were detected. Of those only bis(2-ethylhexyl)phthalate was detected at a concentration (89 µg/kg sediment dry weight) above the detection limit. The other four compounds occurred at low concentrations, and only estimated concentrations were reported; di-*n*-butyl phthalate (35 µg/kg sediment dry weight), diethyl phthalate (17 µg/kg sediment dry weight), *p*-cresol (14 µg/kg sediment dry weight), and phenol (16 g/kg sediment dry weight).

Only three species of fish—brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*), and Sacramento sucker—were observed during the fish surveys at HAPI and POHO (table 9). Brown trout and rainbow trout actually composed most of the biomass because many of the suckers seen were small young-of-the-year. Rainbow trout generally were more abundant than brown trout. However, brown trout usually are more difficult to observe while snorkeling, so counts may be negatively biased. Large numbers of adult suckers were observed only at Pohono in 1995. The other large counts of suckers consisted primarily of small young-of-the-year.

The low numbers of trout observed in 1995 most likely were due to difficult snorkeling conditions and, perhaps, differences in distribution between years. Sucker larvae actually were observed at Happy Isles in 1995 in shallow stream edge areas after the fish survey was concluded. High discharge and low water

Table 2. Basic water quality data collected during NAWQA activities in Yosemite National Park at various sites, 1993–1996

[Site code: See table 1 for full site names. NAWQA activities: denoted as "monitoring," "synoptic," and "study." NASQAN, National Stream Quality Assessment Network. ft^3/s, cubic feet per second; °C, degree Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; mg $CaCO_3/L$, milligrams of calcium carbonate per liter. nd, no data]

Site Code	Sempling Date	Discharge (ft^3/s)	Temperature (°C)	Specific Conductance (µS/cm)	pH	Dissolved Oxygen (mg/L)	Hardness (mg $CaCO_3/L$)	Alkalinity (mg $CaCO_3/L$)	Total Dissolved Solids (mg/L)
				Monitoring					
HAPI	16 Sept 93	43.1	10.5	21	nd	nd	nd	nd	nd
HAPI	[1]17 Aug 94	14.1	15.0	29	7.3	8.1	nd	7	nd
HAPI	13 Sept 94	4.4	11.0	41	7.6	9.6	nd	10	nd
HAPI	[2]17 Nov 94	90	1.0	23	7.8	12.0	6	5	20
HAPI	[2]26 Jan 95	143	2.0	24	7.1	11.8	7	7	23
HAPI	[2]16 May 95	631	9.0	15	6.8	9.9	5	6	12
HAPI	[2]12 July 95	1,990	9.0	7	6.9	9.6	2	2	8
HAPI	12 Sept 95	128	13.0	12	6.8	9.0	3	nd	7
HAPI	[3]17 Sept 96	30	11.0	26	nd	13.2	nd	nd	nd
POHO	[1]18 Aug 94	21.9	20.5	37	8.0	7.9	nd	16	nd
POHO	[1]14 Sept 94	12	14.0	46	7.5	8.8	nd	16	nd
POHO	19 Apr 95	865	4.0	21	5.9	10.3	5	8	22
POHO	16 May 95	1,480	8.5	21	6.5	9.8	5	6	16
POHO	20 June 95	1,220	6.0	10	6.5	10.5	3	4	15
POHO	12 July 95	3,320	8.0	14	7.0	10.2	2	3	9
POHO	29 Aug 95	324	13.5	17	6.6	8.8	5	7	11
POHO	12 Sept 95	183	13.0	18	6.3	8.8	6	7	21
POHO	19 Sept 96	43	13.0	35	6.2	13.0	nd	15	nd
				1994 Fish Synoptic					
HAPI	17 Aug 94	14.1	15.0	29	7.3	8.1	nd	7	nd
POHO	18 Aug 94	21.9	20.5	37	8.0	7.9	nd	16	nd
H140	19 Aug 94	31.8	21.0	43	7.7	10.2	nd	23	nd
FRST	19 Aug 94	31.8	23.5	64	8.1	6.6	nd	17	nd
BRIC	16 Aug 94	38.5	23.5	77	7.8	7.8	nd	24	nd
TENU	17 Aug 94	0.4	12.5	29	6.6	7.2	nd	11	nd
TENL	17 Aug 94	1.2	18.5	39	7.6	6.2	nd	19	nd
SFUP	18 Aug 94	0.7	23.5	51	7.2	8.2	nd	19	nd
SFLO	16 Aug 94	3.9	28.0	120	8.3	7.3	nd	34	nd
				1994 Algae and Invertebrate Synoptic					
HAPI	13 Sept 94	4.4	11.0	41	7.6	9.6	nd	10	nd
POHO	14 Sept 94	12	14.0	46	7.5	8.8	nd	16	nd
H140	15 Sept 94	16.4	17.0	51	8.0	9.2	nd	22	nd
FRST	15 Sept 94	19.5	20.0	81	8.2	7.8	nd	22	nd
BRIC	16 Sept 94	19.1	20.0	95	8.3	9.2	nd	30	nd
TENU	13 Sept 94	0.14	10.5	29	6.6	7.2	nd	11	nd
TENL	12 Sept 94	1.4	13.0	42	7.6	8.4	nd	17	nd
SFUP	14 Sept 94	1.7	17.5	50	7.5	8.1	nd	34	nd
SFLO	16 Sept 94	4.4	21.5	151	8.1	8.9	nd	35	nd
				1995 Algae Study					
HAPI	12 Sept 95	128	13.0	12	6.8	9.0	3	nd	7
CLRK	13 Sept 95	148	11.5	12	6.9	9.6	3	6	8
LODG	12 Sept 95	156	14.5	18	6.9	9.8	4	6	10
SENT	12 Sept 95	151	12.5	18	6.6	9.0	5	5	9
EAGL	12 Sept 95	172	14.0	17	6.4	8.7	5	6	14
ELCP	12 Sept 95	168	13.5	17	6.6	8.3	5	6	18
BRID	12 Sept 95	178	14.0	19	6.6	8.8	5	7	21
POHO	12 Sept 95	183	13.0	18	6.3	8.8	6	7	21

Table 2. Basic water quality data collected during NAWQA activities in Yosemite National Park at various sites, 1993–1996—*Continued*

Site Code	Sampling Date	Discharge (ft^3/s)	Temperature (°C)	Specific Conductance (μS/cm)	pH	Dissolved Oxygen (mg/L)	Hardness (mg $CaCO_3$/L)	Alkalinity (mg $CaCO_3$/L)	Total Dissolved Solids (mg/L)
				1996 Algae and Invertebrate Study					
HAPI	17 Sept 96	30	nd	nd	nd	nd	nd	nd	nd
LODG	18 Sept 96	27	nd	nd	nd	nd	nd	nd	nd
CLRK	17 Sept 96	30	11.0	26	nd	13.2	nd	nd	nd
AWAH	18 Sept 96	27	12.5	20	6.5	10.0	nd	6	nd
STON	19 Sept 96	24	nd	nd	nd	nd	nd	nd	nd
POHO	19 Sept 96	43	13.0	35	6.2	13.0	nd	15	nd

[1] Data collected during synoptic activies but included here for comparative purposes.
[2] Data collected during NASQAN sampling but included here for comparative purposes.
[3] These data were actually collected at the Clarks bridge site just downstream from the Happy Isles site.

Table 3. Nutrient data collected during NAWQA activities in Yosemite National Park at various locations, 1993–1995

[Site code: See table 1 for full site names. NAWQA activities: denoted as "monitoring," "synoptic," and "study." NASQAN, National Stream Quality Assessment Network. NH_3, ammonia; N, nitrogen; NO_2, nitrite; NO_3, nitrate; P, phosphorus. mg/L, milligrams per liter. <, less than specified detection limit. nd, no data]

Site Code	Sampling Date	NH_3-N (mg/L)	NO_2-N (mg/L)	NH_3 + Dissolved Organic-N (mg/L)	NH_3 + Total Organic-N (mg/L)	NO_2 + NO_3-N (mg/L)	Total P (mg/L)	Dissolved P (mg/L)	Ortho-phosphate P (mg/L)
				Monitoring					
HAPI	[1]13 Sept 94	<0.01	<0.01	<0.20	<0.20	0.054	<0.01	0.01	<0.01
HAPI	[2]17 Nov 94	<0.015	0.010	nd	<0.20	<0.05	<0.01	<0.01	<0.01
HAPI	[2]26 Jan 95	<0.015	<0.01	nd	<0.20	<0.05	<0.01	<0.01	<0.01
HAPI	[2]16 May 95	<0.015	<0.01	nd	<0.20	<0.05	<0.01	<0.01	<0.01
HAPI	[2]12 July 95	<0.015	0.010	nd	<0.20	<0.05	<0.01	0.010	<0.01
HAPI	[1]12 Sept 95	<0.015	<0.01	<0.20	<0.20	<0.05	<0.01	0.020	<0.01
POHO	[1]14 Sept 94	<0.01	<0.01	<0.20	<0.20	<0.05	0.010	<0.01	0.010
POHO	19 Apr 95	<0.015	<0.01	<0.20	<0.20	<0.05	<0.01	<0.01	<0.01
POHO	16 May 95	<0.015	<0.01	<0.20	<0.20	<0.05	<0.01	<0.01	<0.01
POHO	20 June 95	<0.015	<0.01	<0.20	<0.20	0.110	<0.01	<0.01	<0.01
POHO	12 July 95	<0.015	0.010	<0.20	<0.20	<0.05	<0.01	<0.01	<0.01
POHO	29 Aug 95	<0.015	<0.01	<0.20	<0.20	<0.05	0.020	<0.01	<0.01
POHO	12 Sept 95	<0.015	<0.01	<0.20	<0.20	<0.05	<0.01	<0.01	<0.01
				1994 Algae and Invertebrate Synoptic					
HAPI	13 Sept 94	<0.01	<0.01	<0.20	<0.20	0.054	<0.01	0.01	<0.01
POHO	14 Sept 94	<0.01	<0.01	<0.20	<0.20	<0.05	0.010	<0.01	0.010
H140	15 Sept 94	0.010	<0.01	<0.20	<0.20	<0.05	<0.01	<0.01	<0.01
FRST	15 Sept 94	<0.01	<0.01	<0.20	<0.20	1.10	<0.01	<0.01	<0.01
BRIC	16 Sept 94	<0.01	<0.01	<0.20	<0.20	0.720	<0.10	<0.10	<0.01
TENU	13 Sept 94	<0.01	<0.01	<0.20	<0.20	0.060	<0.01	<0.01	<0.01
TENL	12 Sept 94	<0.01	<0.01	<0.20	<0.20	<0.05	<0.01	<0.01	<0.01
SFUP	14 Sept 94	<0.01	<0.01	<0.20	<0.20	0.063	<0.01	<0.01	<0.01
SFLO	16 Sept 94	<0.01	<0.01	<0.20	<0.20	<0.05	<0.01	0.010	<0.01
				1995 Algae Study					
HAPI	12 Sept 95	<0.015	<0.01	<0.20	<0.20	<0.05	<0.01	0.020	<0.01
CLRK	13 Sept 95	<0.015	<0.01	<0.20	<0.20	<0.05	<0.01	<0.01	<0.01
LODG	12 Sept 95	<0.015	<0.01	<0.20	<0.20	<0.05	<0.01	<0.01	<0.01
SENT	12 Sept 95	<0.015	<0.01	<0.20	<0.20	<0.05	<0.01	<0.01	<0.01
EAGL	12 Sept 95	<0.015	<0.01	<0.20	<0.20	<0.05	<0.01	0.010	<0.01
ELCP	12 Sept 95	<0.015	<0.01	<0.20	<0.20	<0.05	0.020	<0.01	<0.01
BRID	12 Sept 95	<0.015	<0.01	<0.20	<0.20	<0.05	<0.01	<0.01	<0.01
POHO	12 Sept 95	<0.015	<0.01	<0.20	<0.20	<0.05	<0.01	<0.01	<0.01

[1] Data collected during synoptic activities but included here for comparative purposes.
[2] Data collected during NASQAN sampling but included here for comparative purposes.

Table 4. Mean values for physical data collected at habitat transects during NAWQA activities in Yosemite National Park, 1993–1995

[Site code: See table 1 for full site names. NAWQA activities: denoted as "monitoring," "synoptic," and "study." Data are mean values from six habitat transects (i.e., sample sizes), except for the 1995 algae study when only four transects were used. Insolation measurements were taken only during the 1995 algae synoptic and are given as means of measurements taken at midstream at the upper end, middle and lower end of the sampling reach. m, meters; MJ/m^2/d, megajoules per square meter per day. nd, no data]

Site Code	Sampling Date	Stream Width (m)	Instream Cover (percent)	Open Canopy Angle (degrees)	Canopy Density (percent)	Insolation (MJ/m^2/d)	
						Summer	Annual
				Monitoring			
HAPI	16 Sept 93	17.7	47	88	nd	nd	nd
HAPI	13 Sept 94	13.9	55	69	28	nd	nd
HAPI	8 Sept 95	63.1	54	62	30	nd	nd
POHO	14 Sept 94	24.9	13	78	31	nd	nd
POHO	6 Sept 95	31.8	56	70	33	nd	nd
				1994 Algae and Invertebrate Synoptic			
HAPI	13 Sept 94	13.9	55	69	28	nd	nd
POHO	14 Sept 94	24.9	13	78	31	nd	nd
H140	15 Sept 94	12.2	25	107	11	nd	nd
FRST	15 Sept 94	18.2	10	106	13	nd	nd
BRIC	16 Sept 94	18.6	4	99	12	nd	nd
TENU	13 Sept 94	9.4	35	34	66	nd	nd
TENL	12 Sept 94	16.7	1	32	69	nd	nd
SFUP	14 Sept 94	9.4	10	79	20	nd	nd
SFLO	16 Sept 94	14.2	13	104	17	nd	nd
				1995 Algae Study			
HAPI	12 Sept 95	31.3	98	71	34	16.2	7.8
CLRK	13 Sept 95	20.9	52	76	31	20.3	8.8
LODG	12 Sept 95	40.1	6	100	16	24.2	14.3
SENT	12 Sept 95	28.9	14	114	6	26.8	14.8
EAGL	12 Sept 95	24.6	30	77	17	22.3	10.9
ELCP	12 Sept 95	65.9	8	90	19	21.6	9.9
BRID	12 Sept 95	25.7	84	72	26	16.0	7.4
POHO	12 Sept 95	28.5	35	69	37	16.9	7.4

temperatures likely had delayed spawning compared to 1993 and 1994 resulting in individuals too small to be detected by the surveying techniques used.

Forty-three taxa of algae from three divisions were identified from the RTH samples (table 10), and 83 taxa of algae from six divisions were identified in the DTH samples (table 11). Biovolume data were available for only 14 algae taxa in the RTH samples (table 12) and for only 15 taxa in the DTH samples (table 13).

Diatoms had the highest taxa richness in RTH and DTH samples, composing 88 percent of the identified taxa in both types of samples. Taxa richness at Happy Isles was fairly consistent from year to year, but was lower in all years than that observed at Pohono in 1995. Happy Isles RTH samples from 1993 to 1996 contained from 12 to16 taxa, including 9 to 14 diatom taxa, compared to 27 taxa at Pohono in 1995, including 24 diatom taxa. Happy Isles DTH samples from 1993 to 1996 contained from 33 to 37 taxa, including 31 to 36 diatom taxa, compared to 46 taxa at POHO in 1995, including 41 diatom taxa.

The diatom *Achnanthidium minutissimum* was present in all HAPI and POHO RTH and DTH samples and was the most abundant diatom in all samples. In addition, *A. minutissimum* and *Oscillatoria* sp. 1 (ansfwa) comprised the greatest biovolume of any alga in the HAPI RTH samples. *Oscillatoria* sp. 1 (ansfwa), a taxon of blue-green algae, was the only nondiatom found in all samples. *Oscillatoria* sp. 1 (ansfwa) was responsible for the greatest biovolume of nondiatom algae, except at Pohono where *Audouinella hermanii* exceeded biovolume of both *A. minutissimum* and *Oscillatoria* sp. 1 (ansfwa) (table 12). The result is somewhat surprising given its low density, compared

Table 5. Mean values for physical data collected at points along habitat transects during NAWQA activities in Yosemite National Park, 1993–1995

[Site code: See table 1 for full site names. NAWQA activities: denoted as "monitoring," "synoptic," and "study." Transect data: Measurements were taken at three or more points along each of six transects to characterize general habitat conditions, except during the 1995 algae study when only four transects were used. Collection site data: During the 1995 algae synoptic, measurements were also taken at 10 points along each of two additional transects to better characterize the specific habitat where algae samples were collected. Dominant substrate classification: (1) detritus, (2) silt, (3) mud, (4) sand, (5) gravel, (6) cobble, (7) boulder, or (8) bedrock. m, meters; m/s, meters per second; —, no data]

Site Code	Sampling Date	Transect Data				Collection Site Data			
		Sample Size	Depth (m)	Velocity (m/s)	Dominant substrate	Sample Size	Depth (m)	Velocity (m/s)	Dominant Substrate
				Monitoring					
HAPI	16 Sept 93	18	0.47	0.16	6.3	—	—	—	—
HAPI	13 Sept 94	20	0.41	0.05	6.6	—	—	—	—
HAPI	8 Sept 95	24	0.64	0.46	6.4	—	—	—	—
POHO	14 Sept 94	18	0.69	0.10	5.4	—	—	—	—
POHO	6 Sept 95	22	1.04	0.42	6.3	—	—	—	—
				1994 Algae and Invertebrate Synoptic					
HAPI	13 Sept 94	20	0.41	0.05	6.6	—	—	—	—
POHO	14 Sept 94	18	0.69	0.10	5.4	—	—	—	—
H140	15 Sept 94	19	0.59	0.16	7.0	—	—	—	—
FRST	15 Sept 94	19	0.86	0.29	6.6	—	—	—	—
BRIC	16 Sept 94	21	0.70	0.23	6.6	—	—	—	—
TENU	13 Sept 94	19	0.24	0.05	6.5	—	—	—	—
TENL	12 Sept 94	20	0.31	0.03	5.4	—	—	—	—
SFUP	14 Sept 94	19	0.21	0.16	7.0	—	—	—	—
SFLO	16 Sept 94	21	0.69	0.13	5.6	—	—	—	—
				1995 Algae Study					
HAPI	12 Sept 95	14	0.74	0.51	6.9	20	0.32	0.35	6.3
CLRK	13 Sept 95	13	0.60	0.50	6.6	20	0.26	0.52	5.9
LODG	12 Sept 95	16	0.60	0.36	4.7	20	0.23	0.47	4.9
SENT	12 Sept 95	13	0.60	0.32	4.6	20	0.28	0.50	4.4
EAGL	12 Sept 95	13	0.61	0.44	4.8	20	0.41	0.42	4.7
ELCP	12 Sept 95	19	0.43	0.39	4.7	20	0.36	0.51	5.0
BRID	12 Sept 95	13	0.46	0.67	6.6	20	0.40	0.52	6.9
POHO	12 Sept 95	13	0.87	0.47	6.0	20	0.39	0.74	6.0

to *Oscillatoria* sp. 1 (ansfwa) at the site and is likely because *A. hermanii* had a large cell volume.

The total number of invertebrate taxa collected at the Happy Isles and Pohono monitoring sites (table 14) ranged from 36 to 55. The number of species represented is unclear because many of the specimens collected could only be identified at higher taxonomic levels, primarily genus or family. Mayflies (Ephemeroptera), caddisflies (Trichoptera), and stoneflies (Plecoptera) made up the majority of the organisms collected. Riffle beetles (Elmidae), and the diptera families Chironomidae and Simuliidae, were consistently abundant at Happy Isles and Pohono in all years sampled.

Total density (organisms/m^2) of invertebrates varied considerably between years. At Happy Isles, densities in 1993 and 1994 were similar (6,680 and 5,237, respectively), but density in 1995 was only 1,991. Similarly, density at Pohono in 1994 was 8,608 compared to 2,882 in 1995. The density of EPT (Ephemeroptera+Plecoptera+Trichoptera) taxa exceeded 60 percent of the total invertebrate density in all samples, except the 1994 Pohono sample. The 1994 Pohono sample had much higher percentages of other taxa, particularly chironomids (42 percent) and simuliids (7 percent).

Results indicate that water quality in the Merced River was consistently very good during the study, as indicated by low concentrations of dissolved salts and minerals. Water quality and habitat conditions do vary among and within years, but the range in variation is small. The results of the contaminants surveys indicate the presence of low levels of some synthetic organic compounds in fish and bed sediments, but the concentrations are very low and unlikely to be a problem for fish, wildlife, or humans. The concentration of

Table 6. Major ion data collected during NAWQA activities in Yosemite National Park at various locations, 1993–1995

[Site code: See table 1 for full site names. NASQAN, National Stream Quality Assessment Network. NAWQA activities: denoted as "monitoring" and "study." mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than specified detection limit]

Site Code	Sampling Date	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Flouride (mg/L)	Silicon (mg/L)	Iron (µg/L)	Manganese (µg/L)
					Monitoring						
HAPI	17 Nov 94[1]	2.1	0.20	1.9	0.30	0.40	3.4	<0.10	5.4	60	1
HAPI	26 Jan 95[1]	2.4	0.21	<0.20	0.40	0.40	3.4	<0.10	7.8	44	1
HAPI	16 May 95[1]	1.5	0.18	1.3	0.40	0.30	0.70	<0.10	7.9	34	<1
HAPI	12 July 95[1]	0.68	0.08	0.50	0.20	0.30	0.20	<0.10	3.4	20	4
HAPI	12 Sept 95	1.2	0.12	0.90	0.30	0.30	0.90	<0.10	3.9	33	1
POHO	19 Apr 95	1.8	0.22	1.5	0.50	0.50	0.90	<0.10	9.1	57	3
POHO	16 May 95	1.6	0.20	1.3	0.50	0.30	0.60	<0.10	8.4	50	3
POHO	20 June 95	0.93	0.12	0.70	0.30	0.30	0.20	<0.10	5.0	94	5
POHO	12 July 95	0.79	0.09	0.50	0.20	0.20	0.20	<0.10	3.7	41	5
POHO	29 Aug 95	1.6	0.19	1.1	0.40	0.60	0.70	<0.10	5.4	76	6
POHO	12 Sept 95	1.9	0.24	1.3	0.50	0.50	1.0	<0.10	6.5	27	4
					1995 Algae Study						
HAPI	12 Sept 95	1.2	0.12	0.90	0.30	0.30	0.90	<0.10	3.9	33	1
CLRK	13 Sept95	1.2	0.12	0.90	0.20	0.30	0.90	<0.10	3.8	20	<1
LODG	12 Sept 95	1.5	0.17	1.1	0.40	0.30	1.1	<0.10	5.0	21	4
SENT	12 Sept 95	1.6	0.17	1.1	0.50	0.30	1.1	<0.10	4.9	52	4
EAGL	12 Sept 95	1.7	0.19	1.2	0.40	0.50	1.1	<0.10	5.5	31	3
ELCP	12 Sept 95	1.8	0.21	1.2	0.40	0.50	1.0	<0.10	5.9	58	6
BRID	12 Sept 95	1.8	0.22	1.2	0.50	0.50	1.0	<0.10	6.3	61	5
POHO	12 Sept 95	1.9	0.24	1.3	0.50	0.50	1.0	<0.10	6.5	27	4

[1] Data collected during NASQAN sampling but included here for comparative purposes.

Table 7. Trace element data collected in Yosemite National Park in 1995

[Site code: See table 1 for full site names. NASQAN, National Stream Quality Assessment Network. All measurements are in micrograms per liter; <, less than specified detection limit]

Site Code	Sampling Date	Aluminum	Barium	Cohalt	Lithium	Mang-anese	Molyb-denum	Nickel	Selenium	Strontium	Silver	Vanadium
HAPI	[1]26 Jan 95	30	3	<3	8	1	<10	<1	<1	<1	40	<6
HAPI	[1]16 May 95	60	3	<3	<4	<1	<10	<1	<1	<1	18	<6
HAPI	[1]12 July 95	40	<2	<3	<4	4	<10	<1	<1	<1	6	<6
POHO	16 May 95	50	4	<3	5	3	<10	<1	<1	<1	18	<6
POHO	12 July 95	50	<2	<3	4	5	<10	<1	<1	<1	9	<6

[1]Data collected during NASQAN sampling but included here for comparative purposes.

p,p′-DDE in suckers was less than guidelines for the protection of fish-eating wildlife set by the National Academy of Sciences and National Academy of Engineering (1973). The value also was low compared to results of recent national studies by the U.S. Environmental Protection Agency (1992) and the U.S. Fish and Wildlife Service (Schmitt and others, 1990). The source of the *p,p′*-DDE is unknown, but there are a number of possibilities. Atmospheric deposition from the San Joaquin Valley is one possibility (Zabik and Seiber, 1993; Datta and others, 1998; McConnell and others, 1998) because DDT compounds are still common in the soils there (Brown, 1997). DDT also may have been used in Yosemite Valley for mosquito control or other purposes before the compounds were banned during the early 1970s. The other organic compounds were low in concentration and, seemingly, widespread and very common in the environment at low concentrations. These compounds are also common laboratory contaminants and the low values may be a result of such contamination (Thomas J. Lopes, U.S. Geological Survey, written commun., 1997). Thus, the low concentrations observed at the study sites should not contribute significantly to impairment of water quality.

Table 8. Analytes included in chemical analyses of sucker tissue and sediment collected from the Merced River near Pohono Bridge (POHO) in September 1995

[MDL, method detection limit; T, tissue (µg/kg wet weight); S, sediment (µg/kg dry weight). µg/kg, micrograms per kilogram. na, not analyzed]

Analyte	MDL		Analyte	MDL	
	T	S		T	S
			Organochlorine Compounds		
Aldrin	5	1	Endrin	5	2
α-BHC	5	1	Heptachlor	5	1
β-BHC	5	1	Heptachlor epoxide	5	1
δ-BHC	5	na	Isodrin	na	1
cis-Chlordane	5	1	Lindane	5	1
trans-Chlordane	5	1	*p,p*-Methoxychlor	5	5
Chlorneb	na	1	*o,p*-Methoxychlor	5	5
Dachthal (DCPA)	5	1	Mirex	5	1
o,p'-DDD	5	1	*cis*-Nonachlor	5	1
p,p'-DDD	5	1	*trans*-Nonachlor	5	1
o,p'-DDE	5	1	Oxychlordane	5	1
p,p'-DDE	[1]5	1	Pentachloroanisole	5	50
o,p'-DDT	5	2	*cis*-Permethrin	na	5
p,p'-DDT	5	2	*trans*-Permethrin	na	5
Dieldrin	5	1	PCB	50	50
Endosulfan I	na	1	Toxaphene	200	200
			Semivolatile Organic Compounds		
1,2,5,6-Dibenz[a,h]anthracene	na	50	Benzo[a]pyrene	na	50
1,2,4-Trichlorobenzene	na	50	Benzo[b]flouranthene	na	50
1,2-Dichlorobenzene	na	50	Benzo[c]cinnoline	na	50
1,2-Dimethylnapthalene	na	50	Benzo[g,h,i]perylene	na	50
1,3-Dichlorobenzene	na	50	Benzo[k]fluoranthene	na	50
1,4-Dichlorobenzene	na	50	Bis(2-chloroethoxy)methane	na	50
1,6-Dimethylnapthalene	na	50	Bis(2-ethylhexyl)phthalate	na	[1]50
1-Methyl-9*H*-flourene	na	50	Butylbenzylphthalate	na	50
1-Methylphenanthrene	na	50	C8-Alkylphenol	na	50
1-Methylpyrene	na	50	Carbazole	na	50
2,3,6-Trimethylnapthalene	na	50	Chrysene	na	50
2,2'-Biquinoline	na	50	Dibenzothiophene	na	50
2,4-Dinitrotoluene	na	50	Di-*n*-butyl phthalate	na	[2]50
2,6-Dimethylnapthalene	na	50	Di-*n*-octyl phthalate	na	50
2,6-Dinitrotoluene	na	50	Diethyl phthalate	na	[2]50
2-Chloronapthalene	na	50	Dimethyl phthalate	na	50
2-Chlorophenol	na	50	Fluoranthene	na	50
2-Methylanthracene	na	50	Ideno[1,2,3-c,d]pyrene	na	50
3,5-Dimethylphenol	na	50	Isophorone	na	50
4,5-Methylenephenanthrene	na	50	Isoquinoline	na	50
4-Bromophenylphenylether	na	50	Naphthalene	na	50
4-Chloro-3-methylphenol	na	50	*N*-Nitrosodi-*n*-propylamine	na	50
4-Chlorophenylphenylether	na	50	*N*-Nitrosodiphenylamine	na	50
9h-Flourene	na	50	Nitrobenzene	na	50
Acenaphthene	na	50	*P*-Cresol	na	[2]50
Acenaphthylene	na	50	Pentachloronitrobenzene	na	50
Acridine	na	50	Phenanthrene	na	50
Anthracene	na	50	Phenanthridine	na	50
Anthraquinone	na	50	Phenol	na	[2]50
Azobenzene	na	50	Pyrene	na	50
Benz[a]anthracene	na	50	Quinoline	na	50

[1]Analyte was detected at a concentration greater than the MDL.

[2]Analyte was detected at less than the MDL and an estimated concentration was provided.

Table 9. Number (and percentage) of each fish species observed during surveys in Yosemite National Park at various locations, 1993–1995

[Site code: See table 1 for full site names. Percentage of each species at a site is given in parentheses]

Site Code	Sampling Date	Rainbow Trout	Brown Trout	Sacramento Sucker	Smallmouth Bass	Spotted Bass	Sacramento Squawfish	Riffle Sculpin
				Merced River Sites				
HAPI	16 Sept 93	41 (28)	27 (18)	801 (54)	0	0	0	0
HAPI	17 Aug 94	100 (43)	58 (25)	72 (31)	0	0	0	0
HAPI	6 Sept 95	13 (72)	5 (28)	0	0	0	0	0
POHO	18 Aug 94	23 (20)	23 (20)	70 (60)	0	0	0	0
POHO	6 Sept 95	12 (5)	13 (5)	227 (90)	0	0	0	0
H140	19 Aug 94	20 (4)	3 (1)	315 (59)	13 (2)	0	156 (29)	24 (5)
FRST	19 Aug 94	5 (3)	3 (2)	61 (31)	97 (49)	1 (1)	26 (13)	5 (3)
BRIC	16 Aug 94	0	0	10 (8)	104 (79)	2 (2)	15 (11)	0
				Tributary Sites				
TENU	17 Aug 94	51 (70)	15 (21)	7 (10)	0	0	0	0
TENL	17 Aug 94	10 (11)	78 (87)	2 (2)	0	0	0	0
SFUP	18 Aug 94	52 (49)	1 (1)	54 (50)	0	0	0	0
SFLO	16 Aug 94	0	0	0	76 (99)	0	1 (1)	0

Fish species richness is low in the upper reaches of the Merced River. Accordingly, the use of fish community structure as an indicator of environmental conditions in the area is limited. In contrast, the results of the ecological assessments indicate that the algae and invertebrate communities are responsive to relatively subtle changes in water and habitat quality and would be more appropriate bioindicators in these relatively undisturbed environmental settings.

Ecological Survey

During both the August 1994 fish survey and the September 1994 algae and invertebrate surveys, water temperature, discharge, and specific conductance increased in the Merced River in the downstream direction; however, the range in values was small (table 2) compared to values found throughout the San Joaquin River drainage. Water quality in the tributaries generally was similar to the mainstem Merced River, with lower South Fork having the highest specific conductance in both months.

Nutrient concentrations generally were below or near the analytical detection limit (table 3). The two highest nitrite-plus-nitrate concentrations occurred downstream from the Park sewage treatment plant near the Foresta Road bridge. However, the concentrations detected were low (1.1 mg/L or less) and do not indicate a major input of nutrients to the river.

Overall, there were no clear patterns associated with changes in physical habitat among sites, other than differences in stream discharge. However, the tributary sites tended to be narrower, shallower, and more shaded with lower water velocities than the mainstem sites. Dominant substrate type did not differ substantially between the tributary sites and the mainstem sites.

Principal components analysis of 17 physical and water quality variables resulted in five principal components (PC) with eigenvalues greater than one, which explained 89 percent of the variance in the data set (table 15). The first two PCs explained the majority of the variance (58 percent). The first PC separated sites almost precisely according to altitude (fig. 2, table 1). The second PC is primarily related to discharge and correlated differences in stream depth and width. The upper South Fork Merced River near Wawona, hereinafter referred to simply as "upper South Fork" (site code used in table 1 is SFUP), Tenaya Creek near Group Camp, hereinafter referred to simply as "lower Tenaya" (site code used in table 1 is TENL), and Tenaya Creek below Mirror Lake, hereinafter referred to simply as "upper Tenaya" (site code used in table 1 is TENU) sites sampled in 1994 had the largest scores on PC2. Happy Isles and Pohono in 1995 had the smallest scores on PC2.

There was a clear break in fish species distribution with only rainbow trout, brown trout, and Sacramento sucker upstream of Highway 140. It is likely that the high gradient area in the Merced River gorge between Highway 140 and Pohono bridge acted as an effective barrier to invasion from the downstream sites by smallmouth bass (*Micropterus dolomieu*), spotted bass (*Micropterus punctulatus*), Sacramento

Table 10. Abundance of algae taxa collected in RTH samples during NAWQA monitoring activities in Yosemite National Park near Happy Isles (HAPI) and Pohono (POHO) bridges, 1993–1995

[tax, refer to the appendix for taxonomic name change. Measurements are in algae cells per square centimeter; µm, micrometer]

Taxon	HAPI			POHO
	1993	1994	1995	1995
	Bacillariophyta			
Achnanthes detha	49	0	0	88
Achnanthes linearis	98	0	0	0
Achnanthes marginulata (tax)	0	0	80	0
Achnanthes pseudolinearis	1,920	0	0	442
Achnanthidium affine	0	3,798	320	1,105
Achnanthidium minutissimum	26,003	1,016,001	46,358	17,246
Amphora veneta	0	0	0	88
Cocconeis placentula lineata	98	1,899	0	0
Cymbella affinis	0	11,394	0	88
Cymbella cesatii (tax)	0	0	160	0
Cymbella lunata (tax)	0	0	0	44
Cymbella minuta latens (tax)	196	0	0	0
Cymbella sp. 1 jck	0	7,596	0	0
Encyonema minutum	98	0	0	221
Eunotia incisa	196	0	160	0
Eunotia pectinalis minor	49	0	0	0
Fragilaria construens pumila	0	0	0	88
Fragilaria vaucheriae	492	0	0	221
Gomphonema cf. *clevei*	98	41,779	0	0
Gomphonema olivaceum	0	0	0	309
Gomphonema parvulum	0	41,779	240	3,847
Gomphonema subclavatum	0	0	320	132
Hannaea arcus	49	13,293	0	972
Navicula leptostriata	98	0	0	0
Navicula menisculus	0	0	0	176
Navicula radiosa tenella	0	0	80	0
Navicula secreta apiculata	0	0	160	0
Navicula sp. 1 ans hdsn	0	0	0	530
Nitzschia frustulum	0	0	80	44
Nitzschia frustulum perminuta	0	0	0	44
Nitzschia kuetzingiana	0	0	0	88
Rhoicosphenia abbreviata	0	0	0	44
Staurosirella pinnata	0	0	0	442
Surirella minuta	0	0	0	88
Synedra minuscula	0	0	0	44
Synedra rumpens	0	0	80	132
Synedra ulna	98	0	80	0
Synedra ulna oxyrhynchus	0	1,899	0	0
	Cyanophyta			
Lyngbya sp.	0	58,664	0	0
Oscillatoria lutea	0	0	3,896	0
Oscillatoria sp.	18,348	157,942	0	21,277
Oscillatoria sp. 1 (ansfwa)	54,210	564,079	42,448	794,043
	Rhodophyta			
Audouinella hermanii	0	0	0	69,013
	Unclassified			
(Undetermined cf. clastidium)	0	0	34,850	0
(Undetermined coccoid 1–3 µm)	1,010	3,760	97,780	74,669
(Undetermined coccoid 3–5 µm)	1,415	24,819	0	262,815
(Undetermined coccoid 5–10 µm)	379	0	876	0
(Undetermined filamentous) sp.	0	11,281	3,496	0
(Undetermined) sp.	1,958	0	487	0

Table 11. Abundance of algae taxa collected in DTH samples during NAWQA monitoring activities in Yosemite National Park near Happy Isles (HAPI) and Pohono (POHO) bridges, 1993–1995

[tax, refer to the appendix for taxonomic name change. Measurements are in algae cells per square centimeter; µm, micrometer; >, greater than]

Taxon	HAPI			POHO
	1993	1994	1995	1995
	Bacillariophyta			
Achnanthes deflexa	42,022	30,419	0	0
Achnanthes detha	10,505	40,558	9,446	9,145
Achnanthes linearis	7,003	0	1,111	1,742
Achnanthes marginulata (tax)	7,003	20,279	4,445	0
Achnanthes pseudolinearis	133,071	0	2,222	14,372
Achnanthidium affine	0	0	5,001	3,484
Achnanthidium lanceolatum	7,003	0	0	0
Achnanthidium minutissimum	1,285,193	1,875,842	185,593	117,590
Achnanthidium pusillum (tax)	7,003	0	0	871
Amphora ovalis	0	10,139	0	0
Amphora ovalis pediculus	0	10,139	0	0
Amphora perpusilla	0	30,419	0	0
Aulacoseira ambigua	14,007	0	0	0
Aulacoseira italica tenuissima	0	0	0	871
Brachysira brebissonii	14,007	10,139	0	871
Brachysira vitrea	7,003	81,117	3,889	871
Cocconeis placentula lineata	3,501	30,419	0	0
Cymbella affinis	0	40,558	0	0
Cymbella cesatii (tax)	42,022	0	0	0
Cymbella cuspidata	0	0	1,111	0
Cymbella lunata (tax)	3,501	10,139	0	0
Cymbella microcephala (tax)	0	5,069	1,111	0
Cymbella minuta latens (tax)	35,018	0	0	0
Cymbella sp. 1 jck	7,003	35,488	0	0
Diatoma mesodon	0	0	1,111	4,355
Encyonema minutum	56,030	70,977	17,781	5,226
Eunotia curvata	0	0	0	871
Eunotia exigua	52,528	25,349	13,336	17,420
Eunotia incisa	0	40,558	0	1,742
Eunotia major	7,003	0	0	0
Eunotia naegelii	0	0	555	1,306
Eunotia pectinalis minor	7,003	0	0	0
Eunotia perpusilla	0	0	0	6,968
Eunotia tenella	0	0	0	871
Fragilaria construens pumila	0	0	1,111	10,887
Fragilaria construens venter (tax)	0	0	0	871
Fragilaria pinnata lancettula	0	0	0	871
Fragilaria vaucheriae	10,505	30,419	10,557	4,790
Frustulia rhomboides crassinervia	3,501	10,139	0	0
Gomphonema cf. *clevei*	0	0	0	1,742
Gomphonema intricatum	7,003	0	0	0
Gomphonema parvulum	28,015	121,676	31,673	14,807
Gomphonema subclavatum	14,007	0	3,334	871
Hannaea arcus	28,015	70,977	4,445	1,742
Meridion circulare	0	0	555	435
Navicula arvensis	0	0	0	871
Navicula cryptocephala	14,007	40,558	1,111	871
Navicula decussis (tax)	0	0	0	871
Navicula leptostriata	87,547	121,676	0	871

Table 11. Abundance of algae taxa collected in DTH samples during NAWQA monitoring activities in Yosemite National Park near Happy Isles (HAPI) and Pohono (POHO) bridges, 1993–1995—*Continued*

Taxon	HAPI			POHO
	1993	1994	1995	1995
Navicula minima	38,520	0	0	8,710
Navicula pseudoscutiformis	0	20,279	0	0
Navicula radiosa tenella	0	15,209	0	0
Navicula sp. 1 ans hdsn	0	20,279	0	0
Navicula submolesta	0	20,279	0	0
Neidium affine	7,003	0	0	0
Neidium affine longiceps	14,007	0	0	0
Neidium alpinum	0	0	0	871
Nitzschia dissipata	0	10,139	2,222	871
Nitzschia dissipata media	14,007	0	0	0
Nitzschia frustulum perminuta	0	0	4,445	871
Nitzschia kuetzingiana	0	10,139	2,778	1,742
Nitzschia subtilis	0	0	1,111	0
Pinnularia abaujensis linearis	0	0	0	871
Pinnularia intermedia	0	10,139	1,111	0
Pinnularia major	0	0	0	871
Pseudostaurosira brevistriata	0	0	5,556	0
Sellaphora pupula	0	10,139	0	871
Synedra minuscula	0	15,209	4,445	3,484
Synedra rumpens	14,007	96,327	3,334	8,710
Synedra rumpens familiaris	14,007	30,419	0	0
Synedra rumpens meneghiniana	21,011	0	0	0
Tabellaria fenestrata	0	0	555	0
Tabellaria flocculosa	38,520	20,279	8,335	4,355
	Chlorophyta			
Scenedesmus denticulatus	0	40,112	0	0
Staurastrum sp.	0	0	1,225	0
	Chrysophyta			
Dinobryon sp.	0	0	0	725
	Cyanophyta			
Anabaena sp.	0	142,398	0	0
Oscillatoria sp.	0	0	21,662	0
Oscillatoria sp. 1 (ansfwa)	272,527	752,105	254,218	66,243
	Euglenophyta			
Phacus sp.	0	10,028	0	0
Trachelomonas lacustris	0	0	0	725
Trachelomonas sp.	0	0	0	725
	Rhodophyta			
Audouinella hermanii	0	0	0	2,249
	Unclassified			
(Undetermined cf. clastidium)	0	0	13,231	0
(Undetermined coccoid 1–3 µm)	6,193	0	8,943	0
(Undetermined coccoid 3–5 µm)	0	0	0	3,731
(Undetermined coccoid 5–10 µm)	6,193	10,028	39,694	0
(Undetermined coccoid >10 µm)	0	0	0	725
(Undetermined filamentous) sp.	0	0	35,179	10,416

Table 12. Biovolumes for algae taxa collected in RTH samples during NAWQA monitoring activities in Yosemite National Park near Happy Isles (HAPI) and Pohono (POHO) bridges, 1993–1995

[Measurements are in cubic micrometers per square centimeter; µm, micrometer]

Taxon	HAPI 1993	HAPI 1994	HAPI 1995	POHO 1995
	Bacillariophyta			
Achnanthes pseudolinearis	89,479	0	0	26,714
Achnanthidium minutissimum	1,436,766	83,949,092	2,758,269	1,026,166
Cocconeis placentula lineata	40,419	779,282	0	0
Encyonema minutum	0	0	0	37,675
Fragilaria construens pumila	0	0	0	11,598
Gomphonema cf. *clevei*	8,214	0	0	0
Gomphonema parvulum	0	0	32,769	523,979
Navicula leptostriata	11,776	0	0	0
Navicula sp. 1 ans hdsn	0	0	0	63,309
Nitzschia kuetzingiana	0	0	0	7,531
Staurosirella pinnata	0	0	0	47,022
	Cyanophyta			
Oscillatoria sp.	0	2,242,779	0	0
Oscillatoria sp. 1 (ansfwa)	319,842	3,835,740	305,631	5,717,111
	Rhodophyta			
Audouinella hermanii	0	0	0	24,258,152
	Unclassified			
(Undetermined cf. clastidium)	0	0	1,101,273	0
(Undetermined coccoid 1–3 µm)	0	0	1,124,480	858,694
(Undetermined coccoid 3–5 µm)	0	0	0	5,414,007
(Undetermined coccoid 5–10 µm)	0	0	226,374	0
(Undetermined) sp.	2,793,433	0	0	0

Table 13. Biovolume data for algae taxa collected in DTH samples during NAWQA monitoring activities in Yosemite National Park near Happy Isles (HAPI) and Pohono (POHO) bridges, 1993-1995

[tax, refer to appendix for taxonomic name change. Measurements are in cubic micrometers per square centimeter; µm, micrometer]

Taxon	HAPI 1993	HAPI 1994	HAPI 1995	POHO 1995
	Bacillariophyta			
Achnanthes pseudolinearis	6,199,311	0	134,272	868,221
Achnanthidium minutissimum	71,009,675	154,995,150	11,042,584	6,996,467
Cocconeis placentula lineata	1,437,000	12,482,461	0	0
Encyonema minutum	0	0	3,029,779	890,498
Eunotia exigua	0	0	1,551,252	2,026,385
Fragilaria construens pumila	0	0	145,734	1,427,781
Fragilaria construens venter (tax)	0	0		97,939
Gomphonema parvulum	0	0	4,313,611	2,016,674
Navicula leptostriata	10,467,150	0	0	0
Navicula minima	1,045,454	0	0	252,601
Nitzschia kuetzingiana	0	658,369	236,603	148,354
Pseudostaurosira brevistriata	0	0	1,188,744	0
Sellaphora pupula	0	0	0	384,633
	Cyanophyta			
Oscillatoria sp. 1 (ansfwa)	1,607,913	5,114,320	1,830,373	476,954
	Rhodophyta			
Audouinella hermanii	0	0	0	790,607
	Unclassified			
(Undetermined cf. clastidium)	0	0	418,119	0
(Undetermined coccoid 1–3 µm)	0	0	102,851	0
(Undetermined coccoid 5–10 µm)	0	0	10,249,211	0

Table 14. Densities (rounded to the nearest whole number) of invertebrate taxa collected in richest targeted habitat samples in the upper Merced River drainage, 1993–1995

[See table 1 for site names corresponding to the site codes. Taxa shown are indented in the order phylum, class, order, family, and genus or species. Other taxonomic levels (identified in parentheses) were used as needed to display all data collected.The number in parentheses indicates the species codes used in the figures. Densities are measured in organisms per square meter, rounded to the nearest whole number. *, (asterisk) indicate groups included in canonical correspondence analyses]

Taxon	HAPI			POHO		H140	FRST	BRIC	TENU	TENL	SFUP	SFLO
	1993	1994	1995	1994	1995							
Platyhelminthes												
*Turbellaria (1)	0	0	0	0	0	4	64	16	0	0	0	0
*Nematoda (2)	0	2	0	0	9	8	0	0	0	0	0	0
Mollusca												
*Gastropoda (3)	0	0	0	0	0	0	0	0	0	0	0	68
Basommatophora												
Physidae		0	0	0	0	0	0	0	0	0	0	1
Annelida												
*Oligochaeta (4)	0	32	0	3	2	95	11	3	128	1	260	5
Haplotaxida												
Haplotaxidae	0	0	0	0	2	0	0	0	0	0	0	0
Enchytraeida												
Enchytraeidae	16	0	0	0	0	0	0	0	0	0	0	0
Arthropoda												
Chelicerata												
Acari												
*Hydrachnidia (5)	0	240	96	411	136	1,192	508	180	640	896	456	196
Insecta	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	0	624	0	128	0	72	0	0	0	192	193	128
*Leptophlebiidae (6)	52	65	32	65	8	0	0	0	192	128	66	0
Paraleptophlebia sp.	0	8	0	1	0	1	0	0	0	65	1	0
*Ephemerellidae (7)	6	403	2	7	8	0	64	16	256	192	652	0
Caudatella sp.	4	0	0	0	0	0	0	0	0	0	0	0
Caudatella californica (Allen and Edmunds)	0	0	1	0	0	0	0	0	0	0	0	0
Caudatella sp. nr. *hystrix* (Traver)	0	1	0	0	0	0	0	0	0	0	0	0
Drunella sp.	24	0	16	1	32	128	0	0	4	0	0	0
Drunella coloradensis (Dodds)	0	0	2	0	0	0	0	0	0	0	0	0
Drunella doddsi (Needham)	24	66	16	0	122	0	0	0	0	0	65	0
Drunella flavilinea (McDunnough)	0	0	2	0	0	0	0	0	0	0	0	0
Drunella spinifera (Needham)	0	3	0	0	0	0	0	0	0	0	0	0
Serratella sp.	0	64	0	2	1	0	0	0	0	0	1	4
Serratella tibialis (McDunnough)	56	0	33	64	48	0	0	0	4	65	0	0
*Baetidae (8)	2,646	432	612	395	622	942	994	549	65	65	976	728
Baetis sp.	33	0	1	0	8	0	0	1	0	0	0	0
Baetis tricaudatus Dodds	0	0	0	0	84	0	0	0	0	0	0	0
Siphlonuridae												

Table 14. Densities (rounded to the nearest whole number) of invertebrate taxa collected in richest targeted habitat samples in the upper Merced River drainage, 1993–1995—*Continued*

Taxon	HAPI			POHO		H140	FRST	BRIC	TENU	TENL	SFUP	SFLO
	1993	1994	1995	1994	1995							
**Ameletus* sp. (9)	0	33	0	4	65	0	0	0	131	132	0	0
*Heptageniidae (10)	368	647	0	390	164	777	1,465	1,220	513	320	456	395
Epeorus sp.	117	32	10	10	34	477	1,231	150	0	0	65	206
Rhithrogena sp.	208	227	167	131	169	4	192	131	65	0	64	2
Odonota												
Zygoptera (suborder)												
*Calopterygidae (11)	0	0	0	0	0	0	0	0	0	0	0	2
Hetaerina americana (Fabricius)	0	0	0	0	0	0	0	0	0	0	0	4
*Coenagrionidae (12)	0	0	0	0	0	0	0	0	0	0	0	265
Argia sp.	0	0	0	0	0	0	0	0	16	0	0	16
Anisoptera (suborder)												
*Corduliidae (13)	0	0	0	0	0	0	0	16	0	0	0	0
*Gomphidae (14)	0	0	0	0	0	5	0	0	0	0	0	0
*Libellulidae (15)	0	0	0	0	0	0	0	1	0	1	0	1
Brechmorhoga sp.	0		0	0	0	0	0	0	0	0	0	1
Paltothemis lineatipes Karsch	0	0	0	0	0	0	0	0	0	0	0	2
Plecoptera	0	32	0	130	48	324	408	16	64	0	0	0
*Chloroperlidae (16)	0	0	0	0	32	0	0	0	1	641	0	0
Suwallia sp.	0	0	0	0	4	0	0	0	0	0	0	0
Sweltsa sp.	20	0	21	1	0	0	0	0	0	265	3	0
*Nemouridae (17)	4	2	32	130	0	0	0	0	1,025	590	0	0
Amphinemura sp.	12	0	0	0	0	0	0	0	0	0	0	0
Malenka sp.	0	0	0	0	0	0	0	0	193	5	0	0
Zapada cinctipes (Banks)	0	0	0	0	28	0	0	0	0	0	0	0
Zapada sp.	24	0	0	0	40	0	0	0	0	24	0	0
*Perlidae (18)	57	35	1	1	10	0	1	0	64	0	13	0
Calineuria californica (Banks)	13	4	0	0	0	0	0	2	2	5	17	1
Claassenia sabulosa (Banks)	0	0	0	0	0	1	0	0	0	0	0	0
Doroneuria baumanni Stark and Gaufin	0	0	0	0	0	0	0	0	2	2	0	0
Hesperoperla sp.	5	1	1	27	0	6	2	0	0	0	0	0
Hesperoperla pacifica (Banks)	0	0	0	0	3	0	0	0	0	0	0	0
*Perlodidae (19)	0	2	0	134	8	470	8	0	64	0	0	0
Isoperla sp.	0	0	0	0	0	0	0	0	2	0	0	0
Oroperla barbara Needham	0	1	0	0	0	0	0	0	0	0	0	0
Perlinodes aureus (Smith)	4	7	0	74	16	0	0	0	1	0	64	0
Skwala sp.	21	7	0	81	65	11	11	10	2	2	320	67
Pteronarcyidae												
**Pteronarcys* sp. (20)	1	0	1	1	0	5	0	0	0	0	0	0
Pteronarcys californica Newport	0	0	0	0	0	3	2	0	0	0	0	0
Hemiptera												
Veliidae												

Table 14. Densities (rounded to the nearest whole number) of invertebrate taxa collected in richest targeted habitat samples in the upper Merced River drainage, 1993–1995—*Continued*

Taxon	HAPI			POHO		H140	FRST	BRIC	TENU	TENL	SFUP	SFLO
	1993	1994	1995	1994	1995							
Rhagoveliinae (subfamily)	0	0	0	1	0	0	0	0	0	0	0	0
Megaloptera												
*Corydalidae (21)	0	1	0	66	0	0	0	0	130	0	0	0
Corydalus texana Banks	0	0	0	0	0	0	0	2	0	0	0	9
Orohermes sp.	0	1	0	0	0	0	0	0	0	0	1	0
Orohermes crepusculus (Chandler)	2	0	1	0	0	0	0	0	1	0	0	0
*Neuroptera (22)	0	1	0	0	0	0	0	0	0	0	0	0
Trichoptera	0	12	0	0	8	0	64	0	156	2	11	0
*Glossosomatidae (23)	51	70	208	1	32	2	0	0	64	23	3	0
Agapetus sp.	2	0	0	0	8	0	0	0	68	3	64	0
Glossosoma sp.	10	1	80	0	17	0	0	0	4	3	0	0
*Brachycentridae (24)	0	0	0	194	16	0	0	0	256	128	6,184	0
Micrasema sp.	0	0	0	0	0	0	0	0	64	0	0	0
*Hydroptilidae (25)	0	0	0	0	0	4	0	0	64	64	132	326
Hydroptila sp.	0	0	0	0	0	0	0	0	0	0	257	0
Leucotrichia sp.	0	0	0	0	0	332	0	0	0	0	0	0
Neotrichia sp.	0	0	0	0	0	0	64	0	0	0	0	0
Ochrotrichia sp.	0	0	0	0	0	0	0	0	0	0	0	1
Rhyacophilidae	0	1	0	0	0	0	0	0	0	1	0	0
**Rhyacophila* sp. (26)	89	2	2	69	49	140	137	98	2	0	2	5
Rhyacophila sp. nr. *vuzana* Milne	4	0	0	0	0	0	0	0	0	0	0	0
Annulipalpia (suborder)												
*Philopotamidae (27)	0	0	0	66	1	0	1	0	0	0	0	16
Chimarra sp.	0	0	0	0	0	0	0	415	0	0	0	135
Dolophilodes sp.	112	1	72	138	62	0	1	0	0	0	2	0
Wormaldia sp.	0	0	0	0	41	0	0	0	0	0	0	0
*Hydropsychidae (28)	220	68	34	630	9	143	131	32	260	0	5	1,035
Arctopsychinae (subfamily)	32	0	0	0	0	0	0	0	0	0	0	0
Arctopsyche sp.	48	0	56	0	0	0	0	0	0	0	0	0
Arctopsyche californica Ling	0	231	10	1	0	0	0	0	1	0	0	0
Arctopsyche grandis (Banks)	46	0	0	0	0	4	2	0	0	0	0	0
Hydropsychinae (subfamily)												
Ceratopsyche sp.	18	197	0	64	0	64	0	0	0	0	65	0
Ceratopsyche cockerelli (Banks)	0	1	0	1	0	83	0	0	0	0	0	0
Ceratopsyche oslari (Banks)	0	1	0	0	0	0	0	0	0	0	0	0
Cheumatopsyche sp.	0	0	0	1	0	0	0	32	0	0	137	1
Hydropsyche sp.	0	0	0	67	0	844	403	80	0	0	0	70
Hydropsyche occidentalis Banks	0	0	0	0	2	0	0	0	0	0	0	1
Hydropsyche sp. nr. *occidentalis* Banks	0	0	0	0	0	0	0	0	0	0	0	3
Polycentropidae												

Table 14. Densities (rounded to the nearest whole number) of invertebrate taxa collected in richest targeted habitat samples in the upper Merced River drainage, 1993–1995—*Continued*

Taxon	HAPI			POHO		H140	FRST	BRIC	TENU	TENL	SFUP	SFLO
	1993	1994	1995	1994	1995							
**Polycentropus* sp. (29)	0	0	0	0	0	0	0	1	0	0	0	0
Integripalpia (suborder)	0	0	0	0	1	0	0	0	0	0	0	0
Limnephiloidea (superfamily)	110	0	57	0	14	0	0	0	0	0	0	0
Apataniidae	0	0	0	0	0	0	0	0	0	0	0	0
Pedomoecus sierra Ross	0	0	1	0	0	0	0	0	0	0	0	0
*Lepidostomatidae (30)	0	130	0	0	0	0	0	0	0	0	0	0
Lepidostoma sp.	0	0	0	0	0	0	0	0	998	1,428	875	0
*Limnephilidae (31)	0	0	0	0	1	0	0	0	0	0	0	0
Dicosmoecus gilvipes (Hagen)	0	0	0	6	3	9	0	0	0	0	0	0
*Uenoidae (32)	0	0	0	0	0	0	0	0	4	0	0	0
Helicopsychidae												
**Helicopsyche* sp. (33)	0	0	0	0	0	0	0	0	0	0	224	0
Lepidoptera												
Pyralidae												
**Petrophila* sp. (34)	0	0	0	0	0	201	64	16	0	0	0	0
Coleoptera												
*Dytiscidae (35)	0	0	0	0	0	0	0	0	0	2	0	0
*Elmidae (36)	6	68	0	328	32	135	196	16	0	0	2	1,055
Atractelmis wawona Chandler	0	0	0	1	0	0	0	0	0	0	0	0
Cleptelmis sp.	0	0	0	0	0	0	3	8	0	0	0	0
Cleptelmis addenda (Fall)	4	0	0	0	0	0	0	0	0	0	0	0
Climacia californica Chandler	0	0	0	0	0	0	0	16	0	0	0	0
Heterlimnius sp.	0	0	0	0	8	0	0	0	0	0	0	0
Lara sp.	4	0	0	0	0	0	0	0	0	0	0	0
Microcylloepus sp.	0	0	0	0	0	0	0	0	0	0	0	551
Microcylloepus pusillus (LeConte)	0	0	0	0	0	0	0	84	0	0	0	0
Narpus sp.	12	32	8	0	13	0	0	0	0	0	0	0
Optioservus sp.	48	1	34	68	90	204	128	16	0	128	0	129
Optioservus quadrimaculatus (Horn)	0	100	0	0	0	0	0	0	0	0	0	0
Ordobrevia nubifera (Fall)	20	170	16	70	68	0	1	0	0	64	326	64
Zaitzevia parvula (Horn)	129	139	16	211	44	282	154	340	1	68	132	172
Hydraenidae												
**Hydraena* sp. (37)	0	32	0	0	0	0	0	0	0	0	0	0
Psephenidae												
**Psephenus falli* Casey (38)	0	0	0	0	0	65	131	250	0	0	0	2
Ptilodactylidae												
**Stenocolus scutellaris* LeConte (39)	0	0	0	0	9	4	0	1	0	0	1	2
Diptera	0	64	0	2	0	0	4	0	129	0	64	16
*Athericidae (40)												
Atherix sp.	0	9	0	0	0	0	0	0	0	0	0	0
Atherix pachypus Bigot	16	0	19	0	0	0	0	0	0	0	0	0

Table 14. Densities (rounded to the nearest whole number) of invertebrate taxa collected in richest targeted habitat samples in the upper Merced River drainage, 1993–1995—

Taxon	HAPI			POHO		H140	FRST	BRIC	TENU	TENL	SFUP	SFLO
	1993	1994	1995	1994	1995							
*Blephariceridae (41)	0	0	0	0	0	130	65	0	0	0	0	130
Agathon sp.	0	0	0	0	0	0	0	32	0	0	0	0
Blephariceга sp.	0	0	0	0	0	0	0	1	0	0	0	0
*Ceratopogonidae (42)												
Atrichopogon sp.	0	0	0	1	0	151	76	16	0	0	0	1
Bezzia/Palpomyia sp.	0	0	0	0	0	0	0	0	1	0	4	0
*Chironomidae (43)	205	798	282	3,769	218	365	73	113	3,925	1,482	3731	281
Dixidae	0	0	0	1	0	151	76	16	0	0	0	0
**Dixa* sp. (44)	0	0	0	0	0	0	0	0	64	0	0	0
*Empididae (45)	0	0	0	2	0	2	68	0	0	0	0	0
Chelifera sp.	1	0	0	2	2	1	72	0	0	0	0	0
Clinocera sp.	0	1	0	0	0	0	0	0	0	0	0	0
Hemerodromia sp.	0	0	0	1	0	0	0	0	0	0	0	0
Wiedemannia sp.	0	1	0	0	0	0	0	0	0	0	0	0
Psychodidae												
**Maruina* sp. (46)	0	0	0	0	0	130	65	16	0	0	65	64
*Simuliidae (47)	1,776	134	34	656	340	196	412	997	1	1,172	0	1,414
Simulium sp.	0	0	0	0	18	0	0	0	0	0	0	0
Tipulidae												
**Antocha* sp. (48)	0	0	8	0	0	260	8	342	0	33	2	0
**Dicranota* sp. (49)	0	0	8	0	8	0	0	0	0	128	64	0
**Hexatoma* sp.												

Table 15. Principal component loadings for habitat and water quality variables from principal components analysis (PCA) of physical data from the 1994 ecological survey and additional data from near Happy Isles (HAPI in 1993 and 1995) and Pohono (POHO in 1995) bridges

[Bolded values had absolute values greater than 0.70 and were considered high. **, loadings with absolute values less than or equal to 0.30. mg $CaCO_3$/L, milligrams of calcium carbonate per liter; m, meters; km^2, square kilometers; m^3/s, cubic meters per second; mg/L, milligrams per liter; m/s, meters per second; µS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degree Celsius]

Variable	Principal Component Loadings				
	1	2	3	4	5
Alkalinity (mg $CaCO_3$/L)	**0.72**	0.52	**	**	**
Altitude (m)[1]	**–0.92**	**	**	**	**
Basin area (km^2)[1]	**0.75**	–0.36	**	**	**
Discharge (m^3/s)[1]	**	**–0.90**	**	**	**
Dissolved oxygen (mg/L)	**	**	**–0.70**	–0.62	**
Gradient (percent)[1]	**–0.71**	**	–0.46	**	**
Instream cover (percent area)[1]	–0.62	–0.59	**	**	0.39
Mean depth (m)[1]	0.53	**–0.79**	**	**	**
Mean velocity (m/s)	**	**–0.88**	**	0.37	**
Open canopy (percent)	**0.76**	**	–0.47	**	**
Oxygen saturation (percent)	0.49	–0.35	–0.57	–0.43	**
Mean dominant substrate	**	**	–0.54	**0.73**	0.36
Mean width (m)[1]	**	**–0.79**	**	**	–0.41
Sinuosity[1]	0.42	**	0.61	**	0.43
Specific conductance (µS/cm)[1]	**0.83**	**	**	**	**
pH[1]	**0.90**	**	**	**	**
Water temperature (°C)	**0.84**	**	**	0.40	**
Proportion of variance explained	0.37	0.22	0.14	0.09	0.06

[1]Variables were log10(x+1) transformed for analysis.

squawfish (*Ptychocheilus grandis*), and riffle sculpin (*Cottus gulosus*). Presumably, a similar high gradient area or other barrier also exists in the South Fork Merced River canyon. Smallmouth bass were the most abundant species at the two lowest elevation sites (table 9).

A total of 236 taxa of algae in seven divisions were identified from the QMH samples from the 1994 ecological survey, the additional POHO sample from 1995, and the HAPI samples from 1993 and 1995 (table 16). Diatoms comprised 64 percent (151) of the total number of taxa. Of the total algae taxa, 90, including 59 diatom taxa, were found in only one sample.

Canonical correspondence analysis (CCA) of the presence/absence data using all species indicated a separation of sites and taxa on the basis of specific conductance and discharge (fig. 3). Specific conductance was most important on the first CCA axis and discharge on the second (table 17). The CCA analysis was strongly influence by the presence of species found at a single site. The analysis was rerun using only species that were found at two or more sites. The results were similar (fig. 4), except the upper South Fork became more closely associated with the lower South Fork and the lower mainstem Merced River sites. Alkalinity was substituted for specific conductance in the model. Specific conductance and alkalinity were highly correlated, as indicated by high positive loadings on the first PC of the PCA of environmental variables (table 15). The results suggest that the main difference between the upper and lower South Fork Merced River sites was the presence of rare species that prefer the higher conductivities noted at the lower site (table 2).

An important feature of both models was the separation of the 1995 Happy Isles and Pohono samples from all other sites on the basis of discharge. Discharge in 1995 at both sites was more than twice the value measured in other years (table 2). This suggests that the differences in discharge and correlated habitat and water-quality variables may be important factors influencing the structure of the algae community in this system. The composition of the algae communities at Highway140, Foresta, and Briceburg were similar, indicating that the wastewater treatment plant was not having a measurable effect on the algae communities downstream of the plant.

A total of 147 invertebrate taxa, excluding unidentified Insecta, were identified from sampling

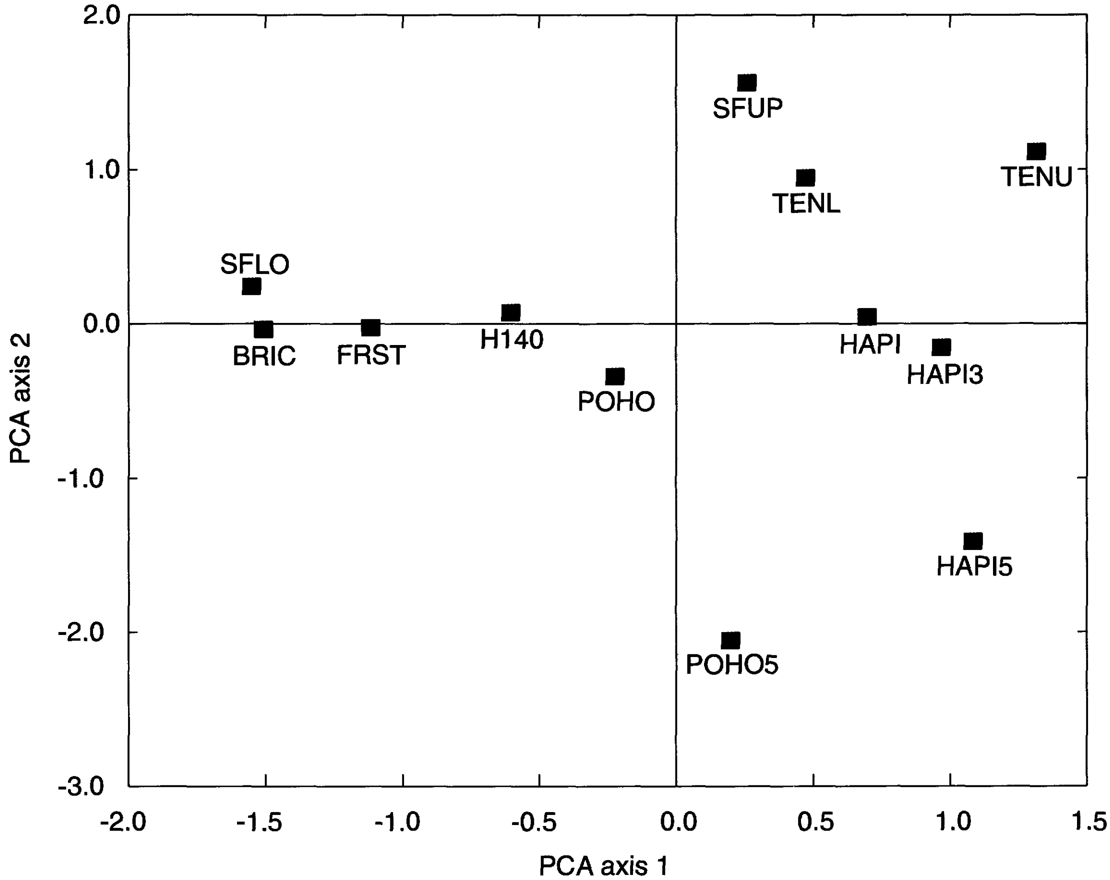

Figure 2. Site scores on the first two axes produced by a principle components analysis (PCA) of habitat and water quality data. Refer to table 1 for the full site names associated with the site codes. The analysis included data from sites in the 1994 ecological survey, plus additional data from near Happy Isles in 1993 (HAPI3)and 1995 (HAPI15) and Pohono in 1995 (POHO5).

sites in the upper Merced River system. At least one individual of 82 genera or species of aquatic insects were identified from the samples. Because of differences among taxa in taxonomic resolution, data were edited for multivariate analysis. Each taxonomic group was examined separately, and the taxonomic level containing the majority of the individuals identified was chosen for analysis. Taxonomic categories below the chosen level were aggregated into that level, and any taxonomic categories above that level were dropped from the analysis. In most instances, organisms were grouped into family level or higher categories for analysis (table 14).

Canonical correspondence analysis of the invertebrate data indicates that open canopy angle, elevation, specific conductance, and alkalinity are important factors in separating the species and sites (fig. 5). Open canopy angle and elevation are important on the first CCA axis and on several subsequent axes (table 17). Specific conductance is important on all axes except CCA axis 1. Alkalinity is only important on CCA axis 3. These variables are highly correlated with one another, as indicated by the PCA (table 15) and the similar trajectories of the vectors representing the physical variables (fig. 5). However, open canopy angle seems to provide important information independent of elevation. In particular, the Tenaya Creek sites had small open canopy angles, and the lower mainstem Merced River sites had large open canopy angles. These differences in riparian canopy can have a significant effect on instream temperature, primary productivity, and, consequently, invertebrate community structure.

Similar to the observations made with respect to the algae community, the grouping of sites Highway 140, Foresta, and Briceburg suggests that the wastewater treatment plant was not having a measurable effect on the invertebrate community during the study. In contrast to the algae, however, the invertebrate community was similar at the Happy Isles and

Table 16. Presence (1) or absence (0) of algae taxa collected in QMH samples for the 1994 ecological survey in the upper Merced River drainage

[Data from Happy Isles (HAPI) and Pohono (POHO) samples collected in 1993 or 1995 are also shown. See table 1 for site names corresponding to the site codes. QMH, qualitative multiple habitat. Taxon codes are used in figures 3 and 4. Total samples is the total number of samples in which a taxon occurred. tax, refer to appendix for taxonomic name change. µm, micrometer; >, greater than; nc, no code assigned]

Taxon	Taxon code	Total samples	HAPI			POHO		H140	FRST	BRIC	TENU	TENL	SFUP	SFLO
			1993	1994	1995	1994	1995							
Bacillariophyta														
Achnanthes bioreti	1	3	0	1	0	1	0	0	0	0	1	0	0	0
Achnanthes detha	2	6	1	1	1	0	1	0	0	1	0	1	0	0
Achnanthes helvetica	3	1	1	0	0	0	0	0	0	0	0	0	0	0
Achnanthes linearis	4	2	0	0	1	0	0	0	0	0	0	1	0	0
Achnanthes linearis curta	5	1	1	0	0	0	0	0	0	0	0	0	0	0
Achnanthes marginulata (tax)	6	5	1	1	1	0	1	0	0	0	0	1	0	0
Achnanthes pseudolinearis	7	7	1	0	1	0	0	1	1	1	0	0	1	1
Achnanthes recurvata	8	1	1	0	0	0	0	0	0	0	0	0	0	0
Achnanthes subhudsonis kraeuselii	9	4	0	0	0	1	0	1	1	1	0	0	0	0
Achnanthidium affine	10	3	0	1	1	0	1	0	0	0	0	0	0	0
Achnanthidium lanceolatum	11	3	1	0	0	0	1	0	0	0	0	1	0	0
Achnanthidium lanceolatum dubium (tax)	12	4	0	0	0	0	0	1	0	1	1	0	0	1
Achnanthidium minutissimum	13	12	1	1	1	1	1	1	1	1	1	1	1	1
Achnanthidium pusillum (tax)	14	2	1	0	0	0	0	0	0	0	0	1	0	0
Amphora ovalis pediculus	15	1	0	0	0	0	0	0	0	0	0	1	0	0
Amphora perpusilla	16	4	1	0	0	1	0	1	1	0	0	0	0	0
Aulacoseira alpigena	17	3	1	0	0	1	0	0	0	0	1	0	0	0
Aulacoseira ambigua	18	1	0	0	0	0	0	0	0	0	0	1	0	0
Aulacoseira distans	19	2	0	0	0	1	0	0	0	0	0	0	0	1
Aulacoseira distans nivalis	20	2	0	0	0	1	0	0	0	0	1	0	0	0
Aulacoseira distans nivaloides	21	1	0	0	0	1	0	0	0	0	0	0	0	0
Aulacoseira italica	22	1	0	0	0	0	0	0	0	0	0	1	0	0
Aulacoseira italica tenuissima	23	1	0	0	0	0	0	0	0	1	0	0	0	0
Bacillaria paxillifer	24	1	0	0	0	0	0	0	1	0	0	0	0	0
Brachysira brebissonii	25	5	1	1	1	1	0	0	0	0	1	0	0	0
Brachysira vitrea	26	5	1	1	1	0	1	0	0	0	0	1	0	0
Caloneis ventricosa	27	1	0	0	0	1	0	0	0	0	0	0	0	0
Caloneis ventricosa truncatula	28	1	0	0	0	0	0	0	0	0	0	1	0	0
Cocconeis placentula euglypta	29	4	0	0	0	0	0	1	1	1	0	0	0	1
Cocconeis placentula lineata	30	10	1	1	1	1	0	1	1	1	1	0	1	1
Craticula cuspidata	31	2	0	0	0	1	0	0	0	0	0	0	1	0
Cyclotella meneghiniana	32	1	0	0	0	0	0	0	0	1	0	0	0	0
Cymbella affinis	33	7	0	1	0	1	0	1	1	1	0	0	1	1
Cymbella cesatii (tax)	34	4	1	0	1	0	0	0	0	0	1	1	0	0
Cymbella hauckii	35	1	1	0	0	0	0	0	0	0	0	0	0	0
Cymbella hebridica	36	1	0	0	0	0	0	0	0	0	0	0	1	0

Table 16. Presence (1) or absence (0) of algae taxa collected in QMH samples for the 1994 ecological survey in the upper Merced River drainage—*Continued*

Taxon	Taxon code	Total samples	HAPI			POHO		H140	FRST	BRIC	TENU	TENL	SFUP	SFLO
			1993	1994	1995	1994	1995							
Cymbella lunata (tax)	37	7	1	1	1	0	0	0	0	0	1	1	1	1
Cymbella microcephala (tax)	38	4	0	0	1	0	1	0	0	0	0	0	1	1
Cymbella microcephala crassa	39	2	0	1	0	0	0	0	0	0	0	1	0	0
Cymbella minuta latens (tax)	40	1	1	0	0	0	0	0	0	0	0	0	0	0
Cymbella naviculiformis	41	3	0	0	0	1	0	0	0	0	1	1	0	0
Cymbella sp. 1 jck	42	2	0	1	0	1	0	0	0	0	0	0	0	0
Cymbella tumida	43	6	0	0	0	1	0	1	1	1	1	0	0	1
Diadesmis confervacea	44	1	0	0	0	0	0	0	0	1	0	0	0	0
Diatoma mesodon	45	5	1	0	1	0	1	0	0	0	1	1	0	0
Diploneis elliptica	46	4	0	0	0	1	0	1	1	0	0	1	0	0
Encyonema minutum	47	11	1	1	1	1	1	1	1	1	1	0	1	1
Epithemia adnata	48	1	0	0	0	0	0	1	0	0	0	0	0	0
Epithemia sorex	49	2	0	0	0	0	0	1	0	0	0	0	0	1
Epithemia turgida	50	4	0	0	0	0	0	0	1	0	0	1	1	1
Eunotia arcus	51	1	0	0	0	0	0	0	0	0	1	0	0	0
Eunotia curvata	52	3	0	0	0	0	1	0	0	0	1	1	0	0
Eunotia exigua	53	5	1	0	1	1	1	0	0	0	0	1	0	0
Eunotia flexuosa	54	2	0	1	0	0	0	0	0	0	0	1	0	0
Eunotia incisa	55	8	1	0	1	1	0	1	0	1	1	1	0	1
Eunotia microcephala	56	1	0	0	0	0	0	0	0	0	0	1	0	0
Eunotia monodon	57	1	0	0	1	0	0	0	0	0	0	0	0	0
Eunotia naegelii	58	2	0	0	1	0	1	0	0	0	0	0	0	0
Eunotia pectinalis minor	59	3	0	0	0	0	1	0	1	0	1	0	0	0
Eunotia perpusilla	60	5	0	0	1	1	1	0	0	1	0	1	0	0
Eunotia rhomboidea	61	1	0	0	0	0	0	0	0	0	1	0	0	0
Eunotia tenella	62	7	1	1	0	1	1	0	1	0	1	1	0	0
Fragilaria brevistriata inflata	63	2	0	0	0	0	0	0	0	1	0	0	0	1
Fragilaria capucina mesolepta	64	2	0	0	0	0	0	0	0	1	0	0	0	1
Fragilaria construens binodis (tax)	65	1	0	0	0	0	0	0	0	0	0	0	0	1
Fragilaria construens pumila	66	5	0	0	0	1	1	0	1	1	0	0	0	1
Fragilaria construens venter (tax)	67	3	0	0	1	0	1	0	0	0	0	0	0	1
Fragilaria crotonensis	68	3	0	1	0	0	0	0	0	1	0	0	0	1
Fragilaria vaucheriae	69	8	1	1	1	1	0	0	1	1	0	1	1	0
Fragilaria virescens exigua	70	1	0	0	0	0	0	0	0	0	0	0	0	1
Fragilariforma bicapitata	71	2	0	0	0	1	0	0	0	0	1	0	0	0
Fragilariforma virescens	72	3	0	0	0	1	0	1	0	0	1	0	0	0
Frustulia rhomboides	73	3	1	0	1	0	1	0	0	0	0	0	0	0
Frustulia rhomboides amphipleuroides	74	1	0	0	0	1	0	0	0	0	0	0	0	0
Frustulia rhomboides crassinervia	75	6	1	1	0	1	1	0	0	1	0	1	0	0
Frustulia rhomboides saxonica	76	1	1	0	0	0	0	0	0	0	0	0	0	0

Table 16. Presence (1) or absence (0) of algae taxa collected in QMH samples for the 1994 ecological survey in the upper Merced River drainage—*Continued*

Taxon	Taxon code	Total samples	HAPI			POHO		H140	FRST	BRIC	TENU	TENL	SFUP	SFLO
			1993	1994	1995	1994	1995							
Frustulia vulgaris	77	1	0	0	0	0	0	0	0	1	0	0	0	0
Gomphoneis herculeana	78	1	0	0	0	0	0	1	0	0	0	0	0	0
Gomphonema acuminatum	79	1	0	0	0	0	0	0	0	0	0	0	0	1
Gomphonema angustatum intermedia	80	2	0	0	0	0	0	0	1	0	0	0	1	0
Gomphonema augur	81	3	0	0	0	1	0	0	0	1	0	1	0	0
Gomphonema cf. *clevei*	82	9	1	1	1	1	0	1	1	1	0	0	1	1
Gomphonema parvulum	83	8	1	0	1	1	1	0	0	1	1	1	0	1
Gomphonema subclavatum	84	7	1	1	0	1	1	0	1	0	0	0	1	1
Gomphonema truncatum capitatum	85	3	1	0	0	0	0	0	0	0	0	0	1	1
Hannaea arcus	86	8	1	1	1	1	1	0	0	1	1	1	0	0
Hantzschia amphioxys	87	1	0	0	1	0	0	0	0	0	0	0	0	0
Luticola cohnii	88	1	0	0	0	0	1	0	0	0	0	0	0	0
Melosira nygaardii	89	1	0	0	0	0	0	0	1	0	0	0	0	0
Melosira varians	90	1	0	0	0	0	0	0	0	0	0	1	0	0
Meridion circulare	91	5	1	0	0	0	1	1	0	0	0	0	1	1
Navicula arvensis	92	3	1	0	1	0	0	0	0	0	0	0	0	1
Navicula bryophila	93	1	0	0	1	0	0	0	0	0	0	0	0	0
Navicula cincta rostrata	94	1	0	0	1	0	0	0	0	0	0	0	0	0
Navicula contenta biceps	95	1	0	0	0	0	0	1	0	0	0	0	0	0
Navicula cryptocephala	96	4	1	1	1	0	0	0	0	0	0	1	0	0
Navicula decussis (tax)	97	5	0	0	0	1	0	1	1	1	0	0	0	1
Navicula elginensis neglecta	98	1	0	0	0	0	0	0	0	1	0	0	0	0
Navicula leptostriata	99	11	1	1	1	1	0	1	1	1	1	1	1	1
Navicula minima	100	2	0	0	0	1	0	0	0	0	0	1	0	0
Navicula minuscula	101	1	0	0	0	0	0	0	0	0	0	0	0	1
Navicula pseudolanceolata	102	3	0	0	0	1	0	0	0	1	0	0	0	1
Navicula pseudoscutiformis	103	1	1	0	0	0	0	0	0	0	0	0	0	0
Navicula radiosa	104	1	0	0	0	0	0	0	0	0	0	0	1	0
Navicula radiosa tenella	105	1	0	0	0	0	0	0	0	0	0	1	0	0
Navicula rhynchocephala	106	1	0	0	0	1	0	0	0	0	0	0	0	0
Navicula rhynchocephala germainii	107	1	0	0	0	0	1	0	0	0	0	0	0	0
Navicula sp. 1 ans hdsn	108	1	0	0	0	0	0	0	0	0	0	0	0	1
Navicula submolesta	109	1	0	0	0	0	1	0	0	0	0	0	0	0
Navicula tantula	110	3	0	0	1	1	1	0	0	0	0	0	0	0
Navicula tripunctata schizonemoides	111	1	0	0	0	0	0	0	1	0	0	0	0	0
Navicula viridula argunensis	112	7	1	1	1	0	0	0	0	1	1	1	1	0
Navicula viridula linearis	113	3	0	0	0	0	0	0	1	1	0	0	0	1
Neidium affine longiceps	114	1	0	0	0	0	1	0	0	0	0	0	0	0
Neidium alpinum	115	2	0	0	1	0	1	0	0	0	0	0	0	0
Nitzschia acula	116	1	0	0	0	0	0	0	0	0	0	1	0	0
Nitzschia bacata	117	1	1	0	0	0	0	0	0	0	0	0	0	0

Table 16. Presence (1) or absence (0) of algae taxa collected in QMH samples for the 1994 ecological survey in the upper Merced River drainage—*Continued*

Taxon	Taxon code	Total samples	HAPI			POHO		H140	FRST	BRIC	TENU	TENL	SFUP	SFLO
			1993	1994	1995	1994	1995							
Nitzschia dissipata	118	3	1	0	1	0	1	0	0	0	0	0	0	0
Nitzschia frustulum	119	4	1	0	1	0	0	0	0	1	0	0	0	1
Nitzschia frustulum perminuta	120	2	0	0	0	0	0	0	1	0	0	0	0	1
Nitzschia frustulum subsalina	121	1	0	0	0	0	0	0	0	0	0	0	0	1
Nitzschia gracilis	122	1	0	0	1	0	0	0	0	0	0	0	0	0
Nitzschia kuetzingiana	123	6	1	0	0	0	0	1	1	1	0	1	0	1
Nitzschia romana	124	1	0	0	0	0	0	0	0	0	0	0	0	1
Nitzschia subtilis	125	1	0	0	1	0	0	0	0	0	0	0	0	0
Pinnularia abaujensis linearis	126	4	0	0	0	0	0	0	1	1	1	0	1	0
Pinnularia biceps	127	1	0	0	0	0	1	0	0	0	0	0	0	0
Pinnularia divergens	128	1	0	0	0	0	0	0	0	0	0	0	1	0
Pinnularia intermedia	129	2	0	0	0	1	1	0	0	0	0	0	0	0
Pinnularia major	130	6	0	0	0	1	0	1	1	0	1	1	0	1
Pinnularia mesogongyla	131	3	0	0	0	1	0	0	0	1	0	1	0	0
Pseudostaurosira brevistriata	132	4	0	0	0	0	1	0	1	1	0	0	0	1
Reimeria sinuata	133	1	0	0	0	0	0	0	0	0	1	0	0	0
Rhoicosphenia abbreviata	134	1	0	0	0	0	0	0	1	0	0	0	0	0
Rhopalodia gibba	135	2	0	0	0	0	0	0	0	0	0	1	0	1
Rhopalodia gibberula	136	1	0	0	0	0	0	0	0	0	0	0	0	1
Sellaphora pupula	137	6	1	1	0	1	0	0	0	1	0	1	0	1
Sellaphora pupula rectangularis	138	4	0	0	0	1	0	0	1	0	0	1	0	1
Stauroneis anceps	139	3	0	0	0	1	0	0	0	0	0	0	1	1
Stauroneis anceps americana	140	3	0	0	1	1	0	0	0	1	0	0	0	0
Stauroneis anceps gracilis	141	1	0	0	1	0	0	0	0	0	0	0	0	0
Stauroneis phoenicenteron	142	5	0	1	0	1	1	0	1	0	0	1	0	0
Staurosirella pinnata	143	4	0	1	0	1	0	0	0	1	0	0	0	1
Synedra minuscula	144	6	1	0	0	1	1	0	0	0	1	1	1	0
Synedra rumpens	145	6	1	0	1	1	1	0	0	1	0	1	0	0
Synedra rumpens familiaris	146	7	0	1	0	1	1	1	1	1	0	0	1	0
Synedra rumpens meneghiniana	147	4	1	1	0	1	0	0	0	0	0	0	1	0
Synedra ulna	148	12	1	1	1	1	1	1	1	1	1	1	1	1
Synedra ulna oxyrhynchus	149	3	0	0	0	1	0	0	0	1	0	0	1	0
Tabellaria fenestrata	150	1	0	0	1	0	0	0	0	0	0	0	0	0
Tabellaria flocculosa	151	6	1	1	1	0	1	0	0	0	1	1	0	0
Chlorophyta														
Ankistrodesmus falcatus	152	7	1	1	0	1	0	1	0	1	0	1	1	0
Ankistrodesmus spiralis	153	1	0	0	0	0	0	0	0	0	0	0	0	1
Chaetophora sp.	154	1	0	0	0	0	0	0	0	0	0	0	0	1
Chlamydomonas sp.	155	2	0	0	1	0	1	0	0	0	0	0	0	0

Table 16. Presence (1) or absence (0) of algae taxa collected in QMH samples for the 1994 ecological survey in the upper Merced River drainage—*Continued*

Taxon	Taxon code	Total samples	HAPI			POHO		H140	FRST	BRIC	TENU	TENL	SFUP	SFLO
			1993	1994	1995	1994	1995							
Cladophora sp.	156	1	0	0	0	0	0	0	0	0	0	0	0	1
Closterium dianae	157	2	0	0	0	0	0	0	0	0	0	1	0	1
Closterium intermedium	158	3	0	0	1	0	1	0	0	0	0	1	0	0
Closterium moniliferum	159	3	0	0	0	1	0	1	0	0	0	1	0	0
Closterium venus	160	2	1	0	0	0	0	0	0	0	0	1	0	0
Coelastrum cambricum	161	1	0	0	0	0	0	0	0	0	0	0	0	1
Coelastrum microporum	162	6	1	0	0	1	0	0	1	1	0	0	1	1
Cosmarium binum	163	1	0	0	0	0	0	0	0	0	0	0	0	1
Cosmarium bioculatum	164	1	0	1	0	0	0	0	0	0	0	0	0	0
Cosmarium granatum	165	1	0	0	0	0	0	0	0	0	0	1	0	0
Cosmarium hammeri schmidlei	166	1	0	0	0	0	0	0	0	0	0	0	0	1
Cosmarium regnesi	167	3	0	0	0	1	0	0	0	0	0	0	1	1
Cosmarium speciosum	168	1	1	0	0	0	0	0	0	0	0	0	0	0
Cosmarium subcrenatum	169	3	1	1	0	0	0	0	0	0	0	0	1	0
Crucigenia crucifera	170	1	0	0	0	0	0	0	0	1	0	0	0	0
Crucigenia fenestrata	171	1	0	0	0	0	0	0	0	0	0	0	0	1
Desmatractum bipyramidatum	172	1	0	0	0	0	0	0	0	0	0	0	0	1
Kirchneriella sp.	173	2	0	0	0	0	0	0	0	1	0	0	1	0
Microspora pachyderma	174	2	0	0	0	1	0	0	0	0	0	0	0	1
Microspora quadrata	175	1	0	0	0	1	0	0	0	0	0	0	0	0
Microspora stagnorum	176	1	0	0	0	1	0	0	0	0	0	0	0	0
Mougeotia sp.	177	6	0	0	1	1	0	0	0	1	0	1	1	1
Oedogonium sp.	178	4	0	0	0	0	0	0	1	1	0	0	1	1
Oocystis sp.	179	1	0	0	0	0	0	0	0	1	0	0	0	0
Pediastrum biradiatum	180	6	0	1	0	1	1	1	0	0	0	0	1	1
Pediastrum boryanum	181	2	0	0	0	0	0	0	0	1	0	0	0	1
Pediastrum duplex	182	1	0	0	0	0	0	1	0	0	0	0	0	0
Pediastrum tetras	183	5	0	1	0	0	0	1	1	1	0	0	0	1
Scenedesmus acuminatus	184	7	0	0	0	1	0	1	1	1	0	1	1	1
Scenedesmus acutus	185	6	0	0	1	1	0	1	1	1	0	0	1	0
Scenedesmus denticulatus	186	8	1	1	0	1	0	1	1	1	0	0	1	1
Scenedesmus ecornis	187	3	0	0	0	0	0	0	0	1	0	1	1	0
Scenedesmus ovalternus	188	1	0	0	0	0	0	0	0	0	0	0	0	1
Scenedesmus quadricauda	189	2	0	0	0	1	0	0	0	0	0	0	0	1
Scenedesmus spinosus	190	5	0	0	0	1	0	1	1	1	0	0	1	0
Sphaerozosma granulatum	191	2	0	0	0	1	0	0	0	1	0	0	0	0
Spirogyra sp.	192	9	1	1	0	1	1	1	1	1	0	0	1	1
Staurastrum alternans	193	2	0	0	0	1	0	1	0	0	0	0	0	0
Staurastrum coarctatum	194	2	0	0	0	0	0	0	0	1	0	0	0	1
Staurastrum dickiei	195	2	0	0	0	0	0	0	0	1	0	0	0	1
Staurastrum dilatatum	196	1	1	0	0	0	0	0	0	0	0	0	0	0

Table 16. Presence (1) or absence (0) of algae taxa collected in QMH samples for the 1994 ecological survey in the upper Merced River drainage—*Continued*

Taxon	Taxon code	Total samples	HAPI			POHO		H140	FRST	BRIC	TENU	TENL	SFUP	SFLO
			1993	1994	1995	1994	1995							
Staurastrum gracile nanum	197	1	0	0	0	0	0	0	0	0	0	0	0	1
Staurastrum granulosum	198	1	0	0	1	0	0	0	0	0	0	0	0	0
Staurastrum orbiculare	199	3	0	0	1	1	1	0	0	0	0	0	0	0
Staurastrum punctulatum	200	1	0	0	0	0	1	0	0	0	0	0	0	0
Staurastrum sp.	201	1	0	0	0	0	1	0	0	0	0	0	0	0
Stigeoclonium lubricum	202	2	0	0	0	1	0	0	1	0	0	0	0	0
Tetraedron caudatum	203	2	0	0	0	0	0	0	0	1	0	0	0	1
Tetraedron minimum	204	1	0	0	0	0	0	0	0	0	0	0	0	1
Ulothrix sp.	205	1	0	0	1	0	0	0	0	0	0	0	0	0
Ulothrix subconstricta	206	1	0	0	0	0	0	0	0	1	0	0	0	0
Ulothrix subtilissima	207	1	0	0	0	0	0	1	0	0	0	0	0	0
Ulothrix zonata	208	4	0	0	0	1	0	0	0	0	1	1	1	0
Zygnema sp.	209	5	1	1	1	0	1	0	0	1	0	0	0	0
Chrysophyta														
Dinobryon sp.	210	1	0	0	0	0	0	0	0	0	0	0	0	1
Cyanodophyta														
Anabaena sp.	211	8	0	0	1	1	1	1	0	1	0	1	1	1
Calothrix parietina	212	3	0	0	0	1	0	1	1	0	0	0	0	0
Chamaesiphon incrustans	213	1	0	0	0	0	0	0	0	0	0	1	0	0
Coelosphaerium kuetzingianum	214	1	0	0	0	0	0	0	0	1	0	0	0	0
Hydrocoleum brebissonii	215	6	0	0	1	1	0	1	1	1	0	0	1	0
Lyngbya aerugineo-caerulea	216	1	0	0	0	0	0	0	1	0	0	0	0	0
Nostoc sp.	217	2	0	0	0	0	0	0	0	0	0	1	0	1
Oscillatoria curviceps	218	1	0	0	0	0	0	0	0	1	0	0	0	0
Oscillatoria limnetica	219	5	0	0	1	0	0	1	1	1	0	1	0	0
Oscillatoria prolifica	220	1	0	0	1	0	0	0	0	0	0	0	0	0
Oscillatoria sp.	221	2	1	0	1	0	0	0	0	0	0	0	0	0
Oscillatoria sp. 1 (ansfwa)	222	12	1	1	1	1	1	1	1	1	1	1	1	1
Oscillatoria sp. 1 anslap	223	1	0	0	1	0	0	0	0	0	0	0	0	0
Oscillatoria subbrevis	224	1	0	0	0	0	0	1	0	0	0	0	0	0
Schizothrix arenaria	225	1	0	0	0	0	0	0	0	0	0	1	0	0
Euglenophyta														
Euglena sp.	226	3	0	0	1	1	0	0	1	0	0	0	0	0
Lepocinclis sp.	227	1	0	0	0	0	0	0	0	0	0	1	0	0
Trachelomonas atomaria	228	3	0	0	0	0	0	0	0	1	0	0	1	1
Trachelomonas hispida	229	1	0	0	0	0	0	0	0	0	0	1	0	0
Trachelomonas hispida coronata	230	1	0	0	0	0	0	0	0	0	0	1	0	0

Table 16. Presence (1) or absence (0) of algae taxa collected in QMH samples for the 1994 ecological survey in the upper Merced River drainage—*Continued*

Taxon	Taxon code	Total samples	HAPI			POHO		H140	FRST	BRIC	TENU	TENL	SFUP	SFLO
			1993	1994	1995	1994	1995							
Trachelomonas intermedia	231	1	0	0	0	1	0	0	0	0	0	0	0	0
Trachelomonas sp.	232	1	0	0	0	0	0	0	0	0	0	0	0	1
Trachelomonas volvocina	233	2	1	0	0	0	0	0	0	0	0	1	0	0
Pyrrophyta														
Glenodinium sp.	234	2	0	0	0	1	0	0	0	0	0	0	0	1
Rhodophyta														
Audouinella hermanii	235	3	0	0	0	1	0	0	0	0	1	1	0	0
Batrachospermum sp.	236	1	0	0	0	0	0	0	0	0	1	0	0	0
Unclassified														
(Undetermined coccoid 1-3 µm)	nc	3	1	0	0	0	0	1	1	0	0	0	0	0
(Undetermined coccoid 3-5 µm)	nc	6	1	0	0	0	1	1	1	0	1	0	1	0
(Undetermined coccoid 5-10 µm)	nc	6	1	0	0	0	1	0	1	1	0	0	1	1
(Undetermined coccoid >10 µm)	nc	3	1	0	1	0	0	0	0	1	0	0	0	0
(Undetermined filamentous) sp. 1 anslap	nc	1	0	0	0	0	0	0	0	0	0	0	0	1
(Undetermined flagellate)	nc	2	1	0	0	0	0	1	0	0	0	0	0	0
(Undetermined) sp.	nc	1	0	0	0	0	0	0	1	0	0	0	0	0

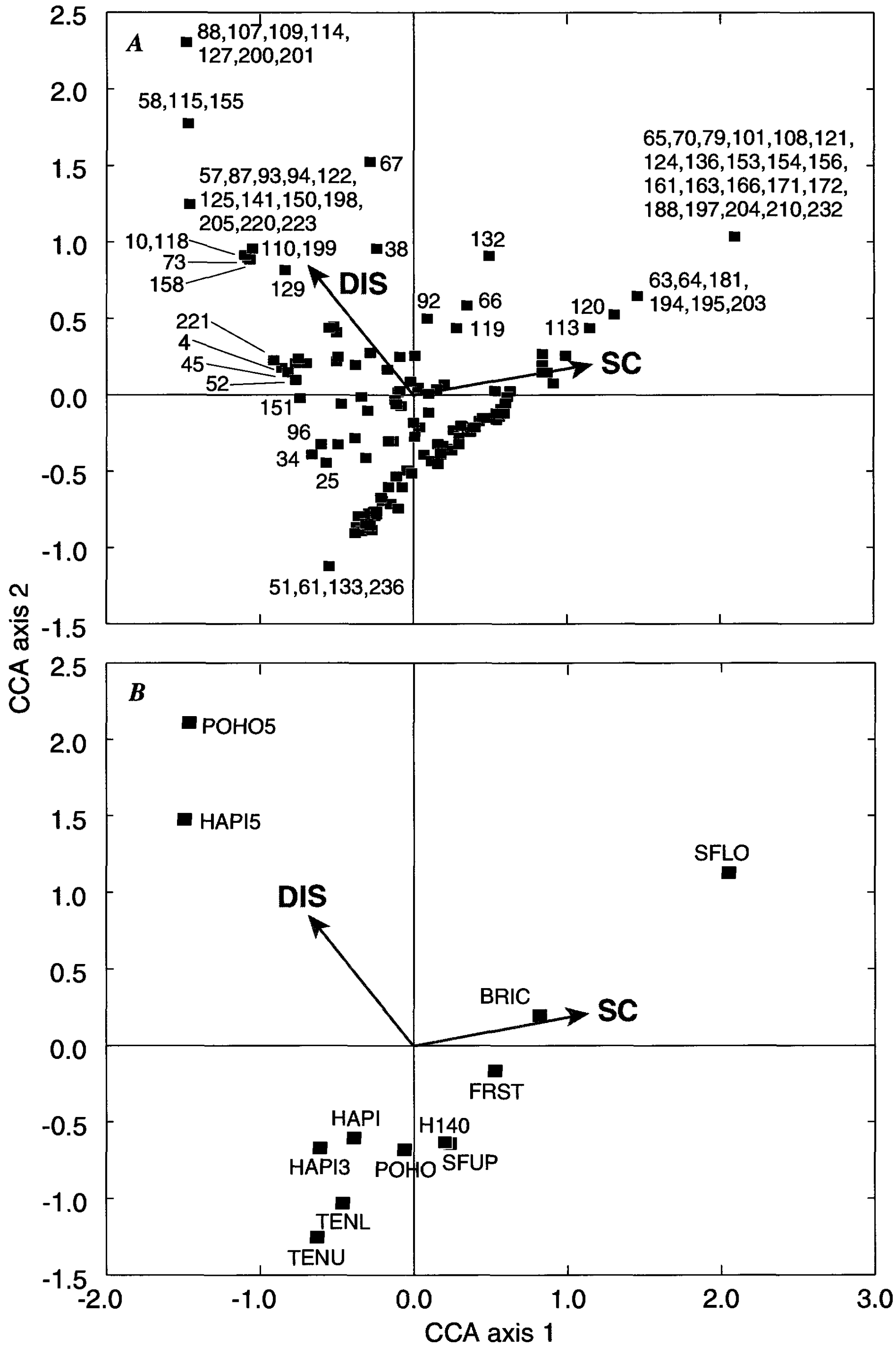

Figure 3. Plots of taxa scores (*A*) and site scores (*B*) on the first two axes derived from a canonical correspondence analysis (CCA) of algae presence/absence for all algae taxa found and environmental variables. Refer to table 16 for the algae taxa associated with the taxa codes. Refer to table 1 for the full site names associated with the site codes. The analysis included data from sites in the 1994 ecological survey, plus additional data from Happy Isles in 1993 (HAPI3) and 1995 (HAPI5) and Pohono in 1995 (POHO5). The labeled arrows show associations of taxa and site scores with environmental variables. The environmental variables shown were significant in the CCA model (table 17) and include discharge (DIS) and specific conductance (SPC). The value of the environmental variable increases in the direction the arrow is pointing. The length of the arrow reflects the importance of the variable in the CCA model.

Table 17. Results of canonical correspondence analysis for environmental variables

[nd, no data]

Environmental Variable	Eigen Value	Canonical Coefficient			
		Axis 1	Axis 2	Axis 3	Axis 4
All Algae Taxa					
Specific conductance	0.45	[1]0.89	[1]0.71	nd	nd
Discharge	0.34	[1]–0.21	[1]1.11	nd	nd
Percentage of species variance explained		15.1	11.2	nd	nd
Percentage of species-environment relation explained		57.4	42.6	nd	nd
Algae Taxa Present At Two Or More Sites					
Alkalinity	0.32	[1]–0.84	[1]0.85	nd	nd
Discharge	0.20	[1]0.26	[1]1.17	nd	nd
Percentage of species variance explained		18.7	11.3	nd	nd
Percentage of species-environment relation explained		62.5	37.5	nd	nd
All Invertebrate Taxa					
Open canopy angle	0.27	0.49	–0.65	[1]-0.26	1.29
Specific conductance	0.12	[1]–0.03	1.19	–1.54	0.55
Elevation	0.11	–0.62	[1]0.46	[1]0.49	1.73
Alkalinity	0.10	[1]–0.03	[1]0.31	1.56	[1]0.09
Percentage of species variance explained		31.0	12.3	10.3	8.2
Percentage of species-environment relation explained		50.2	19.8	16.7	13.3

[1]T-value for the canonical coefficient was less than 2.1, indicating that the variable did not make an important contribution to the canonical axis (ter Braak 1987).

Pohono sites during 1994 and 1995. Accordingly, the invertebrate community appears to be much less responsive than the algae community to stream discharge conditions.

Specific conductance was generally low throughout the mainstem Merced and South Fork Merced drainages; however, relatively high specific conductance at lower South Fork suggests possible geologic differences between drainages or, perhaps, some effects of evaporation during the summer. The PCA results highlighted distinct differences in habitat and water quality; however, many of the variables were correlated with elevation, suggesting an elevational gradient rather than site-specific differences in physical and chemical characteristics.

Fish assemblages have been shown to vary with habitat and water quality characteristics in low elevation areas within the San Joaquin River drainage (Brown, 1998); however, fishes do not seem to be an appropriate indicator of environmental conditions in the Park. In the lower elevation areas, species richness was higher, and fish community structure did show some differences among sites. The low species richness within the Park makes it difficult to use the fish community as a bioindicator, especially given the generally good environmental conditions at all sites. Differences might exist in species density, age structure, or fish condition (health) among sites, but the expense involved with such detailed evaluations probably make them impractical for long-term monitoring of environmental quality.

The differences in fish communities between the sites downstream of El Portal and the higher elevation sites are very pronounced and likely due to hydrologic factors associated with differences in physical conditions, particularly gradient, rather than environmental quality. Fish community data from the lower reaches suggest an ecological effect of smallmouth bass on the native species probably because of predation. However, the strength of this effect in any particular year probably is influenced by an interaction of flow regime with the ability of smallmouth bass to invade the system from the downstream reservoir (McClure Reservoir). Recent studies suggest that California stream fish communities remain intact in streams where the natural hydrology is maintained because exotic species are unable to invade such systems (Moyle and Light, 1996a,b; Brown and Moyle, 1997).

Canonical correspondence analysis indicated that the algae community was definitely correlated to the physical environment. Algae community structure showed changes correlated to specific conductance or alkalinity within the 1994 data. Community structure also was influenced by discharge as illustrated by the

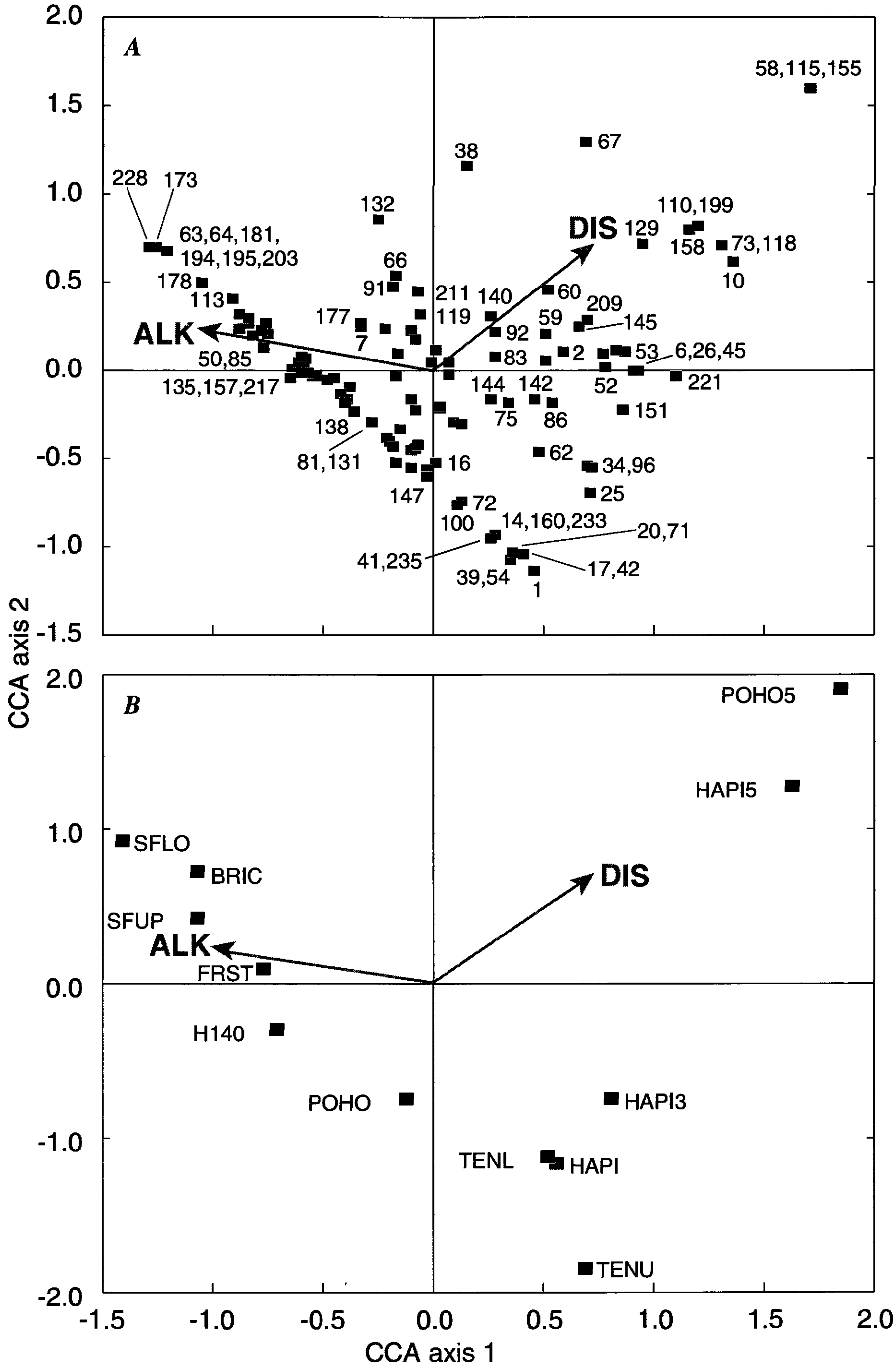

Figure 4. Plots of taxa scores (*A*) and site scores (*B*) on the first two axes derived from a canonical correspondence analysis (CCA) of algae presence/absence for all algae taxa found at two or more sites and environmental variables. Refer to table 16 for the algae taxa associated with the taxa codes. Refer to table 1 for the full site names associated with the site codes. The analysis included data from sites in the 1994 ecological survey, plus additional data from Happy Isles in 1993 (HAPI3) and 1995 (HAPI5) and Pohono in 1995 (POHO5). The labeled arrows show associations of taxa and site scores with environmental variables. The environmental variables shown were significant in the CCA model (table 17) and include discharge (DIS) and alkalinity (ALK). The value of the environmental variable increases in the direction the arrow is pointing. The length of the arrow reflects the importance of the variable in the CCA model.

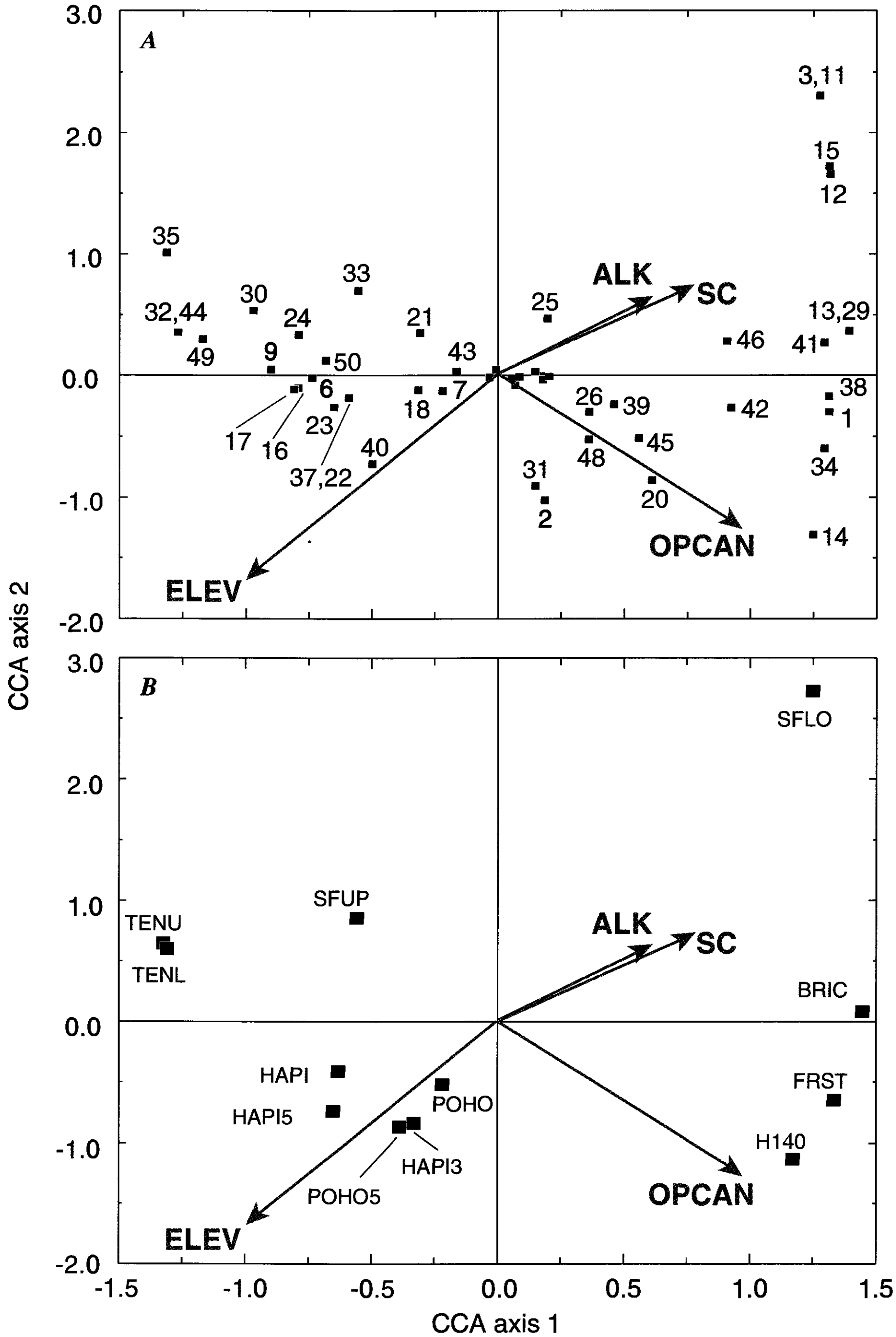

Figure 5. Plots of taxa scores (*A*) and site scores (*B*) on the first two axes derived from a canonical correspondence analysis (CCA) of invertebrate taxa density and environmental variables. Refer to table 14 for the invertebrate taxa associated with the taxa codes. Refer to table 1 for the full site names associated with the site codes. The analysis included data from sites in the 1994 ecological survey, plus additional data from Happy Isles in 1993 (HAPI3) and 1995 (HAPI5) and Pohono in 1995 (POHO5). The labeled arrows show associations of taxa and site scores with environmental variables. The environmental variables shown were significant in the CCA model (table 17) and include alkalinity (ALK), elevation (ELEV), open canopy angle (OPCAN), and specific conductance (SC). The value of the environmental variable increases in the direction the arrow is pointing. The length of the arrow reflects the importance of the variable in the CCA model.

outlying position of the 1995 data from Happy Isles and Pohono. Principal components analysis indicates that the differences in algae communities among sites sampled in 1994 are likely due to water quality and habitat changes correlated with specific conductance or alkalinity, rather than those variables in particular. Similarly, many of the variables were correlated with elevation, suggesting a general elevational gradient. The sensitivity of the algae community to annual variations in discharge suggests that algae studies might be most useful when used for comparisons among locations within a single short time period when hydrologic conditions are relatively constant. Otherwise, large annual fluctuations in discharge might mask any response of the algae community to more subtle changes in water quality or habitat conditions.

In contrast, the invertebrate community did not appear as responsive to spatial and short-term temporal changes in discharge. The differences between the algae and invertebrate communities with respect to stream discharge suggests that invertebrates may be a more appropriate biomonitor of long-term (annual) trends in environmental quality. Similar to the results found in the analysis of the algae community data, many of the environmental variables identified as important in the analysis of the invertebrate community data are correlated with elevation; however, the independent importance of open canopy angle suggests that the invertebrate community may be responding to other related factors such as food resource availability and temperature.

Algae Study

Most water-quality conditions were similar among sites included in the study. Specific conductance and total dissolved solids did increase in the downstream direction, but the overall range in values was small for both variables in 1995 (12–19 µS/cm and 7–21 mg/L, respectively) (table 2). Nutrient concentrations were consistently less than the analytical detection limit (table 3). Calcium, magnesium, sodium, potassium, sulfate, silica, and manganese tended to increase in the downstream direction, as would be expected from the pattern in total dissolved solids and specific conductance.

Overall, habitat conditions were similar among sites. The most notable differences were observed for open canopy angle, percent canopy density, and dominant substrate type (tables 4 and 5). In particular, sand was the dominant substrate at Lodge and sites on the Merced River above Sentinel Creek, below El Capitan Bridge, and below Eagle Creek, hereinafter referred to simply as "Sentinel", "El Capitan", and "Eagle", respectively (site codes used in table 1 are SENT, ELCP, and EAGL, respectively). Differences did not seem to follow an elevational gradient.

Analysis of variance indicated significant differences among sites in chlorophyll-*a*, pheophytin-*a*, absorbance ratio, and ash-free dry mass (table 18). Chlorophyll-*a* and pheophytin-*a* generally were lowest at the most upstream sites, with Happy Isles, Clarks, Lodge, and Sentinel having the lowest values for both pigments. Patterns in AFDM were less clear because Sentinel, a site with low concentrations of pigment, had a high value for AFDM. The results of the chlorophyll-*a* and pheophytin-*a* absorbance ratio analyses indicated that the algae communities were in good physiological condition at all sites. The lack of large differences among sites for all the variables is indicated by the large overlap among the groups identified by the Neuman-Keul's Studentized Range Test. Furthermore, these results are consistent with the results for water quality and are indicative of a river unimpaired by chemical or physical degradation.

Both chlorophyll-*a* and pheophytin-*a* were positively correlated to AFDM ($r=0.50$ and 0.43, respectively, both $p<0.01$). Chlorophyll-*a* and pheophytin-*a* were also positively correlated ($r=0.70$, $p<0.001$). Absorbance ratio was negatively correlated to pheophytin-*a* ($r=-0.64$, $p<0.001$), suggesting that changes in the ratio primarily were due to pheophytin-*a* concentrations.

Chlorophyll-*a*, pheophytin-*a*, absorbance ratio, and AFDM (mean values at a site) exhibited few correlations with the physical variables. Chlorophyll-*a* was positively correlated to mean water velocity ($r=0.71$, $p<0.05$) and mean depth of the collection site ($r=0.83$, $p<0.05$). Pheophytin-*a* was also positively correlated to water depth of the collection site ($r=0.96$, $p<0.05$). Absorbance ratio was negatively correlated to depth of the primary sampling riffle ($r=-0.79$, $p<0.05$). AFDM was not significantly correlated to any of the physical variables. Chlorophyll-*a* and pheophytin-*a* were also positively correlated to total biovolume measured at a site ($r=0.86$, $p<0.01$ and $r=0.74$, $p<0.05$).

A total of 102 algae taxa, including 88 taxa of diatoms, were collected in the 1995 algae study RTH samples (table 19). A total of 40 taxa were found in only one sample, including 34 of the diatom taxa.

Table 18. Chlorophyll-*a*, pheophytin-*a*, absorbance ratio, and ash-free dry mass (mean±1 standard deviation) from algae samples collected September 13–15 during the 1995 algae study

[Site code: See table 1 for full site names. Letters within columns indicate means that were not significantly different on the basis of the Newman-Keul's Studentized Range Test. Mean values of transformed data were compared among sites with one-way analysis of variance. mg/m^2, milligram per square meter; g/m^2, gram per square meter]

Site	Chlorophyll-*a*[1] (mg/m^2)	Pheophytin-*a*[2] (mg/m^2)	Absorbance Ratio[1]	Ash-Free Dry Mass[2] (g/m^2)
HAPI	1.70±0.23 A	0.16±0.15 A	1.57±0.16 AB	1.16±0.25 A
CLRK	2.03±0.91 A	0.04±0.09 A	1.69±0.05 BC	1.70±0.58 A
LODG	0.60±0.16 B	0.02±0.03 A	1.84±0.1 C	1.59±0.14 A
SENT	1.67±0.92 A	0.18±0.18 A	1.71±0.16 BC	2.87±0.61 B
EAGL	5.06±2.27 C	1.23±0.65 B	1.53±0.04 AB	2.83±1.05 B
ELCP	1.85±0.20 A	0.86±0.18 B	1.48±0.04 A	1.89±0.36 A
BRID	9.86±2.33 D	1.15±0.45 B	1.63±0.01 AB	2.66±0.53 B
POHO	3.54±1.37 C	0.71±0.50 B	1.58±0.07 AB	1.52±0.29 A

[1]Data were log(x+1) transformed for analysis of variance.
[2]Data were $(x)^{0.5}+(x+1)^{0.5}$ transformed for analysis of variance.

Only 29 taxa, including 17 diatom taxa, occurred in sufficient abundance to be included for multivariate analysis. Biovolume data were only available for 12 taxa, including 10 diatom taxa. Correspondence analyses of the log-transformed density and biovolume data did not reveal consistent differences in density or biovolume among sites. Analysis of species densities indicated that Clarks and Happy Isles samples 1, 3, 4, and 5 were different. Happy Isles 3 was distinctive based on the presence of two green algae, *Stigeoclonium* sp. and *Zygnema* sp. *Zygnema* sp. was also present at Clarks, as was *Lyngbya* sp., a blue-green alga. Happy Isles 1,4, and 5 were distinctive because of high abundances of *Calothrix* sp., another blue-green alga. *Calothrix* sp. was also present at Clarks resulting in a close association with Happy Isles 1, 4, and 5.

Biovolume data separated two large groups. Each group contained one or more replicates from the three sites where five replicates were collected. The analysis indicates that Pohono 1 and El Capitan were very different from the other sites. Pohono 1 was distinctive because of the presence of two diatoms, *Navicula rhynchocephala germainii* and *Pseudostaurosira brevistriata*, that were not found in any other sample. ELCP was distinctive primarily because of the presence of the diatom *Melosira varians*. The only other site where *Melosira varians* was found was Pohono 1.

Correspondence analyses of percentage abundance based on abundance or biovolume data gave similar results. Only the percentage abundance data are discussed because the greater number of species in the abundance data set presumably gives that data set more power to show differences. Lodge 1 through 5 grouped closely with El Capitan (fig. 6). These sites were characterized by the presence of 19 of the 29 total algae taxa analyzed. Percentage abundances for most of these species were low (less than 1 percent), but many were not found at other sites (table 19). Pohono 1 through 5 grouped closely with the site on the Merced River at Bridalveil Moraine, hereinafter referred to simply as "Bridalveil" (site code used in table 1 is BRID). These sites were characterized by high percentage abundances of the blue-green algae *Oscillatoria* sp. 1 (ansfwa). *Lyngbya* sp. 1 (ansfwa) also was important because it occurred only in two Pohono samples. Clarks was unique based on the presence of the blue-green alga *Lyngbya* sp., which was found at no other site. Happy Isles was the most taxonomically variable site. Happy Isles 4 and 5 were most distinctive on the basis of high percentage abundances of *Calothrix* sp. and the diatom *Achnanthidium affine*. Happy Isles 1 was similar but had lower percentage abundances of these species. The algae community structure at Happy Isles 3 was different because of the absence of *Calothrix* sp., high percentage abundance of the diatom *Achnanthidium minutissimum*, and the presence of the green algae *Zygnema* sp. (also found at Clarks) and *Stigeoclonium* sp. (found in no other sample). Happy Isles 2 grouped more closely with Sentinel and Eagle than with the other Happy Isles samples. These sites were intermediate to the sites already discussed, occupying a central position in the plot; however, each was different based on differences in composition of the algal communities. Happy Isles 2 was characterized by high percentage abundance of *Oscillatoria* sp. 1 (ansfwa) and the presence of *Oscillatoria* sp., which was not found in any of the other Happy Isles samples. Sentinel was distinctive because of the presence of the blue-green algae *Chamaesiphon* sp. which was found only at Sentinel and Bridalveil. Eagle was distinctive because of the presence of *Hydrocoleum brebissonii*, which was found nowhere else.

Correspondence analyses of species occurrence data gives similar site groupings, but replicate samples collected at Pohono and Lodge are less tightly grouped than in the percentage abundance analysis. There are also a few other minor differences. Bridalveil was always closely linked to Pohono. El Capitan was most similar to Lodge. Eagle was similar to Lodge rather than being intermediate. Clarks was less distinct from Happy Isles, but Happy Isles remained the most taxonomically variable site. Sentinel and Happy Isles 2 maintained their central position in relation to the other sites.

The pattern of some sites with relatively even representation of taxa and other sites characterized by high percentages or the presence of one or a few taxa suggests that differences in species diversity might exist among sites. To assess this hypothesis, Shannon-Weaver diversity values and total species richness were compared using ANOVA at the three sites with replicate RTH samples—Happy Isles, Lodge, and Pohono. There were significant differences in species richness (ANOVA, $p<0.001$). On the basis of the Neuman-Keul's Studentized Range Test, Lodge had more species (31±5, mean±1 SD) than either Happy Isles (13±3) or Pohono (15±4). Happy Isles and Pohono were not significantly different. There were also statistically significant differences in diversity (ANOVA, $p<0.001$). Pohono had significantly lower diversity (0.69±0.17) than Happy Isles (1.29±0.09) and Lodge (1.57±0.32). Though diversity at Lodge was higher than at Happy Isles, the difference is not statistically significant.

As indicated by the CA analyses, the low diversity values were associated with high percentages of one or two species. At Pohono, *Oscillatoria* sp. 1 (ansfwa) made up 69 to 88 percent of each sample. At Happy Isles, two of the three species (*Achnanthidium minutissimum*, *Calothrix* sp., and *Oscillatoria* sp. 1 [ansfwa]) composed 63 to 84 percent of each sample. Variability among sites in the two most important taxa contributed to the differences among the Happy Isles samples. Lodge also had two species, *Achnanthidium minutissimum* and *Audouinella hermanii*, that tend to dominate the samples (43–81 percent) but, compared to the other two sites, always had a larger number of taxa with low to moderate percentage abundances.

Total taxa richness increased in the following order (means for sites with multiple samples): Happy Isles (13), Pohono (15), Bridalveil (17), Clarks (20), Sentinel (23), Eagle (31), Lodge (31), El Capitan (41). Diversity increased in the following order: Pohono (0.69), Bridalveil (1.01), Clarks (1.12), Eagle (1.24), Happy Isles (1.29), El Capitan (1.43), Lodge (1.57), and Sentinel (1.74).

Pearson product-moment correlations of total taxa richness and diversity with the physical variables and algae standing crop were calculated. Both total taxa richness and diversity were not significantly correlated with any measure of algae standing crop. Total taxa richness and diversity were not significantly correlated. Total taxa richness was significantly correlated to mean dominant substrate ($r=-0.82$, $p<0.05$), stream width ($r=0.76$, $p<0.05$), instream cover ($r=-0.75$, $p<0.05$) of the sampling reach, and canopy density at the collection site ($r=-0.74$, $p<0.05$). Diversity was significantly correlated to summer solar radiation ($r=0.81$, $p<0.05$), annual solar radiation ($r=0.85$, $p<0.01$), canopy density in the reach ($r=-0.84$, $p<0.05$), open canopy angle at the collection site ($r=0.78$, $p<0.05$), and biovolume ($r=-0.75$, $p<0.05$).

The high abundances of blue-green algae and the importance of these taxa in separating sites indicates that the Merced River in Yosemite Valley is a nutrient poor system, at least during the 1995 algae study. This is consistent with the results of dissolved nutrient analyses. Despite the nutrient poor environment, the algae communities appeared to be in good physiological condition. There were differences in absorbance ratio, but all sites had algae in good to excellent physiological condition and site groups broadly overlapped, indicating that the differences were not large and exhibited no strong pattern among sites.

Differences in measures of standing crop did not follow a simple gradient from Happy Isles to Pohono. Chlorophyll-*a* tended to be lowest at the upstream sites (Happy Isles, Clarks, Lodge, and Sentinel) and at the sites with sandy substrate (Lodge, Sentinel, and El Capitan). Eagle was the exception. Pheophytin-*a* was much lower at the upstream sites (Happy Isles to Sentinel). The pigments are positively correlated with each other and with biovolume, indicating that the differences are due to the abundance of algae cells.

Table 19. Algae taxa collected in richest targeted habitat samples during the 1995 algae study in Yosemite National Park

[Samples: number of samples in which a taxon was present. Sites: number of sites at which a taxon was present. See table 1 for site names corresponding to the site codes. X, taxon comprised 0.01 percent or greater of the abundance of all taxa; +, taxon comprised less than 0.01 percent of the abundance of all taxa. Superscripts indicate species that are included in the abundance (A) and biovolume (V) analyses; tax, refer to the appendix for taxonomic name change]

Taxon	Samples	Sites	HAPI					CLRK	LODG				
			1	2	3	4	5		1	2	3	4	5
Bacillariophyta													
Achnanthes bioreti	1	1	0	0	0	0	0	0	0	0	0	0	0
Achnanthes detha[A]	13	7	0	0	+	0	0	0	X	+	+	+	+
Achnanthes helvetica	2	2	0	0	0	0	0	0	+	0	+	0	0
Achnanthes linearis	3	2	0	0	0	0	0	0	0	0	+	0	+
Achnanthes marginulata (tax)	3	3	0	0	0	0	0	0	+	0	0	0	0
Achnanthes pseudolinearis[A,V]	17	7	+	+	+	0	0	0	X	X	X	X	X
Achnanthes recurvata	1	1	0	0	0	0	0	0	0	0	0	0	+
Achnanthidium affine[A]	11	6	+	X	X	X	X	+	0	0	+	+	0
Achnanthidium biporomum	1	1	0	0	0	0	0	0	0	0	0	0	0
Achnanthidium lanceolatum	3	3	0	0	0	0	0	0	+	0	0	0	0
Achnanthidium lanceolatum dubium (tax)	3	2	0	0	0	0	0	0	0	0	0	0	0
Achnanthidium minutissimum[A,V]	20	8	X	X	X	X	X	X	X	X	X	X	X
Amphora ovalis pediculus	1	1	0	0	0	0	0	+	0	0	0	0	0
Amphora perpusilla	4	4	0	0	0	0	0	0	0	0	0	+	0
Amphora submontana	1	1	0	0	0	0	0	0	0	0	0	0	0
Amphora veneta	4	4	0	+	0	0	0	0	0	0	0	0	+
Aulacoseira alpigena	3	2	0	0	0	0	0	0	0	+	+	0	0
Aulacoseira ambigua	1	1	0	0	0	0	0	0	0	0	0	0	0
Brachysira brebissonii	2	2	0	0	+	0	0	0	0	0	0	+	0
Brachysira vitrea	3	2	0	0	0	0	0	0	+	0	0	+	0
Cocconeis placentula lineata[V]	4	3	0	0	0	0	0	0	0	+	0	+	0
Cyclotella meneghiniana	1	1	0	0	0	0	0	0	0	0	0	0	0
Cyclotella pseudostelligera	1	1	0	0	0	0	0	0	0	0	0	0	0
Cymbella cesatii (tax)[A]	9	7	0	0	0	0	+	+	0	0	+	+	+
Cymbella lunata (tax)	4	3	0	0	+	0	0	0	+	0	0	+	0
Cymbella microcephala (tax)	3	3	0	0	0	0	0	0	0	0	+	0	0
Cymbella microcephala crassa	1	1	0	0	0	0	0	+	0	0	0	0	0
Cymbella naviculiformis	2	1	0	0	0	0	0	0	0	+	0	+	0
Diatoma mesodon	2	2	0	0	0	0	0	0	0	0	+	0	0
Diploneis elliptica	1	1	0	0	0	0	0	0	0	0	0	0	0
Encyonema minutum[A,V]	17	8	0	+	0	+	0	+	+	X	+	+	+
Eunotia exigua[A,V]	7	4	0	0	+	0	0	0	+	+	0	+	+
Eunotia incisa	6	3	0	+	0	0	0	+	+	0	+	0	+

Table 19. Algae taxa collected in richest targeted habitat samples during the 1995 algae study in Yosemite National Park—*Continued*

Taxon	SENT	EAGL	ELCP	BRID	POHO				
					1	2	3	4	5
Bacillariophyta									
Achnanthes bioreti	0	+	0	0	0	0	0	0	0
Achnanthes detha[A]	+	+	X	+	+	+	+	0	0
Achnanthes helvetica	0	0	+	0	0	0	0	0	0
Achnanthes linearis	0	+	0	0	0	0	0	0	0
Achnanthes marginulata (tax)	0	0	+	0	+	0	0	0	0
Achnanthes pseudolinearis[A,V]	X	+	X	+	+	+	+	+	+
Achnanthes recurvata	0	0	0	0	0	0	0	0	0
Achnanthidium affine[A]	+	+	+	0	0	0	0	0	0
Achnanthidium biporomum	0	+	0	0	0	0	0	0	0
Achnanthidium lanceolatum	0	+	+	0	0	0	0	0	0
Achnanthidium lanceolatum dubium (tax)	+	0	0	0	+	0	0	0	+
Achnanthidium minutissimum[A,V]	X	X	X	X	X	X	X	X	X
Amphora ovalis pediculus	0	0	0	0	0	0	0	0	0
Amphora perpusilla	0	+	+	0	0	0	0	0	+
Amphora submontana	0	0	+	0	0	0	0	0	0
Amphora veneta	+	+	0	0	0	0	0	0	0
Aulacoseira alpigena	0	0	+	0	0	0	0	0	0
Aulacoseira ambigua	0	0	+	0	0	0	0	0	0
Brachysira brebissonii	0	0	0	0	0	0	0	0	0
Brachysira vitrea	0	+	0	0	0	0	0	0	0
*Cocconeis placentula lineata*V	0	0	+	0	0	0	0	+	0
Cyclotella meneghiniana	0	+	0	0	0	0	0	0	0
Cyclotella pseudostelligera	+	0	0	0	0	0	0	0	0
Cymbella cesatii (tax)[A]	+	0	+	+	0	0	0	+	0
Cymbella lunata (tax)	0	0	0	0	0	0	+	0	0
Cymbella microcephala (tax)	0	+	0	0	0	+	0	0	0
Cymbella microcephala crassa	0	0	0	0	0	0	0	0	0
Cymbella naviculiformis	0	0	0	0	0	0	0	0	0
Diatoma mesodon	0	0	+	0	0	0	0	0	0
Diploneis elliptica	0	0	+	0	0	0	0	0	0
Encyonema minutum[A,V]	+	+	+	+	+	+	+	+	+
Eunotia exigua[A,V]	0	+	+	0	0	0	0	0	0
Eunotia incisa	+	0	0	0	0	0	0	0	0

Table 19. Algae taxa collected in richest targeted habitat samples during the 1995 algae study in Yosemite National Park—*Continued*

Taxon	Samples	Sites	HAPI					CLRK	LODG				
			1	2	3	4	5		1	2	3	4	5
Eunotia pectinalis minor[A]	8	5	0	0	0	0	0	0	0	+	+	+	+
Eunotia perpusilla	3	3	0	0	0	0	0	0	0	0	0	+	0
Eunotia tenella[A]	15	7	+	0	0	0	0	0	+	X	+	+	+
Fragilaria brevistriata inflata	2	2	0	0	0	0	0	0	+	0	0	0	0
Fragilaria construens venter (tax)	2	2	0	0	0	0	0	0	0	0	0	0	0
Fragilaria vaucheriae[A]	8	4	0	0	0	0	+	0	+	+	+	+	+
Fragilariforma virescens	1	1	0	0	0	0	0	0	0	+	0	0	0
Frustulia rhomboides crassinervia	3	2	0	0	+	0	0	0	0	0	0	+	+
Frustulia vulgaris	1	1	0	0	0	0	0	0	0	0	0	+	0
Gomphonema angustatum intermedia	1	1	0	0	0	0	0	0	0	0	0	0	0
Gomphonema cf. *clevei*[A]	8	5	0	0	0	0	0	+	0	+	+	0	0
Gomphonema grunowii	3	2	0	0	+	0	+	0	0	0	+	0	0
Gomphonema olivaceum	2	2	0	0	0	0	0	0	0	0	0	+	0
Gomphonema parvulum[A,V]	20	8	+	+	+	+	+	+	X	X	X	X	X
Gomphonema subclavatum[A]	16	8	0	+	0	0	+	+	+	+	+	+	+
Hannaea arcus[A]	14	7	0	0	0	0	+	+	+	+	+	+	+
Melosira varians[V]	2	2	0	0	0	0	0	0	0	0	0	0	0
Meridion circulare	1	1	0	0	0	0	0	0	0	0	0	0	+
Navicula cincta rostrata	1	1	0	0	0	0	0	0	0	0	+	0	0
Navicula cryptocephala	5	3	0	0	0	0	0	0	0	+	+	0	+
Navicula leptostriata	3	2	0	0	0	0	0	0	0	+	0	0	+
Navicula menisculus	2	2	0	+	0	0	0	0	0	0	+	0	0
Navicula minima[A]	5	4	0	0	0	0	0	0	0	0	0	0	+
Navicula rhynchocephala germainii[V]	1	1	0	0	0	0	0	0	0	0	0	0	0
Navicula secreta apiculata	1	1	0	0	0	0	0	0	+	0	0	0	0
Navicula sp. 1 ans hdsn	2	2	0	+	0	0	0	0	0	+	0	0	0
Navicula viridula argunensis	1	1	0	0	0	0	0	0	0	0	0	0	+
Navicula viridula linearis	1	1	0	0	0	0	0	0	0	0	+	0	0
Neidium alpinum	1	1	0	0	0	0	0	0	0	0	0	0	0
Neidium bisulcatum	1	1	0	0	0	0	0	0	0	0	+	0	0
Nitzschia amphibia	1	1	0	0	0	0	0	+	0	0	0	0	0
Nitzschia dissipata	1	1	0	0	0	0	0	0	0	0	0	0	0
Nitzschia frustulum	3	3	0	+	0	0	0	0	0	0	0	+	0
Nitzschia frustulum perminuta	3	3	0	+	0	0	0	0	0	0	0	+	0
Nitzschia frustulum subsalina	1	1	0	0	+	0	0	0	0	0	0	0	0
Nitzschia kuetzingiana	1	1	0	0	0	0	0	0	0	0	0	0	+
Nitzschia palea	1	1	0	0	0	0	0	0	+	0	0	0	0

Table 19. Algae taxa collected in richest targeted habitat samples during the 1995 algae study in Yosemite National Park—*Continued*

Taxon	SENT	EAGL	ELCP	BRID	POHO				
					1	2	3	4	5
Eunotia pectinalis minor[A]	+	+	+	0	+	0	0	0	0
Eunotia perpusilla	0	+	+	0	0	0	0	0	0
Eunotia tenella[A]	X	+	+	+	+	+	+	+	+
Fragilaria brevistriata inflata	0	0	+	0	0	0	0	0	0
Fragilaria construens venter (tax)	0	0	+	0	0	0	0	+	0
Fragilaria vaucheriae[A]	0	+	+	0	0	0	0	0	0
Fragilariforma virescens	0	0	0	0	0	0	0	0	0
Frustulia rhomboides crassinervia	0	0	0	0	0	0	0	0	0
Frustulia vulgaris	0	0	0	0	0	0	0	0	0
Gomphonema angustatum intermedia	0	0	0	0	0	0	0	+	0
Gomphonema cf. *clevei*[A]	0	0	+	+	+	+	+	0	0
Gomphonema grunowii	0	0	0	0	0	0	0	0	0
Gomphonema olivaceum	+	0	0	0	0	0	0	0	0
Gomphonema parvulum[A,V]	X	X	X	X	+	+	X	+	+
Gomphonema subclavatum[A]	+	+	+	+	+	+	+	+	0
Hannaea arcus[A]	0	+	+	+	+	+	+	+	0
Melosira varians[V]	0	0	+	0	+	0	0	0	0
Meridion circulare	0	0	0	0	0	0	0	0	0
Navicula cincta rostrata	0	0	0	0	0	0	0	0	0
Navicula cryptocephala	+	+	0	0	0	0	0	0	0
Navicula leptostriata	0	0	+	0	0	0	0	0	0
Navicula menisculus	0	0	0	0	0	0	0	0	0
Navicula minima[A]	0	0	+	+	0	+	+	0	0
Navicula rhynchocephala germainii[V]	0	0	0	0	+	0	0	0	0
Navicula secreta apiculata	0	0	0	0	0	0	0	0	0
Navicula sp. 1 ans hdsn	0	0	0	0	0	0	0	0	0
Navicula viridula argunensis	0	0	0	0	0	0	0	0	0
Navicula viridula linearis	0	0	0	0	0	0	0	0	0
Neidium alpinum	0	0	+	0	0	0	0	0	0
Neidium bisulcatum	0	0	0	0	0	0	0	0	0
Nitzschia amphibia	0	0	0	0	0	0	0	0	0
Nitzschia dissipata	0	0	0	0	+	0	0	0	0
Nitzschia frustulum	+	0	0	0	0	0	0	0	0
Nitzschia frustulum perminuta	0	0	+	0	0	0	0	0	0
Nitzschia frustulum subsalina	0	0	0	0	0	0	0	0	0
Nitzschia kuetzingiana	0	0	0	0	0	0	0	0	0
Nitzschia palea	0	0	0	0	0	0	0	0	0

Table 19. Algae taxa collected in richest targeted habitat samples during the 1995 algae study in Yosemite National Park—*Continued*

Taxon	Samples	Sites	HAPI					CLRK	LODG				
			1	2	3	4	5		1	2	3	4	5
Nitzschia tarda	1	1	0	0	0	0	0	0	0	+	0	0	0
Pinnularia abaujensis linearis	1	1	0	0	0	0	0	0	0	0	0	+	0
Pinnularia biceps	1	1	0	0	0	0	0	0	0	+	0	0	0
Pseudostaurosira brevistriata[V]	1	1	0	0	0	0	0	0	0	0	0	0	0
Rhoicosphenia abbreviata	1	1	0	0	0	0	0	0	0	0	0	+	0
Sellaphora pupula[V]	5	4	0	0	0	0	0	0	+	0	0	+	0
Sellaphora pupula rectangularis	3	2	0	0	0	0	0	0	0	0	+	+	0
Stauroneis anceps americana	1	1	0	0	0	0	0	0	+	0	0	0	0
Staurosirella pinnata	3	3	0	0	0	0	0	0	0	+	0	0	0
Surirella minuta	1	1	0	0	0	0	0	0	0	+	0	0	0
Synedra minuscula[A]	6	3	0	0	0	0	0	0	0	+	+	+	+
Synedra rumpens	7	3	0	0	+	0	0	0	+	+	+	X	+
Synedra rumpens familiaris	4	3	+	0	0	+	0	0	0	0	0	+	0
Synedra rumpens meneghiniana	2	2	0	0	0	0	0	0	0	0	0	0	0
Synedra ulna[A]	10	6	0	0	0	+	0	+	0	0	+	+	+
Synedra ulna oxyrhynchus	1	1	0	0	0	+	0	0	0	0	0	0	0
Tabellaria fenestrata	3	2	0	0	0	0	0	0	0	0	0	+	+
Tabellaria flocculosa[A]	11	6	0	0	0	0	+	+	+	+	+	+	+
Chlorophyta													
Oedogonium sp.	1	1	0	0	0	0	0	0	0	0	+	0	0
Scenedesmus sp.	1	1	0	0	0	0	0	0	0	0	0	0	0
Staurastrum sp.[A]	2	1	0	0	0	0	0	0	0	0	0	+	+
Stigeoclonium sp.[A]	1	1	0	0	X	0	0	0	0	0	0	0	0
Zygnema sp.[A]	2	2	0	0	X	0	0	X	0	0	0	0	0
Chrysophyta													
Dinobryon sp.	1	1	0	+	0	0	0	0	0	0	0	0	0
Cyanophyta													
Calothrix sp.[A]	4	2	X	0	0	X	X	X	0	0	0	0	0
Chamaesiphon sp.[A]	2	2	0	0	0	0	0	0	0	0	0	0	0
Hydrocoleum brebissonii[A]	1	1	0	0	0	0	0	0	0	0	0	0	0
Lyngbya sp.[A]	1	1	0	0	0	0	0	X	0	0	0	0	0
Lyngbya sp. 1 (ansfwa)[A]	2	2	0	0	0	0	0	0	0	0	0	0	0
Oscillatoria sp.[A]	9	5	0	X	0	0	0	X	X	X	X	0	X
Oscillatoria sp. 1 (ansfwa)[A,V]	19	8	X	X	X	X	X	X	0	X	X	X	X
Rhodophyta													
Audouinella hermanii[A,V]	10	8	X	X	X	X	X	+	X	X	X	X	X

Table 19. Algae taxa collected in richest targeted habitat samples during the 1995 algae study in Yosemite National Park—*Continued*

Taxon	SENT	EAGL	ELCP	BRID	POHO				
					1	2	3	4	5
Nitzschia tarda	0	0	0	0	0	0	0	0	0
Pinnularia abaujensis linearis	0	0	0	0	0	0	0	0	0
Pinnularia biceps	0	0	0	0	0	0	0	0	0
Pseudostaurosira brevistriata[V]	0	0	0	0	+	0	0	0	0
Rhoicosphenia abbreviata	0	0	0	0	0	0	0	0	0
Sellaphora pupula[V]	+	+	+	0	0	0	0	0	0
Sellaphora pupula rectangularis	0	+	0	0	0	0	0	0	0
Stauroneis anceps americana	0	0	0	0	0	0	0	0	0
Staurosirella pinnata	0	0	+	0	0	0	0	0	+
Surirella minuta	0	0	0	0	0	0	0	0	0
Synedra minuscula[A]	0	0	X	+	0	0	0	0	0
Synedra rumpens	0	0	+	0	0	0	0	0	0
Synedra rumpens familiaris	0	0	+	0	0	0	0	0	0
Synedra rumpens meneghiniana	0	+	+	0	0	0	0	0	0
Synedra ulna[A]	0	+	0	+	+	+	+	0	0
Synedra ulna oxyrhynchus	0	0	0	0	0	0	0	0	0
Tabellaria fenestrata	+	0	0	0	0	0	0	0	0
Tabellaria flocculosa[A]	+	+	0	0	0	0	+	+	0
Chlorophyta									
Oedogonium sp.	0	0	0	0	0	0	0	0	0
Scenedesmus sp.[A]	0	0	+	0	0	0	0	0	0
Staurastrum sp.	0	0	0	0	0	0	0	0	0
Stigeoclonium sp.[A]	0	0	0	0	0	0	0	0	0
Zygnema sp.[A]	0	0	0	0	0	0	0	0	0
Chrysophyta									
Dinobryon sp.	0	0	0	0	0	0	0	0	0
Cyanophyta									
Calothrix sp.[A]	0	0	0	0	0	0	0	0	0
Chamaesiphon sp.[A]	X	0	0	X	0	0	0	0	0
Hydrocoleum brebissonii[A]	0	X	0	0	0	0	0	0	0
Lyngbya sp.[A]	0	0	0	0	0	0	0	0	0
Lyngbya sp. 1 (ansfwa)[A]	0	0	0	0	X	X	0	0	0
Oscillatoria sp.[A]	0	0	0	X	0	0	X	X	0
Oscillatoria sp. 1 (ansfwa)[A,V]	X	X	X	X	X	X	X	X	X
Rhodophyta									
Audouinella hermanii[A,V]	X	X	X	X	X	X	X	X	X

Table 19. Algae taxa collected in richest targeted habitat samples during the 1995 algae study in Yosemite National Park—*Continued*

Taxon	Samples	Sites	HAPI					CLRK	LODG				
			1	2	3	4	5		1	2	3	4	5
Unclassified													
(Undetermined cf. clastidium)	7	3	+	+	+	+	+	+	0	0	0	0	0
(Undetermined coccoid 1-3 µm)	5	2	0	0	0	0	0	+	0	0	0	0	0
(Undetermined coccoid 3-5 µm)	18	8	+	+	+	0	0	+	+	+	+	+	+
(Undetermined coccoid 5-10 µm)	1	1	0	0	0	0	0	+	0	0	0	0	0
(Undetermined filamentous)	2	2	0	0	0	0	+	0	0	0	+	0	0
(Undetermined filamentous) sp.	1	1	0	0	0	0	0	+	0	0	0	0	0
(Undetermined) sp.	1	1	0	0	0	0	0	0	0	0	0	0	0

Further, water depth at the collection site is the only habitat variable correlated with the pigments and absorbance ratio. The pattern of correlations suggests that algae abundance increases with depth, but physiological condition declines slightly with depth. This might be indicative of an effect of light levels, but it seems unlikely given that more direct measures of light availability were not correlated with pigments and absorbance and water transparency was high; hence, light attenuation over the relatively shallow depths in this study seems unlikely. It seems more likely that differences in nutrient availability among sites were not detected in the chemical analysis. The watershed above Yosemite Valley is dominated by granitic outcrops; consequently, a significant contribution by geologic sources is unlikely. However, the Merced River flows through several large meadow systems within Yosemite Valley, beginning below Clarks, and these meadows may provide local sources of nutrients to the river. The extremely high value for chlorophyll-*a* at the Bridalveil seems especially supportive of this hypothesis because it is immediately downstream of Bridalveil Creek, which drains several large meadows before entering Yosemite Valley. The absence of dissolved nutrients can be explained by rapid uptake by the algae community.

Spatial differences in species richness and diversity may be due to physical disturbance and variability in solar radiation. Of the three 1995 sites with multiple samples, Lodge had significantly more species than Happy Isles and Pohono. Of the single sample sites only El Capitan had more taxa than Happy Isles, Pohono, or Lodge; Eagle had a similar number of taxa. Happy Isles, Pohono, and Lodge were less dominated by blue-green algae than were the other sites (fig. 6). Presumably, some characteristic of these sites suppresses blue-greens somewhat and allows for proliferation of other algae species. The significant correlation with dominant substrate indicated that dominance of fine substrate (less than 2 mm in diameter) might be a significant factor affecting algae community composition.

Shannon-Weaver diversity values showed a similar pattern but Lodge was not significantly different from Happy, whereas diversity at Pohono was significantly lower than the other two sites. Lodge and El Capitan had high values for diversity, but Sentinel with low taxa richness had the highest value. Sentinel was similar to Lodge, El Capitan, and Eagle in not being dominated by a blue-green alga. Shannon-Weaver diversity was correlated with almost every measure of light that was part of the study, including open canopy angle, canopy density, and incident solar radiation.

The relation between substrate and taxa richness suggests that the frequency of bed load movement may be an important factor affecting the occurrence and distribution of algae taxa. When nutrients are limiting, blue-green algae tend to dominate the community by forming mats over the surface of substrate particles, oftentimes limiting the growth of other species. Constant turnover of particles exposes new surfaces and abrades established algae mats, providing open space for other species. Human-induced bed turnover also may be important in Yosemite Valley. Particularly at Sentinel and Lodge, recreational activities, such as wading and rafting in shallow riffles, occur during most of the summer tourist season.

The relation between light and Shannon-Weaver diversity suggests that light also may be a limiting factor for the less common algae species. Shannon-Weaver diversity is a measure of community structure

Table 19. Algae taxa collected in richest targeted habitat samples during the 1995 algae study in Yosemite National Park—*Continued*

Taxon	SENT	EAGL	ELCP	BRID	POHO				
					1	2	3	4	5
Unclassified									
(Undetermined cf. clastidium)	0	0	0	0	0	0	+	0	0
(Undetermined coccoid 1-3 μm)	0	0	0	0	+	+	0	+	+
(Undetermined coccoid 3-5 μm)	+	+	+	+	+	+	+	+	+
(Undetermined coccoid 5-10 μm)	0	0	0	0	0	0	0	0	0
(Undetermined filamentous)	0	0	0	0	0	0	0	0	0
(Undetermined filamentous) sp.	0	0	0	0	0	0	0	0	0
(Undetermined) sp.	0	0	0	0	0	0	+	0	0

and is based on evenness of abundance among species. SENT had high diversity with low taxa richness, suggesting that abundant light resulted in relatively equal percentage abundances of the species present. Overall, the data indicate a complex interaction of light, substrate disturbance, and nutrients over the 9 river miles between Pohono and Happy Isles. Biomass measures suggest a possible gradient in nutrient availability with biomass increasing in downstream areas. Substrate size and susceptibility to particle movement caused by natural and human-related events seem to be important factors promoting taxa richness. Light may be limiting to some taxa, with greater light levels promoting greater evenness in species percentage abundances.

It is unclear how representative 1995 results will be of other years. The ecological survey showed that Happy Isles and Pohono were very different in 1995 compared to 1993 and 1994. The processes observed in 1995 may be, more or less, important in more typical years. Another interesting observation highlighting the special nature of 1995 was the abundance of *Audouinella hermanii* in the Happy Isles samples (and every other sample) from the 1995 algae study, but the absence of the species from the RTH and DTH samples taken at Happy Isles just a week earlier. The species also was absent from Happy Isles in 1993 and 1994. This species is very responsive to temperature (Korch and Sheath, 1989) and it seems likely that a bloom that normally occurs early in the year was delayed by the high discharge in 1995. It also is possible that the single sample collected earlier simply failed to account for the presence of this species, but this seems unlikely given the wide spatial range and abundance of the species in the later samples.

Algae and Invertebrate Baseline Study

Physical data collected at the six baseline sites are presented in table 20. The results for RTH invertebrate samples are given in table 21. Algae data were unavailable at the time this report was prepared.

Table 20. Mean values for physical data collected from the upper Merced River drainage in Yosemite National Park as part of the 1996 baseline study

[Site code: See table 1 for full site names. N, number of measurements for variables appearing to the right of the value. Dominant substrate classification: (1) detritus, (2) silt, (3) mud, (4) sand, (5) gravel, (6) cobble, (7) boulder, or (8) bedrock. Embededness, the degree to which gravel or coarser substrate particles are buried in finer substrates: (1) 75 percent or greater, (2) 50 to 75 percent, (3) 25 to 50 percent, (4) 5 to 25 percent, or (5) less than 5 percent. Stream width was measured as the width of the wetted channel. m, meters; m/s, meters per second]

Site Code	Sampling Date	N	Stream Width (m)	Open Canopy Angle (degrees)	Canopy Density (percent)	N	Depth (m)	Velocity (m/s)	Dominant Substrate	N	Embededness
HAPI	17 Sept 96	6	18.1	79	20	19	0.48	0.17	6.1	19	3.0
CLRK	17 Sept 96	6	18.4	78	20	20	0.42	0.16	6.0	20	3.4
AWAH	16 Sept 96	6	37.6	71	13	19	0.22	0.13	4.9	18	3.3
STON	19 Sept 96	6	33.7	91	12	19	0.20	0.12	5.2	18	3.6
LODG	18 Sept 96	6	20.3	101	14	20	0.61	0.17	4.5	15	3.2
POHO	19 Sept 96	6	27.4	81	19	20	0.81	0.13	6.0	20	2.9

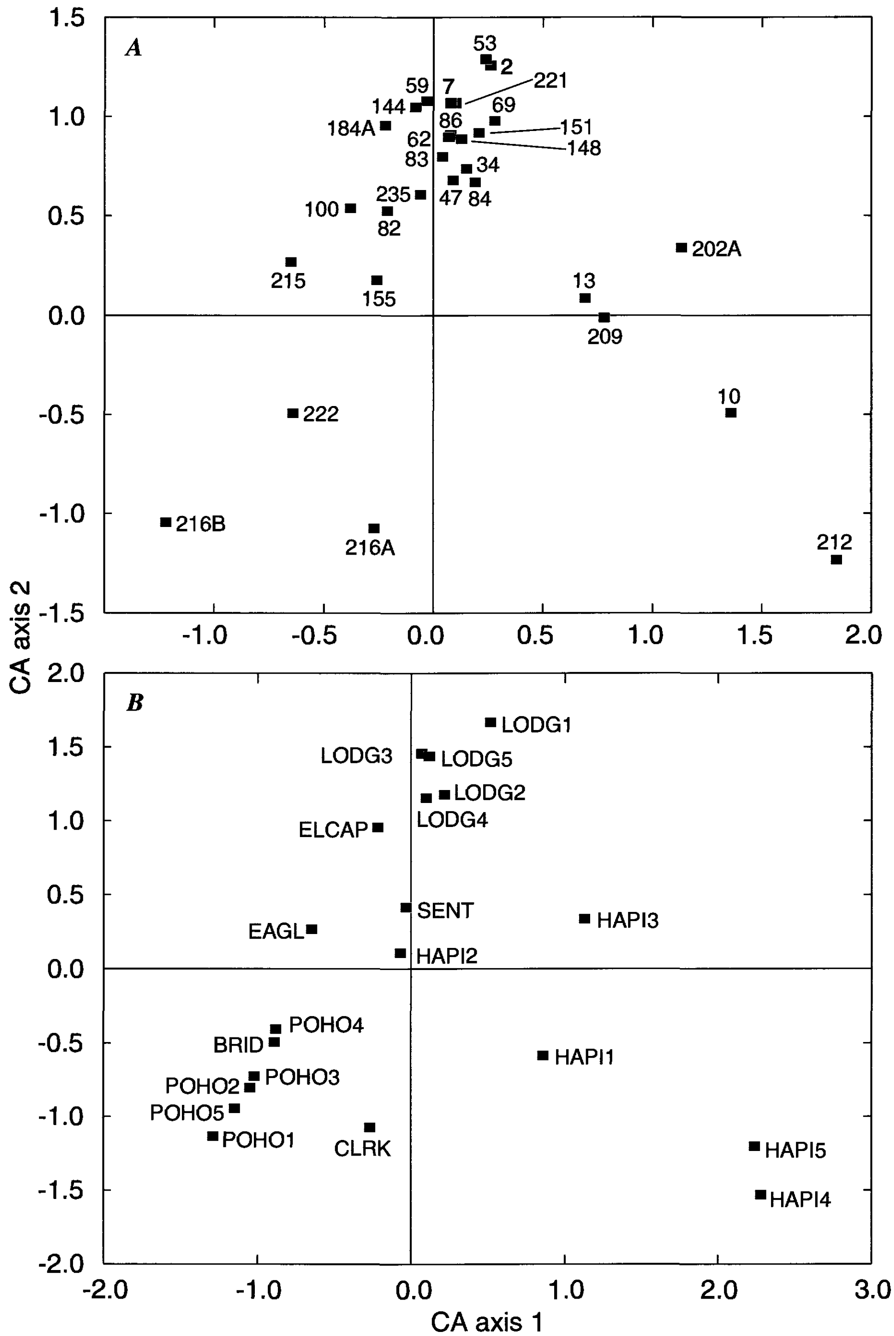

Figure 6. Plots of taxa scores (*A*) and site scores (*B*) on the first two axes derived from a correspondence analysis (CA) of algae taxa percentage abundances. The analysis included data from sites in the 1994 algae study. Only taxa composing >0.01% of species percentage abundance for all sites combined were included in the analysis. Refer to table 16 for the algae taxa associated with the taxa codes. Refer to table 1 for the full site names associated with the site codes. The numbers (1-5) appended to the site codes designate the five replicate samples collected at Happy Isles, Lodge, and Pohono.

Table 21. Densities (rounded to the nearest whole number) of invertebrate taxa collected in richest targeted habitat samples in the upper Merced River drainage, 1996

[See table 1 for site names corresponding to the site codes. Taxa shown are indented in the order phylum, class, order, family, and genus or species. Other taxonomic levels (identified in parentheses) were used as needed to display all data collected. Densities are measured in organisms per square meter, rounded to the nearest number]

Taxon	HAPI	CLRK	AWAH	STON	LODGE	POHO
Platyhelminthes						
Turbellaria	0	0	0	1	0	0
Nematoda	8	0	10	9	0	33
Annelida						
Oligochaeta	0	0	0	1	0	1
Haplotaxida						
Haplotaxidae	0	0	1	0	8	0
Haplotaxis s	0	0	0	1	0	0
Tubificida						
Naididae	0	32	0	0	0	0
Tubificidae	0	0	0	0	10	0
Enchytraeida						
Enchytraeidae	0	0	16	0	0	0
Arthropoda						
Chelicerata						
Acari						
Hydrachnidia	124	79	185	216	112	530
Insecta	0	0	0	0	0	0
Ephemeroptera	8	32	0	0	968	48
Leptophlebiidae	0	183	348	64	24	112
Paraleptophlebia sp.	4	0	2	0	0	0
Ephemerellidae	141	773	1,593	1,407	9	871
Caudatella sp.	0	1	0	0	0	0
Drunella sp.	16	40	18	9	8	17
Drunella doddsi (Needham)	24	16	11	0	0	16
Drunella grandis (Eaton)	1	0	0	0	0	0
Serratella sp.	5	4	0	0	0	0
Serratella tibialis (McDunnough)	0	0	20	41	0	64
Baetidae	373	1,217	54	211	57	33
Baetis sp.	59	85	16	33	0	1
Baetis tricaudatus Dodds	0	0	13	0	32	66
Siphlonuridae						
Ameletus sp.	0	1	21	30	18	48
Heptageniidae	345	969	3,250	2,734	875	320
Epeorus sp.	117	85	16	80	0	1
Heptagenia sp.	0	0	6	0	0	0
Rhithrogena sp.	102	501	679	418	234	160
Plecoptera	0	16	9	72	56	17
Capniidae	8	0	0	0	0	0
Chloroperlidae	8	20	105	112	33	48
Sweltsa sp.	0	18	82	50	1	16
Amphinemurinae	0	0	0	0	9	0
Amphinemura sp.	0	0	3	16	0	0
Zapada cinctipes (Banks)	0	5	0	0	0	1

Table 21. Densities (rounded to the nearest whole number) of invertebrate taxa collected in richest targeted habitat samples in the upper Merced River drainage, 1996—*Continued*

Taxon	HAPI	CLRK	AWAH	STON	LODGE	POHO
Zapada sp.	0	0	17	8	0	17
Perlidae	8	21	40	48	16	0
Calineuria californica (Banks)	1	4	11	1	0	0
Claassenia sabulosa (Banks)	0	1	2	1	0	0
Hesperoperla sp.	0	0	0	0	0	16
Hesperoperla pacifica (Banks)	0	0	0	0	2	0
Perlodidae	0	0	0	0	0	172
Cultus sp.	0	0	0	8	0	73
Perlinodes aureus (Smith)	8	36	13	60	0	64
Skwala sp.	15	24	65	36	42	159
Pteronarcyidae						
Pteronarcys sp.	4	0	0	0	0	0
Pteronarcys princeps Banks	0	2	1	0	0	0
Megaloptera						
Corydalidae	0	0	0	0	0	16
Orohermes crepusculus (Chandler)	0	1	3	0	0	2
Trichoptera	1	8	0	0	0	1
Glossosomatidae	573	2,190	1	23	2	0
Agapetus sp.	0	0	0	10	0	0
Glossosoma sp.	57	0	6	26	0	5
Brachycentridae	0	0	2	0	8	114
Hydroptilidae	1	0	0	2	0	1
Hydroptila sp.	0	0	0	1	0	0
Rhyacophilidae	0	0	0	0	0	0
Rhyacophila sp.	14	117	7	16	16	48
Rhyacophila spp.	0	0	0	0	0	59
Rhyacophila angelita Banks	0	0	0	0	0	16
Rhyacophila bifila Banks	0	0	0	0	0	1
Rhyacophila kernada Ross	0	0	0	0	0	1
Philopotamidae	0	0	0	8	0	67
Dolophilodes sp.	92	50	0	0	0	143
Hydropsychidae	81	52	9	8	0	2
Arctopsyche sp.	43	81	0	0	8	0
Arctopsyche grandis (Banks)	19	26	5	2	0	1
Ceratopsyche sp.	69	242	9	32	8	537
Ceratopsyche cockerelli (Banks)	0	0	0	0	0	4
Ceratopsyche oslari (Banks)	0	0	0	0	0	209
Limnephiloidea	0	0	10	15	2	34
Apataniidae	6	0	0	0	0	0
Apatania sp.	0	0	0	0	0	1
Lepidostomatidae	0	0	0	0	0	0
Lepidostoma sp.	0	4	20	0	24	0
Limnephilidae	0	0	0	0	0	0
Dicosmoecus sp.	0	0	0	0	1	0
Dicosmoecus gilvipes (Hagen)	0	0	0	0	0	1
Uenoidae	0	0	0	0	0	0
Neophylax sp.	0	8	0	0	0	0
Coleoptera						

Table 21. Densities (rounded to the nearest whole number) of invertebrate taxa collected in richest targeted habitat samples in the upper Merced River drainage, 1996—*Continued*

Taxon	HAPI	CLRK	AWAH	STON	LODGE	POHO
Elmidae	24	122	27	4	8	92
Cleptelmis sp.	0	0	0	0	0	33
Cleptelmis addenda (Fall)	0	0	0	8	0	0
Cleptelmis ornata (Schaeffer)	0	0	0	0	0	33
Heterlimnius sp.	8	0	0	0	0	0
Narpus sp.	17	21	43	9	0	0
Optioservus sp.	8	37	151	67	17	105
Ordobrevia nubifera (Fall)	16	53	0	9	8	19
Zaitzevia parvula (Horn)	24	149	84	100	80	150
Psephenidae						
Eubrianax edwardsi (LeConte)	0	0	1	0	0	0
Diptera	0	1	0	8	0	0
Atherixidae						
Atherix pachypus Bigot	20	9	2	8	8	1
Ceratopogonidae						
Bezzia/Palpomyia sp.	0	0	0	0	8	0
Chironomidae	127	619	516	295	517	2,056
Deuterophlebiidae						
Deuterophlebia sp.	8	0	0	0	0	0
Empididae	0	0	0	8	0	17
Chelifera sp.	0	4	0	8	0	23
Clinocera sp.	0	4	0	0	0	1
Hemerodromia sp.	0	0	16	0	8	2
Simuliidae	388	188	0	16	0	1
Simulium sp.	8	4	0	0	0	0
Tipulidae						
Antocha sp.	0	32	4	16	0	129
Dicranota sp.	0	23	7	8	1	16

SUMMARY

Despite the high density of human use of the Merced River, water quality is very good, as indicated by low concentrations of dissolved solids. Concentrations of organic contaminants in fish tissue and bed sediment also were low. The fish community exhibits patterns consistent with the importance of landscape-level features in physical barriers to dispersal limiting distribution of species. The biological effects of smallmouth bass as a major predator may be important in the lower drainage. Algae seem very sensitive to differences in habitat and water quality in the upper Merced River Basin and in the Merced River within Yosemite Valley. The sensitivity of algae to substrate size, disturbance, and light make them particularly appropriate biomonitors for the effects of stream restoration activities on the ecosystem of the river, particularly when considering short-term disturbance events. Invertebrates seem less responsive to hydrologic differences among sites compared to algae, but nevertheless are excellent biomonitors of most physical and chemical water quality conditions, and probably are more useful for assessing longer-term changes in physical and chemical water-quality conditions.

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Appendix: Changes in algal taxonomy taking place during the writing of this report

Old Name	New Name
Achnanthes marginulata	*Psammothidium marginulatum*
Achnanthidium lanceolatum dubium	*Planothidium dubium*
Achnanthidium pusillum	*Rossithidium pusillum*
Cymbella cesatii	*Encyonopsis cesatii*
Cymbella lunata	*Encyonema lunatum*
Cymbella microcephala	*Encyonopsis microcephala*
Cymbella minuta latens	*Encyonema latens*
Fragilaria construens binodis	*Staurosira construens binodis*
Fragilaria construens venter	*Staurosira construens venter*
Navicula decussis	*Geissleria decussis*