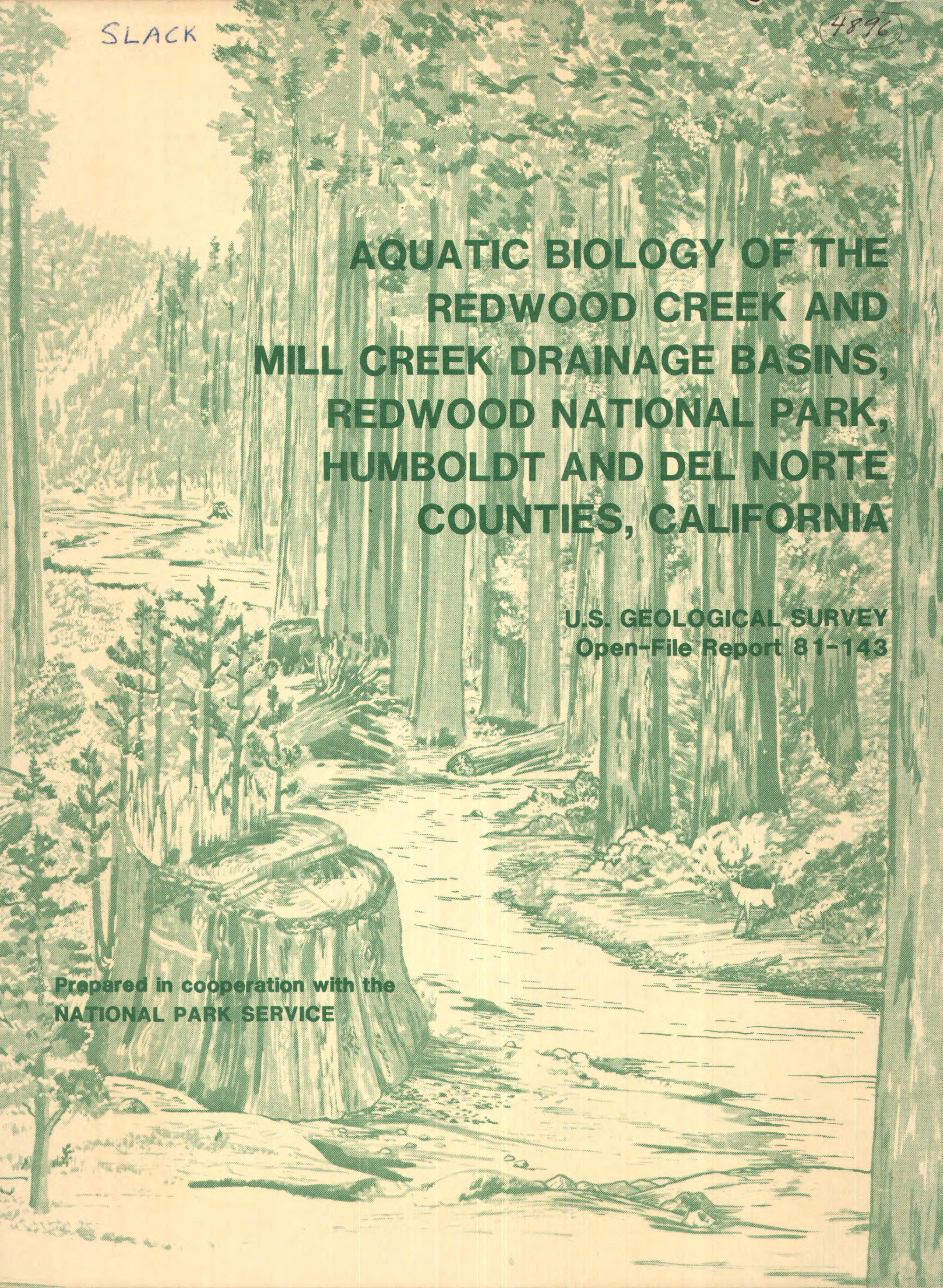

AQUATIC BIOLOGY OF THE REDWOOD CREEK AND MILL CREEK DRAINAGE BASINS, REDWOOD NATIONAL PARK, HUMBOLDT AND DEL NORTE COUNTIES, CALIFORNIA

U.S. GEOLOGICAL SURVEY
Open-File Report 81-143

Prepared in cooperation with the NATIONAL PARK SERVICE

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By Rick T. Iwatsubo and Robert C. Averett

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NATIONAL PARK SERVICE

Menlo Park, California
May 1981

UNITED STATES DEPARTMENT OF THE INTERIOR

JAMES G. WATT, Secretary

GEOLOGICAL SURVEY

Doyle G. Frederick, Acting Director

For additional information write to:

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Water Resources Division
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CONVERSION FACTORS

For readers who prefer to use International System of units rather than inch-pound units, the conversion factors for the terms used in this report are listed below:

Multiply	By	To obtain
acre	0.4047	hm^2 (square hectometer)
ft (foot)	0.3048	m (meter)
ft/mi (foot per mile)	0.1894	m/km (meter per kilometer)
ft^3/s (cubic foot per second)	0.02832	m^3/s (cubic meter per second)
inch	25.4	mm (millimeter)
mi (mile)	1.609	km (kilometer)
mi^2 (square mile)	2.590	km^2 (square kilometer)

To convert degrees Fahrenheit (°F) to degrees Celsius (°C):

$$°F = 1.8°C + 32$$

Additional abbreviations:

col/100 mL (colony per 100 milliters)
g/m^2 (grams per square meter)
$inverts/m^2$ (invertebrates per square meter)
mg/L (milligrams per liter)
mL (milliliter)
$organisms/mm^2$ (organisms per square millimeter)

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ABSTRACT

A 2-year study of the aquatic biota in the Redwood Creek and Mill Creek drainage basins of Redwood National Park indicated that the aquatic productivity is low.

Densities of coliform bacteria were low except in Prairie Creek, a tributary to Redwood Creek, where a State park, county fish hatchery, grazing land, lumber mill, and scattered residential areas are potential sources of fecal coliform bacteria.

Benthic-invertebrate data indicated a diverse fauna which varied considerably between streams and among stream sections. The abundance of benthic invertebrates appeared to decrease as the size of streambed sediments decreased. Spring densities were frequently several orders of magnitude lower than autumn densities. Functional group analysis of the benthic-invertebrate data indicated collectors were dominant. Nonparametric statistical tests revealed significant differences ($\alpha<0.01$) in mean diversity and similarity-index values of benthic invertebrates collected from drainage basins being logged and control tributary basins in the Redwood Creek basin. Noteworthy findings include: (1) benthic invertebrates rapidly recolonized the streambed following a major storm, and (2) man-caused disruption or sedimentation of the streambed during low flow can result in drastic reductions of the benthic-invertebrate community.

Seven species of fish representing species typically found in northern California coastal streams were captured during the study. Nonparametric statistical tests indicate that condition factors of steelhead trout were significantly larger ($\alpha<0.05$) at sampling stations with less shading, regardless of drainage basin land-use history.

Periphyton and phytoplankton communities were diverse, variable in density, and dominated by diatoms. Periphyton rates of accrual were low because of shading from the dense forest canopy. The phytoplankton community was dominated by detached periphytic algae. The variability of the periphyton and phytoplankton communities could not be directly related to differences in land-use history of the basins sampled.

Seston concentrations were extremely variable between stations and at each station sampled. The seston is influenced seasonally by aquatic productivity at each station and amount of allochthonous material from the terrestrial ecosystem. Time-series analysis of some seston data indicated larger and sharper peak concentrations being flushed from a logged drainage basin than from a control drainage basin.

INTRODUCTION

Redwood National Park, in northwestern California, was created on October 2, 1968, when Congress enacted Public Law 90-545, which states that the park was established in order to "...preserve significant examples of the primeval coastal redwood (Sequoia sempervirens) forests and the streams and seashores with which they are associated for purposes of public inspiration, enjoyment, and scientific study...." The coast redwoods are the tallest trees on earth. The first, second, third, and sixth tallest trees in the world are located on alluvial flats along Redwood Creek. These trees and the associated vegetation and wildlife provide an area of esthetic and recreational enjoyment for park visitors. Coast redwood is a soft, colorful wood that is highly resistant to decay and insect infestation; thus, in areas surrounding Redwood National Park, coast redwoods have been and are being harvested commercially.

At the time of the study, 10 and 50 percent, respectively, of the Redwood Creek and Mill Creek basins were in Redwood National Park (fig. 1). Limited Federal control is exercised on land-management practices upstream from the park boundaries. The parklands have recently been expanded by 48,000 acres in the Redwood Creek basin, including all the basins upstream to Copper Creek and Devil's Creek. In addition, a 36,000-acre Park Protection Zone was established by Public Law 95-750 (fig. 2). This zone includes Coyote, Panther, and Lack's Creeks, and within these drainage basins the Secretary of the Interior has additional responsibility to insure that land-use practices will not have detrimental influences on downstream park resources.

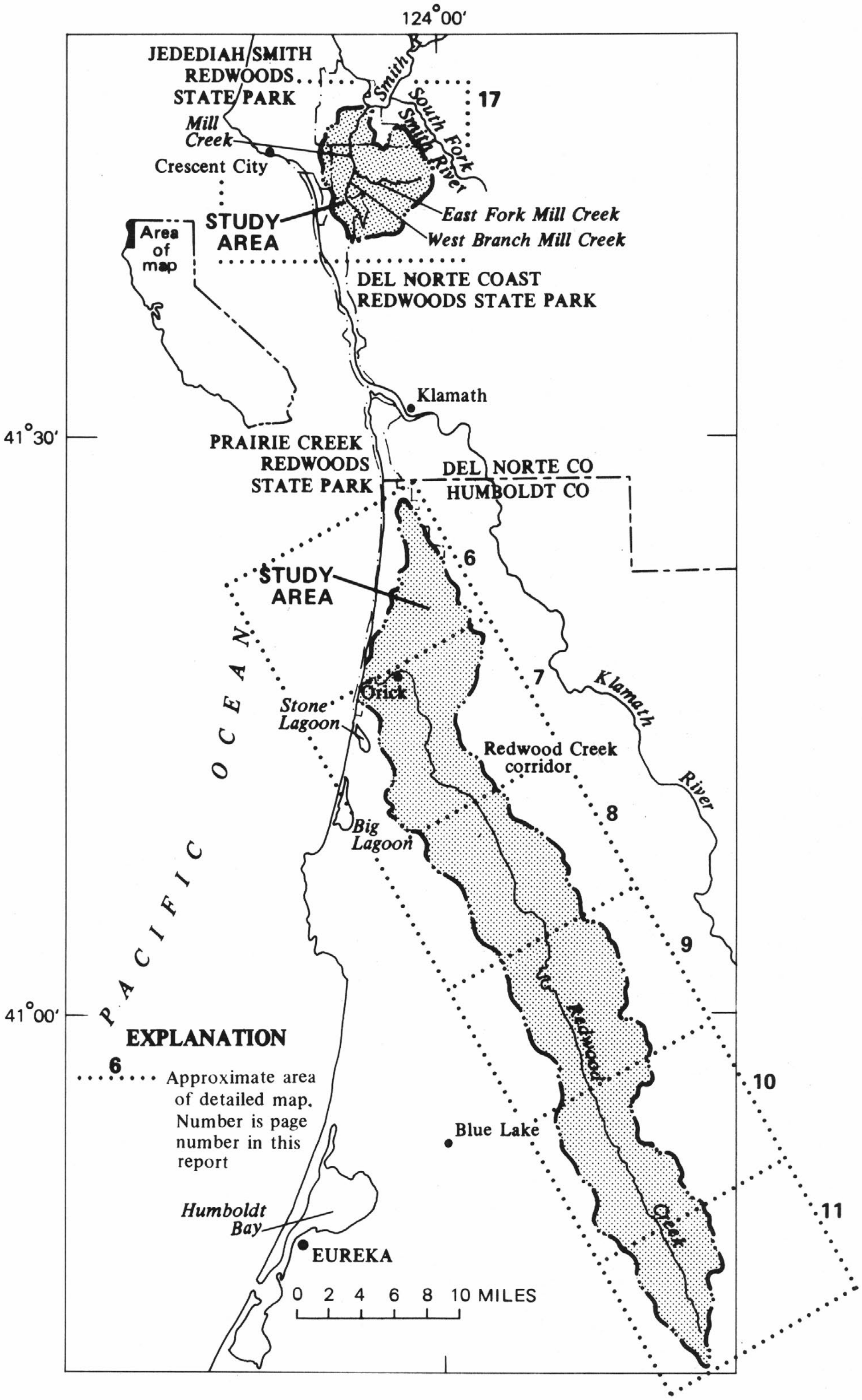

FIGURE 1.--Index map of Redwood National Park.

At the time of the study, large areas of private timberland were upstream from parklands and created many land-use and park-management problems. Major concerns were the potential impact of timber harvest and associated road construction on landslide mass movement, fluvial erosion and deposition of sediment, water temperature, chemical quality, and aquatic biota. These problems were most acute in the half-mile wide and 7-mile long Redwood Creek corridor at the south end of the park (fig. 2). The majority of the terrain upstream from the corridor is naturally unstable and has been undergoing intensive timber harvest (Janda, 1975a). The dominant method of logging in recent years has been the clearcutting of adjoining harvest units that are several hundred acres in size and removing the fallen timber by downhill tractor yarding. During the study period, timber-harvest practices were modified in accordance with recent changes in California State forest practice regulations and by cooperative agreements between the National Park Service and adjacent private landowners. These changes in timber-harvest practices include alternate harvest units, reduction in harvest unit size, and use of uphill-cable yarding techniques (Iwatsubo and others, 1976).

Directly after the establishment of Redwood National Park, the National Park Service initiated a series of studies designed to assist in understanding land-management options for the protection of park resources. Stone and others (1969) were the first to make these studies and recommended an 800-ft buffer zone along the perimeter of the park. A special task force reviewed the Redwood Creek land-management problem and stated that management actions were needed upstream from the proposed 800-ft buffer zone (Richard C. Curry, written commun., 1973). In addition, the task force suggested that the National Park Service, in cooperation with the U.S. Geological Survey, make studies to provide data needed in formulating management activities related to the preservation of park resources (Janda and others, 1975b). On August 16, 1973, the National Park Service authorized a 3-year data-collection program by the Geological Survey; this was begun in September 1973. To date, results of the data collected have been released in several testimonials and reports: Woods (1975), Janda (1975a, 1975b, 1976, 1977a, 1977b), Janda and others (1975a, 1975b), Averett and Iwatsubo (1975), Lee and others (1975), Nolan and Harden (1976), Nolan and others (1976a, 1976b), Iwatsubo and others (1975, 1976), Harden (1977), Harden and others (1978), and Bradford and Iwatsubo (1978).

Purpose and Scope

The aquatic fauna and flora are vital parts of Redwood National Park. These organisms are important ecologically in the stream environment. Recognizing the importance of aquatic organisms, the National Park Service and the U.S. Geological Survey began a study designed to describe the aquatic biota in the Redwood Creek and Mill Creek basins in relation to Redwood National Park and to assess the possible effect on the aquatic biota of land-use activities upstream from park boundaries.

Bacteria, benthic invertebrates, fish, periphyton, phytoplankton, and seston samples were collected during the study. The study period began in September 1973 and continued through September 1975. Because of streamflow conditions and timing with periods of maximum aquatic productivity, the majority of the biological data were collected during the receding-flow periods of spring and the low-flow periods of summer and early autumn.

Acknowledgments

The authors of this report would like to extend their appreciation to Arcata Redwood Company, Louisiana-Pacific Corporation, Rellim Redwood Company, and Simpson Timber Company for permitting field teams access to sampling stations. Appreciation is also extended to: Donna S. Washabaugh, U.S. Geological Survey, for her valuable technical assistance in rewriting the report; Jan B. Brocksen, Susswasser, for the identification and enumeration of the periphyton and phytoplankton; Donald B. Green, Stephen K. Sorenson, and Johnevan M. Shay, U.S. Geological Survey, for the identification and enumeration of the benthic invertebrates; Robert J. Kocourek, U.S. Geological Survey, for the seston analyses; Paul F. Woods, U.S. Geological Survey, for assistance in the collection of fish; and the personnel of the National Park Service and the Eureka field office of the U.S. Geological Survey for their assistance.

DESCRIPTION OF STUDY AREA

Redwood Creek

The Redwood Creek basin (fig. 2) covers 282 mi^2 in the northern Coast Range of California. The basin is characterized by high relief, steep and unstable slopes, and narrow valleys. The basin is elongated north-northwesterly and is about 63 mi long and 4½ to 7 mi wide. The overall drainage pattern is trellised; however, some tributary drainage basins display a dendritic pattern. The altitude ranges from sea level at the mouth to 5,300 ft at the upstream end of the basin. Relief is about 2,000 ft in the north and greater than 3,000 ft near the head of the basin. Average hillslope gradients range from 31 percent in the northern quarter to 34 percent in the southern quarter of the drainage basin. Flood plains along Redwood Creek are discontinuous and seldom exceed 200 ft in width except for areas between Minor Creek and Mill Creek, near the mouth of Lack's Creek, and near Orick.

Janda and others (1975b) have described seven distinct reaches of the Redwood Creek stream channel (table 1). The tributaries to Redwood Creek show stream-channel characteristics comparable to reach 7 of Redwood Creek. Tributary channel gradients are steep; average gradients range from 250 to 1,500 ft/mi. Streambed materials are extremely variable in size and range from large blocks of bedrock to fine sand and silt. Pebbles and cobble gravel are the most prevalent materials. Small streamside slides and gullies are common. Numerous debris accumulations and large blocks of colluvium in the downstream end of many tributaries restrict the upstream migration of anadromous fish. Logging-related barriers to anadromous fish are less abundant. In streams draining recent timber-harvest areas, coarse logging debris has accumulated on preexisting channel obstructions (Janda and others, 1975b). Many tributaries are intermittent in their lower reaches during low-flow periods of summer and early autumn, and fish habitat often is restricted to pooled areas. In perennial streams, riffles and undercut banks provide additional habitat for fish.

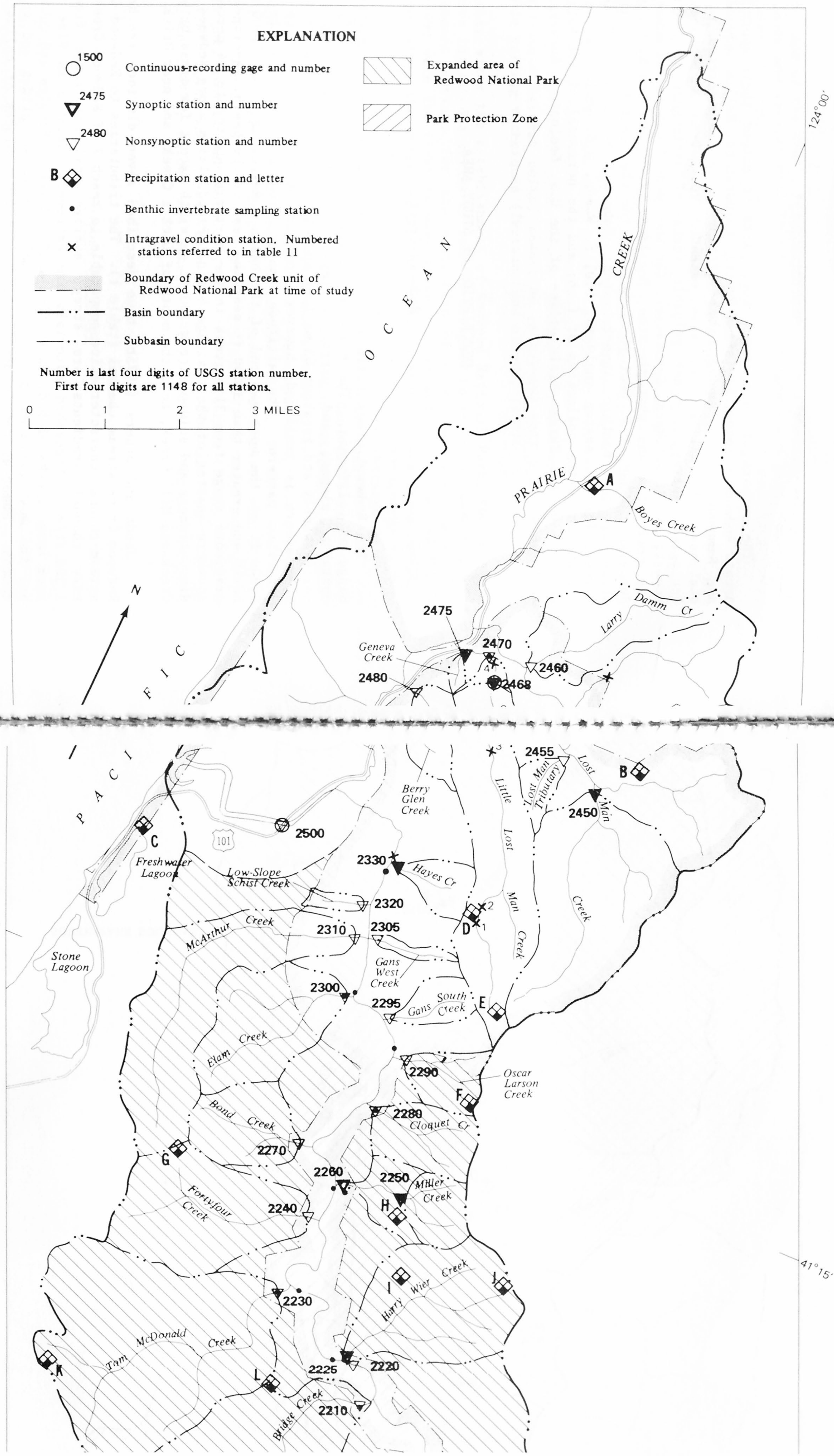

FIGURE 2.--Redwood Creek drainage basin and sampling stations (continued on following pages).

FIGURE 2.--Continued.

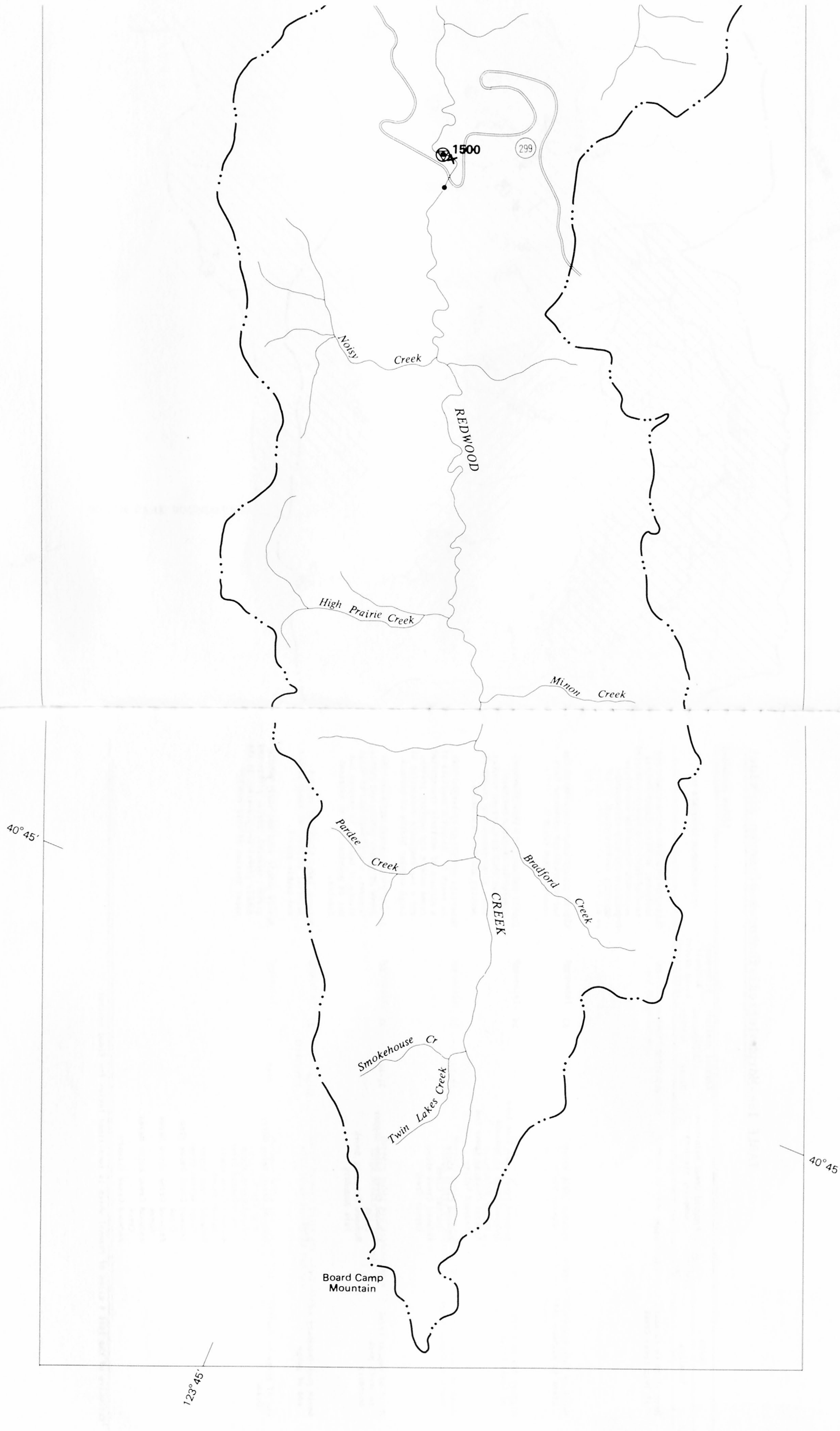

FIGURE 2.--Continued.

TABLE 1.--Morphological features of seven distinct

[From Janda and

Reach			Redwood Creek main-stem sampling stations	Channel gradient (ft/mi)		Streambank actively being eroded (percentage)	Streambed materials
Number	Location	Distance (mi)		Range	Average		
7	Head of basin to mouth of Twin Lakes Creek	4.5	None.	125-1,000	550	64	Subangular to subrounded cobble and boulders, angular blocks several tens of feet in diameter. Trapped sediments behind log and debris jams are the only alluviated sections of this reach.
6	Mouth of Twin Lakes Creek to Highway 299	14.5	Redwood Creek above Highway 299	34-50	83	62	Cobble gravel composing most of the bed material and colluvium less abundant than reach 7.
5	Highway 299 to mouth of Lacks Creek	16	Redwood Creek near Blue Lake Redwood Creek at Redwood Valley Bridge Redwood Creek at Lower End Redwood Valley	--	24	56	Cobble and boulders less abundant, smaller in diameter and more rounded than in upstream reaches. There is an increasing amount of pebbles and fine sediments.
4	Mouth of Lacks Creek to mouth of Copper Creek	9	Redwood Creek above Panther Creek Redwood Creek above Copper Creek	19-30	22	52	Materials are slightly larger than in reach 5. Alluvium consists of a mixture of actively transported round cobble and boulder gravel, and a lag component consisting of large angular blocks of bedrock.
3	Mouth of Copper Creek to south park boundary	2	Redwood Creek below Copper Creek Redwood Creek at South Park Boundary	31-38	35	68	Actively transported alluvium consists of mostly pebble and cobble; however, a lag component of large blocks of bedrock is present but not as prominent as in adjacent reaches.
2	South park boundary to end of gorge	1	None.	(High irregular)	47	>50	Between large blocks of bedrock, material consists of sandy pebble and cobble gravel.
1	End of gorge to Pacific Ocean	16	Redwood Creek below Harry Wier Creek Redwood Creek above Tom McDonald Creek Redwood Creek above Miller Creek Redwood Creek below Oscar Larson Creek Redwood Creek below Elam Creek Redwood Creek above Hayes Creek Redwood Creek below Hayes Creek Redwood Creek Estuary	8-40	11	[1]41	Mostly pebble sand and sandy pebble gravel; however, coarse pebble and cobble gravel are prevalent in the upper section of this reach.

[1]Exclusive of the last 4 miles of channel which is rock-lined levies for flood control.

reaches of the Redwood Creek stream channel

others, 1975b]

Log and debris accumulation	Streamflow	Nursery area for fish
Natural barrier to anadromous fish at downstream end of reach, created by accumulation of angular blocks of sandstone several tens of feet in diameter. Thirty log and debris jams upstream creating falls from 50 to 100 ft.	Intermittent during late summer and early autumn.	Limited by flow and pool areas.
Eighteen log and debris jams--only one is large enough to efficiently trap sediments.	Perennial.	Few and limited to pool areas created by eddies behind large blocks of bedrock and accumulation of organic debris.
Several large accumulations of log and other wooden debris; however, no barrier to anadromous fish is created.	Perennial.	Some large nursery pools occur in the steep, rocky section above Minor Creek and in the incised meanders. Otherwise, pools are nearly nonexistent.
Small and few in number.	Perennial.	Nursery pools are associated with the large blocks of bedrock.
Several large accumulations of log and debris occur on large blocks of bedrock.	Perennial.	Nursery pools are associated with the large blocks of bedrock.
--	Perennial.	Large nursery pools are associated with large blocks of bedrock.
Large accumulations of log and debris occur; however, they do not create any barriers to anadromous fish.	Perennial.	Nursery pools are sparse and created by eddies behind large blocks of bedrock, fallen trees, and in the incised meanders.

Redwood Creek enters the Pacific Ocean just west of Orick (fig. 2). The estuary at the mouth of Redwood Creek is small and restricted by stream channelization (fig. 3). A small tributary enters the Redwood Creek estuary from the north, and remnants of the original Redwood Creek channel, prior to channelization, enter from the south. During low-flow periods of summer and early autumn, the mouth of Redwood Creek is usually closed to the Pacific Ocean by an emergent sandbar. The first autumn freshet usually opens the passage to the ocean and allows anadromous fish to begin their upstream migration. Local fishermen sometimes open the mouth before the autumn rains. Salmonids that enter the estuary prior to autumn rains cannot migrate upstream because of the low flow and are vulnerable to fishermen. In addition to fishermen, local ranchers sometimes open the mouth of Redwood Creek to alleviate backwater flooding of pastures.

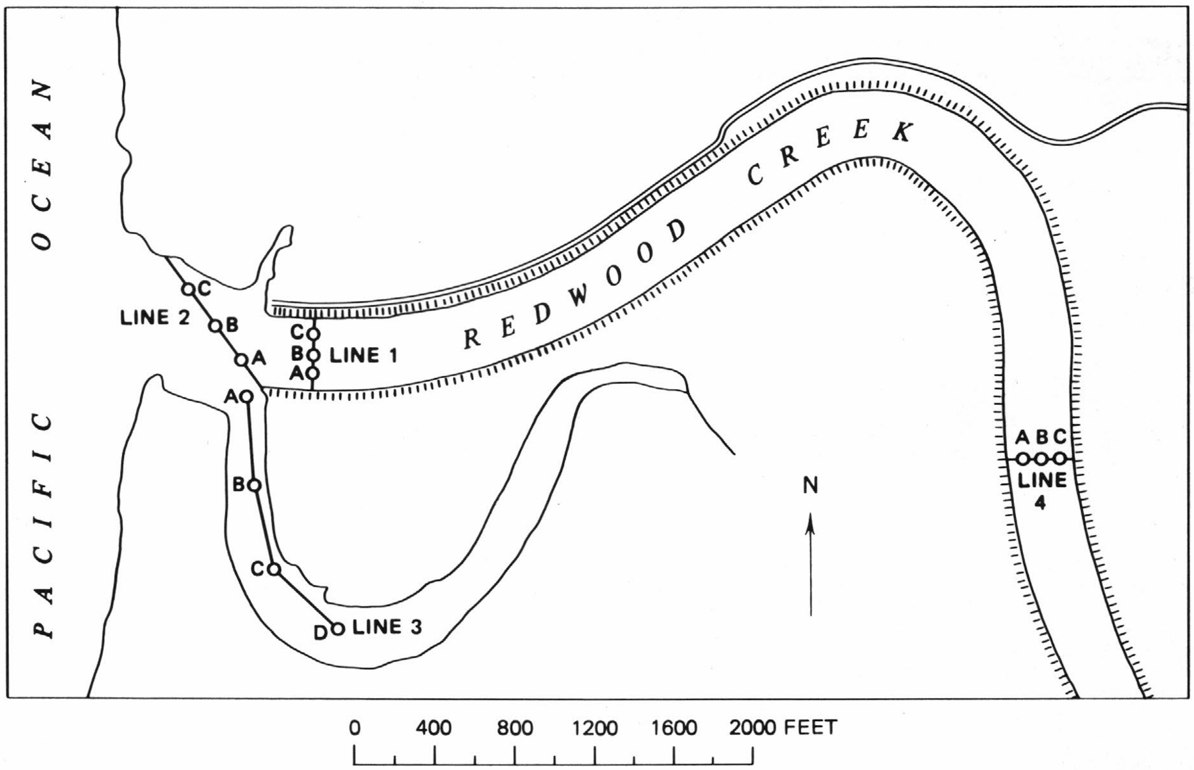

FIGURE 3.--Redwood Creek estuary and sampling stations.

The saltwater gradient of the Redwood Creek estuary was described by Bradford and Iwatsubo (1978). During the winter and spring, the discharge of Redwood Creek is high enough to prevent saltwater from entering the estuary. With the decrease in discharge during the summer, saltwater enters the estuary, and a salt-wedge estuary, as described by Pritchard (1967), is formed.

The dominant geologic unit of the Redwood Creek basin is the Franciscan Complex (Strand, 1962 and 1963). The east side of the Redwood Creek basin, upstream from Prairie Creek, is underlain by virtually unmetamorphosed Franciscan sedimentary rocks such as graywacke sandstone, mudstone, and conglomerate. The soil profile developed on this side of the drainage basin includes the Hugo, Kneeland, Melbourne, Mendocino, and Tyson soil series. On the west side of Redwood Creek, the drainage basin is underlain by mostly medium-gray, well foliated quartz-mica schist, quartz-mica-feldspar schist, and quartz-graphite schist. These schists have weathered mostly to the Orick, Masterson, and Sites soil series (Iwatsubo and others, 1975). A transition zone exists between the unmetamorphosed sedimentary rocks of the east side of the drainage basin and the schists of the west side. Sheared rocks in this zone (Grogan, South Fork Mountain, Bald Mountain, and numerous small cross faults) are the parent material for the Atwell soil series, which is extremely unstable and susceptible to landslides.

The northern part of the Redwood Creek basin has a coastal Mediterranean climate which is characterized by mild winters and short, warm, dry summers with frequent fog due to the proximity of the Pacific Ocean. The southern part of the basin has an interior Mediterranean climate with mild winters and hot, dry summers with infrequent fog (Critchfield, 1966).

Precipitation in the Redwood Creek basin is greater than that usually associated with a Mediterranean climate. Rantz (1969) has estimated a basin-wide precipitation total of 80 inches per year. Orographic influences cause extreme local variations in precipitation quantities (Janda and others, 1975b). Average annual rainfall ranges generally from 70 inches at Orick to 100 inches or more at Board Camp Mountain near the head of the basin (Iwatsubo and others, 1975). Nearly all the precipitation in the Redwood Creek basin is rain. Snow occasionally falls at altitudes higher than 1,750 ft but has little effect on annual runoff.

Air temperatures are generally mild throughout the year. In the northern part of the basin, mean monthly temperatures range from 60°F in August to about 44°F in January (Janda and others, 1975b). In the southern part of the basin, temperatures are less influenced by the Pacific Ocean. The mean maximum-minimum temperatures range from about 95°F in July to about 32°F in January.

Streamflow is variable along the main stem of Redwood Creek, with highest flows occurring between November and April and lowest flows between August and October. Three continuous-recording gages are located on Redwood Creek (fig. 2). At the time of the study, Redwood Creek near Blue Lake station, with 8 years of recorded data, had a maximum discharge of 12,200 ft^3/s and a minimum of 2.7 ft^3/s. Redwood Creek at South Park Boundary, with 5 years of recorded data, had maximum and minimum discharges of 33,000 and 4.5 ft^3/s, respectively. Redwood Creek at Orick, with 24 years of recorded data, had maximum and minimum discharges of 50,500 and 9.3 ft^3/s (U.S. Geological Survey, 1975).

The overall quality of water in the Redwood Creek basin is excellent. Dissolved-solids concentrations in samples ranged from 25 to 139 mg/L. Nitrogen and phosphorus concentrations are generally too low to support nuisance algal growths. However, nitrogen and phosphorus concentrations are high enough to support modest algal growths, especially in the main stem where insolation is high (Bradford and Iwatsubo, 1978).

Vegetation in the Redwood Creek basin is diverse (Janda and others, 1975b). Along the lower flood plain of Redwood Creek and near the estuary, Sitka spruce (Picea sitchensis) is the dominant tree. Coast redwoods and associated vegetation dominate the remaining forest areas in the northern part of the basin. Overstory conifers associated with the coast redwoods include Douglas fir (Pseudotsuga menziesii), western hemlock (Tsuga heterophylla), grand fir (Abies grandis), and Sitka spruce. Hardwood trees associated with the coast redwoods include tanoak (Lithocarpus densiflorus), madrone (Arbutus menziesii), big leaf maple (Acer macrophyllum), California bay (Umbellularia californica), and red alder (Alnus rubra). Understory vegetation of the coastal redwood forest includes oxalis (Oxalis oregana), sword fern (Polystichum munitum), hazel (Corylus cornuta), rhododendron (Rhododendron macrophyllum), azalea (Rhododendron occidentale), dogwood (Cornus nuttallii), salal (Gaultheria shallon), and black and red huckleberry (Vaccinium ovatum and V. parviflorum). In higher and drier parts of the basin, Douglas-fir forests are dominant and the coast redwoods are restricted to moist flood plains and terraces adjacent to streams. Near the headwaters, white fir (Abies concolor) and incense cedar (Libocedrus decurrens) are abundant. Blackoak (Quercus kelloggii), giant chinquapin (Castanopsis chrysophylla), Oregon white oak (Quercus garryana), canyon live oak (Quercus chrysolepis), vine maple (Acer circinatum), and poison oak (Rhus diversiloba) are locally abundant.

In April 1975, 65 percent of the Redwood Creek basin was cutover timberland. Old-growth forests covered 20 percent of the basin, and prairies, woodland, and brush covered the remaining 15 percent (Janda and others, 1975b).

Mill Creek

The Mill Creek basin covers 37 mi^2 and is a major tributary to the Smith River (fig. 4). The basin is characterized by high relief and steep terrain that is more stable than that in the Redwood Creek basin. The shape of the Mill Creek basin, although nearly circular, is slightly elongated in a northerly direction. The overall drainage pattern is dendritic; however, some parts of the basin display a weakly trellised pattern. The altitude of the basin ranges from 70 ft at the mouth to 2,330 ft at Childs Hill. Stream-channel gradients are nearly regular and moderately steep. Some local irregularities in gradient are associated with organic debris accumulations. The average channel gradient for both West Branch and East Fork Mill Creek is about 240 ft/mi. The average channel gradient for the entire drainage basin is 130 ft/mi. The hillslopes of the basin are characterized by straight or convex profiles and steep gradients, with slopes frequently exceeding 50 percent. Mill Creek and its major tributaries have broad flat valley bottoms that abut the steep hillslopes. The main channel of Mill Creek downstream from the confluence of the west branch and east fork is rockwalled, and streambed materials consist primarily of sandy pebble and cobble gravel (Iwatsubo and others, 1976).

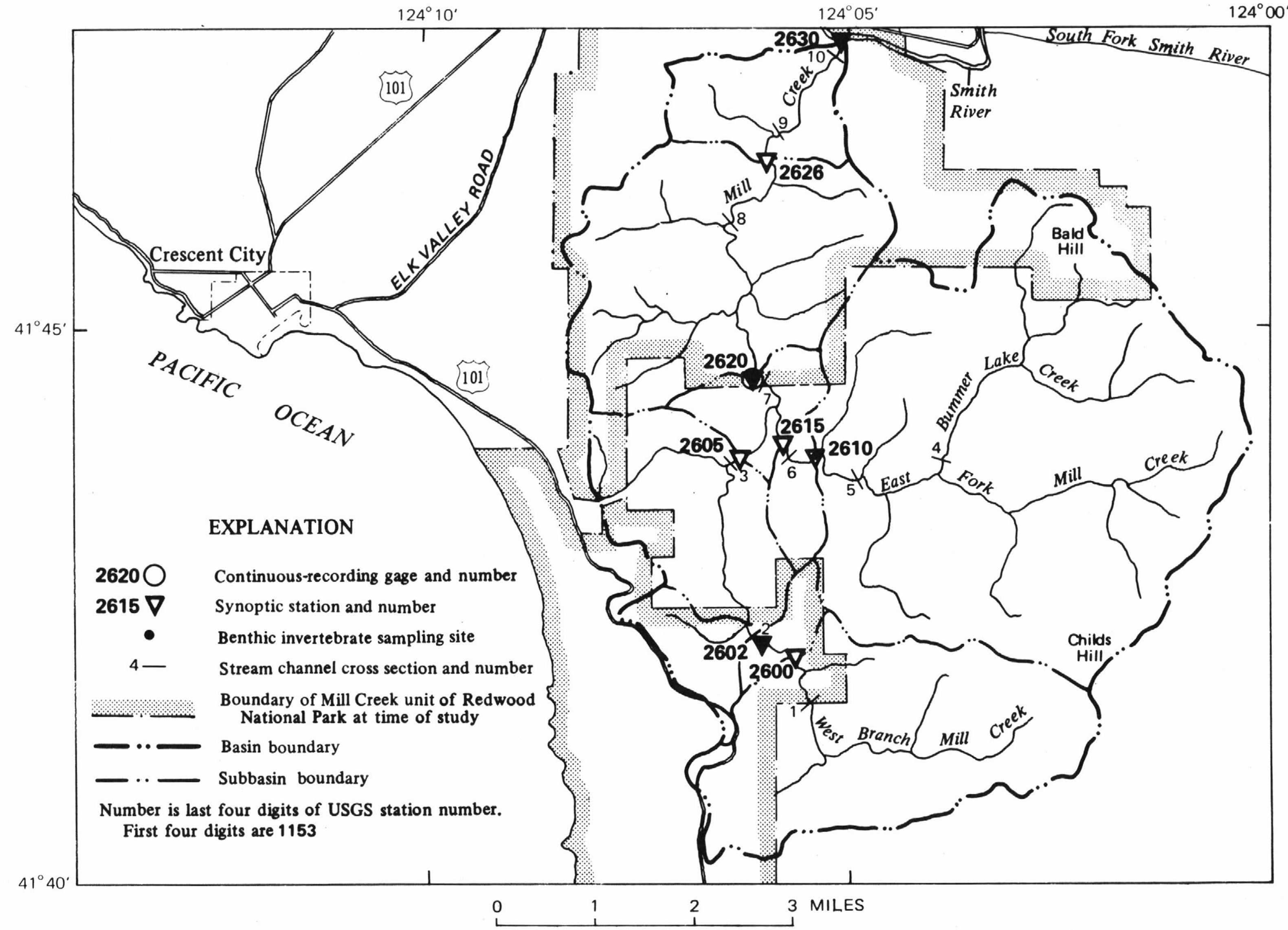

FIGURE 4.--Mill Creek drainage basin and sampling stations.

The Mill Creek basin is mostly underlain by unmetamorphosed sandstones of the Franciscan Complex. Outcrops of metamorphic rocks occur along the east side of the north-northwest trending South Fork Mountain fault (Strand, 1963). Serpentine and peridotite crop out along the basin boundary between Mill Creek and South Fork Smith River. Ridges along the northeastern part of the basin are capped by marine deposits of Miocene age, and unnamed alluvial gravels of late Cenozoic age crop out along ridge crests in the southern and central parts of the basin. Rocks in the Mill Creek basin are not as pervasively fractured and sheared as comparable rocks in the Redwood Creek basin. The rocks have weathered to the Melbourne and Josephine soil series, which are more cohesive than the Hugo soil series formed from comparable sandstone in the Redwood Creek basin (Iwatsubo and others, 1976).

The Mill Creek basin has a coastal Mediterranean climate characterized by large quantities of winter rainfall, mild winter temperatures, and short, warm summers with frequent fog. Rantz (1969) estimated that the annual rainfall on the drainage basin ranges from 80 to 90 inches. Mean maximum and minimum temperatures recorded near Crescent City range from 66°F in July to 37°F in January (U.S. National Oceanic and Atmospheric Administration, 1974-75).

Vegetation in the Mill Creek basin is primarily a coast redwood and Douglas-fir forest with understory species similar to those found in the Redwood Creek basin. Coast redwood groves dominate the vegetation on flood plains, low terraces, and adjacent hillslopes along stream channels. In the Bald Hill area, Jeffrey pine (*Pinus jeffreyi*), Douglas fir, and grass woodlands grow on soils derived from serpentine and peridotite. In 1974, about 49 percent of the basin consisted of old-growth forest, 30 percent recently logged area, 19 percent advanced second-growth forest, and 2 percent natural prairie and cleared area (Iwatsubo and others, 1976).

Streamflow in the Mill Creek basin is variable, as in the Redwood Creek basin, with highest flows occurring between November and April and lowest flows between August and October. At the time of the study, Mill Creek near Crescent City (the only station with a continuous recorder), with less than 2 years of recorded data, had a maximum discharge of 4,460 ft^3/s and a minimum discharge of 2.5 ft^3/s (U.S. Geological Survey, 1975).

The quality of water in the Mill Creek basin is excellent. Dissolved-solids concentrations in samples ranged from 21 to 49 mg/L. Nitrogen and phosphorus concentrations are generally too low to support nuisance algal growths (Bradford and Iwatsubo, 1978).

SAMPLING STATIONS AND METHODS

Sampling Stations

Biological data were collected at 54 sampling stations, 50 in the Redwood Creek basin and 4 in the Mill Creek basin (figs. 2, 3, and 4). A brief description of the sampling stations and types of aquatic organisms collected was given in Iwatsubo and others (1976) and is in table 2. The sampling stations were chosen on the basis of size of drainage area, location in reference to Redwood National Park, geology, and history of land use. The drainage basin of each sampling station has been categorized (table 2) according to its history of land use or as a Redwood Creek main-stem or estuary station. Land-use categories are control (limited activities of man in the basin), regenerating after being logged, and presently being logged.

Methods

Biological assessments were made for bacteria (fecal coliforms and fecal streptococci), benthic invertebrates, fish, periphyton, phytoplankton, and seston. All biological samples were collected during the study period, September 1973 through September 1975. All techniques and methods used in the study conformed with those described by Slack and others (1973). Most of the aquatic organisms were collected during the receding-flow periods of spring and the low-flow periods of summer and early autumn. High streamflow limited winter sampling to the collection of bacteria and seston.

Water samples for bacterial analysis were collected in sterilized glass containers. The membrane-filter incubation method was used to determine bacterial colony density. Bacteria were retained on 0.45-micrometer pore-size membrane filters.

Benthic invertebrates were collected with a Surber sampler in the stream or with an Ekman dredge in the Redwood Creek estuary. Benthic invertebrates from the 1973 samples were separated from detritus in the field with the use of forceps. Invertebrates from 1974 and 1975 samples were separated from detritus in the laboratory by the floatation technique described by Anderson (1959). Identification and enumeration of benthic invertebrates were made by using selected taxonomic references.[1]

Fish were collected by using either a 50-foot straight seine with a 0.25-inch mesh opening at a depth of 5 ft, or a backpack electrofishing unit. Tricaine methanesulfonate was used to anesthetize the fish prior to identification and determination of length and weight (salmonids only).

Periphyton were collected on artificial substrates made of clear acrylic strips measuring 4 inches by 18 inches. Substrates were generally given 8 to 10 weeks for periphyton colonization before removal. Identification and biomass analysis were done in the laboratory.

Water samples for phytoplankton analysis were collected in 1-liter polyethylene bottles and preserved with Lugol's solution. Phytoplankton were identified and enumerated by the inverted microscope method.

Water samples for seston analysis were collected in 2-liter polyethylene bottles, chilled to 39.2°F, and brought to the field laboratory for analysis. The glass-fiber filter method was used to determine total and organic concentrations of seston.

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[1]Borror and DeLong (1971); Edmondson (1959); Edmunds and others (1963); Gaufin and Tarzwell (1952); Jewett (1960); Johannsen (1969); Mason (1973); Pennak (1953); Ross (1944); Smith and Carlton (1975); Usinger (1956).

Station description				Drainage basin		Average stream gradient (ft/mi)	Stream order
	Number and name	Latitude	Longitude	Area (mi²)	Average altitude (ft)		
--	Redwood Creek above Highway 299 bridge	40°54'03"	123°48'33"	65.9	--	--	5
11481500	Redwood Creek near Blue Lake	40°54'22"	123°48'51"	67.7	3,030	165	5
11482020	Redwood Creek at Redwood Valley Bridge, near Blue Lake	40°57'48"	123°50'20"	96.0	2,780	142	5
--	Redwood Creek at Lower End, Redwood Valley	41°03'00"	123°52'20"	123	--	--	6
11482120	Redwood Creek above Panther Creek, near Orick	41°05'21"	123°54'23"	150	2,500	99	6
11482140	High-Slope Schist Creek near Orick	41°07'25"	123°56'51"	.53	1,720	1,552	2
--	Redwood Creek above Copper Creek, near Orick	40°08'53"	123°56'00"	17.7	--	--	6
11482160	Copper Creek near Orick	41°08'58"	123°55'53"	2.78	1,920	951	4
--	Redwood Creek below Copper Creek, near Orick	41°09'02"	123°55'59"	180	--	--	6
11482190	Slide Creek near Orick	41°10'19"	123°56'49"	1.16	1,810	1,351	3
11482200	Redwood Creek at South Park Boundary, near Orick	41°10'19"	123°56'55"	185	2,310	98	6
11482210	Bridge Creek near Orick	41°11'32"	123°58'52"	11.6	1,520	318	4
11482220	Redwood Creek above Harry Wier Creek, near Orick	41°11'50"	123°59'30"	202	2,250	85	6
11482225	Harry Wier Creek, near Orick	41°11'53"	123°59'32"	2.96	1,390	766	4
--	Redwood Creek below Harry Wier Creek, near Orick	41°11'50"	123°59'40"	205	--	--	6
--	Redwood Creek above Tom McDonald Creek, near Orick	41°12'25"	124°00'26"	206	--	--	6
11482230	Tom McDonald Creek near Orick	41°12'16"	124°00'53"	6.86	1,360	370	4
--	Redwood Creek below Tom McDonald Creek, near Orick	41°12'28"	124°00'41"	213	--	--	6
11482240	Fortyfour Creek near Orick	41°13'15"	124°00'44"	3.09	920	552	3
--	Redwood Creek above Miller Creek, near Orick	41°13'41"	124°00'37"	218	--	--	6
11482250	Miller Creek near Orick	41°13'54"	123°59'30"	.67	1,520	1,093	3
11482260	Miller Creek at mouth, near Orick	41°13'46"	124°00'36"	1.36	1,370	1,057	3

stations for aquatic biota

Streambed composition[1]	Canopy (Estimated percentage)[2]	Biological sampling[3]	History of land use[4] (percentage of area)			Basin classification
			Logged since establishing park	Logged prior to establishing park	Virgin and advanced second growth	
Small cobble, gravel, sand, and silt	5	BI	--	--	--	Main stem
Small cobble, gravel, sand, and silt	30	B,BI,S	<5	>55	40	Main stem
Cobble, gravel, sand, silt	<1	B,BI,F,S	<5	>60	35	Main stem
Small cobble, mainly gravel, sand, some silt	5	BI	--	--	--	Main stem
Cobble, gravel, sand	10	B,BI,S	<5	>60	35	Main stem
Boulders, cobble, some gravel, sand	98	BI,S	--	--	100	Control
Cobble, gravel, sand	<1	BI,F	--	--	--	Main stem
Cobble, gravel, much sand, silt	<1	BI,F,S	20	30	50	Being logged
Some boulders, mainly cobble, gravel, sand	<1	BI	--	--	--	Main stem
Cobble, gravel, sand, silt	95	BI	30	40	30	Being logged
Cobble, some gravel, sand	5	B,BI,P_1,P_2,S	<5	65	>30	Main stem
Cobble, little gravel, sand, silt	3	BI,F,P_1,P_2,S	21	55	24	Being logged
Small cobble, mainly gravel and sand, some silt	5	B,S	5	60	35	Main stem
Cobble, little gravel, sand silt	95	B,BI,F,P_1,P_2,S	40	--	60	Being logged
Small cobble, mainly gravel and sand, some silt	5	BI,F	--	--	--	Main stem
Small cobble, gravel, sand	5	BI	--	--	--	Main stem
Few boulders, cobble, some gravel, sand, silt	50	BI,F,S	6	80	14	Being logged
Cobble, sand	5	BI	--	--	--	Main stem
--	--	S	20	75	5	Being logged
Small cobble and gravel, sand, silt	5	BI	--	--	--	Main stem
Small cobble, gravel, sand, silt	70	B,BI,P_1,P_2,S	90	--	10	Being logged
Small cobble, gravel, sand, silt	85	B,BI,F,P_1,P_2,S	77	--	23	Being logged

Station description				Drainage basin		Average stream gradient (ft/mi)	Stream order
Number and name		Latitude	Longitude	Area (mi²)	Average altitude (ft)		
11482270	Bond Creek near Orick	41°14'02"	124°01'14"	1.37	920	727	3
11482280	Cloquet Creek near Orick	41°14'42"	124°00'37"	1.14	1,250	1,161	2
--	Redwood Creek below Oscar Larson Creek, near Orick	41°15'23"	124°00'33"	225	--	--	6
11482300	Elam Creek near Orick	41°15'49"	124°01'29"	2.49	1,040	474	3
--	Redwood Creek below Elam Creek near Orick	41°15'52"	124°01'27"	229	--	--	6
11482310	McArthur Creek near Orick	41°16'31"	124°01'42	3.73	950	249	3
11482320	Low-Slope Schist Creek near Orick	41°16'53"	124°01'49"	.19	875	1,276	2
--	Redwood Creek above Hayes Creek, near Orick	41°17'19"	124°01'42"	235	--	--	6
11482330	Hayes Creek near Orick	41°17'24"	124°01'36"	.58	940	1,250	3
--	Redwood Creek below Hayes Creek, near Orick	41°17'30"	124°01'49"	236	--	--	6
--	Redwood Creek above Prairie Creek, near Orick	41°18'00"	124°02'55"	237	--	--	6
--	Prairie Creek near Orick	41°18'01"	124°02'57	39.7	--	--	--
11482450	Lost Man Creek near Orick	41°19'06"	123°59'15"	3.97	1,400	547	4
11482460	Larry Damm Creek near Orick	41°19'46"	124°00'46"	1.87	470	498	3
11482468	Little Lost Man Creek at Site No. 2, near Orick	41°19'20"	124°01'10"	3.46	1,440	398	4
11482470	Little Lost Man Creek near Orick	41°19'42"	124°01'29"	3.64	1,270	349	4
11482475	Geneva Creek near Orick	41°19'36"	124°01'53"	.08	520	1,280	2
11482480	Berry Glen Creek near Orick	41°18'59"	124°02'17"	.40	710	1,379	2
11482500	Redwood Creek at Orick	41°17'18"	124°03'27"	278	1,810	71	6
411734 124051301	Redwood Creek Estuary Site 1A, near Orick	41°17'34"	124°05'13"	282	--	--	--
411734 124051302	Redwood Creek Estuary Site 1B, near Orick	41°17'34"	124°05'13"	282	--	--	--
411734 124051303	Redwood Creek Estuary Site 1C, near Orick	41°17'34"	124°05'13"	282	--	--	--
411734 124051801	Redwood Creek Estuary Site 2A, near Orick	41°17'34"	124°05'18"	282	--	--	--
411734 124051802	Redwood Creek Estuary Site 2B, near Orick	41°17'34"	124°05'18"	282	--	--	--

stations for aquatic biota--Continued

Streambed composition[1]	Canopy (Estimated percentage)[2]	Biological sampling[3]	History of land use[4] (percentage of area)			Basin classification
			Logged since establishing park	Logged prior to establishing park	Virgin and advanced second growth	
--	--	S	27	--	18	Being logged
Small cobble, gravel, sand, silt	60	BI	55	--	45	Being logged
Small cobble, mainly gravel and sand, silt	5	BI	--	--	--	Main stem
Small cobble, gravel, sand, heavily coated with oxidized material	90	BI,S	40	30	30	Being logged
Few cobbles, some gravel, mainly sand	5	BI	--	--	--	Main stem
--	--	S	30	45	25	Being logged
--	--	S	--	--	100	Control
Large cobble, gravel, sand	<1	BI,F,P_1	--	--	--	Main stem
Cobble, gravel, sand, silt	85	B,BI,P_1,P_2,S	--	4	96	Control
Cobble, gravel, mainly sand	<1	BI,F	--	--	--	Main stem
--	--	B	--	--	--	Main stem
--	--	B	--	--	--	--
Cobble, little gravel, sand, silt	60	B,BI,P_1,P_2,S	--	87	13	Regenerating
--	--	S	--	70	30	Regenerating
Cobble, gravel, sand, some silt	60	B,BI,P_1,P_2,S	--	6	94	Control
Cobble, gravel, sand, silt	40	BI,F,S	--	8	92	Control
Small cobble, gravel, sand	95	BI,S	--	100	--	Regenerating
--	--	S	--	100	--	Regenerating
--	<1	B,P_2,S	10	50	40	Main stem
Sand, silt	<1	BI	--	--	--	Estuary
Sand, silt	<1	BI,P_2	--	--	--	Estuary
Sand, silt	<1	BI	--	--	--	Estuary
Sand, silt	<1	BI	--	--	--	Estuary
Sand, silt	<1	BI,P_2	--	--	--	Estuary

Station description				Drainage basin		Average stream gradient (ft/mi)	Stream order
Number and name		Latitude	Longitude	Area (mi^2)	Average altitude (ft)		
411734 124051803	Redwood Creek Estuary Site 2C, near Orick	41°17'34"	124°05'18"	282	--	--	--
411732 124051801	Redwood Creek Estuary Site 3A, near Orick	41°17'32"	124°05'18"	282	--	--	--
411732 124051802	Redwood Creek Estuary Site 3B, near Orick	41°17'32"	124°05'18"	282	--	--	--
411732 124051803	Redwood Creek Estuary Site 3C, near Orick	41°17'32"	124°05'18"	282	--	--	--
11532602	West branch Mill Creek below Red Alder Campground, near Crescent City	41°42'11"	124°06'04"	6.90	1,060	340	5
11532610	East Fork Mill Creek near Crescent City	41°43'51"	124°05'20"	16.1	≈1,190	≈235	6
11532620	Mill Creek near Crescent City	41°44'32"	124°06'06"	28.6	940	145	6
11532630	Mill Creek at Mouth near Crescent City	41°47'29"	124°05'01"	37	810	130	6

[1]Subjective field observations.
[2]Streambed exposure to direct sunlight at each station was influenced by deciduous riparian vegetation.
[3]B=bacteria; BI=benthic invertebrates; F=fish; P_1=periphyton; P_2=phytoplankton; S=seston.
[4]History of land use as of August 1975.
[5]History of land use as of December 1974.

AQUATIC BIOLOGY

Bacteria

Bacteria can serve as biological indicators for assessing the sanitary quality of water. The presence of fecal-coliform and fecal-streptococcal bacteria indicates recent fecal-waste contamination by warm-blooded animals.

The California State Water Resources Control Board has established water-quality objectives for the bacteriological quality of surface water in the North Coast Region. For water-contact recreation (swimming and wading), the median fecal-coliform concentration should not exceed 50 col/100 mL, based on a minimum of 5 samples for any 30-day period. In addition, no more than 10 percent of the total sample during any 30-day period shall exceed 400 col/100 mL (California State Water Resources Control Board, 1975). At this time, there are no specific water-quality objectives for fecal-streptococcal concentrations in surface water.

Bacterial densities in the Redwood Creek and Mill Creek basins were low (table 3). One exception was Prairie Creek, a tributary to Redwood Creek. Most of the bacterial results, however, were based on less than ideal colony counts, which occur when the number of bacterial colonies on a membrane filter

Streambed composition[1]	Canopy (Estimated percentage)[2]	Biological sampling[3]	History of land use[4] (percentage of area)				Basin classification
			Logged since establishing park	Logged prior to establishing park	Virgin and advanced second growth		
Sand, silt	<1	BI	--	--	--		Estuary
Sand, silt	<1	BI	--	--	--		Estuary
Sand, silt	<1	BI,P_2	--	--	--		Estuary
Sand, silt	<1	BI	--	--	--		Estuary
			Logged as of 1974	Advanced second growth	Prairie or cleared area	Virgin area[5]	
Cobble, large gravel, sand	50	B,BI,P_1,P_2, S	39	17	0	44	Being logged
Cobble, gravel, sand	60	B,BI,P_1,P_2, S	≈48	≈1	≈4	≈47	Being logged
Some boulders, cobble, gravel, sand	40	B,BI,F,P_1, P_2,S	38	20	3	39	Main stem
Cobble, gravel, sand	55	B,BI,S	30	19	2	49	Main stem

fall outside the range of 20 to 60 colonies per filter for fecal-coliform bacteria and 20 to 100 colonies for fecal-streptococcal bacteria (Slack and others, 1973).

Fecal-coliform and fecal-streptococcal bacteria densities in the Redwood Creek basin ranged from <1 to 220 and <1 to 750 col/100 mL, with mean densities of 16 and 49 col/100 mL. At Redwood Creek main-stem stations, fecal-coliform and fecal-streptococcal bacteria densities ranged from <1 to 47 and 1 to 280 col/100 mL, with mean densities of 13 and 35 col/100 mL. Bacterial densities of selected tributaries to Redwood Creek ranged from <1 to 220 col/100 mL for fecal-coliform bacteria and from <1 to 750 col/100 mL for fecal-streptococcal bacteria, with mean densities of 21 and 70 col/100 mL. The largest bacterial densities for fecal-coliform and fecal-streptococcal bacteria (220 and 753 col/100 mL) were in water samples collected at Prairie Creek. Several potential sources of bacterial contamination in Prairie Creek include a state park, county fish hatchery, grazing land, lumber mill, and scattered residential areas in the drainage basin. Excluding Prairie Creek, bacterial densities in the selected Redwood Creek tributaries ranged from <1 to 30 col/100 mL for fecal-coliform bacteria and from <1 to 190 col/100 mL for fecal-streptococcal bacteria, with mean densities of 5 and 22 col/100 mL.

In the Mill Creek basin, fecal-coliform and fecal-streptococcal bacteria densities ranged from 3 to 18 and 4 to 21 col/100 mL, with mean densities of 10 and 10 col/100 mL.

TABLE 3.--Summary of fecal-coliform and fecal-streptococcal bacteria data

[In computations, <1 colony/mL was counted as 1 colony/mL]

Station name	Bacteria (colonies per 100 mL)					
	Fecal coliform			Fecal streptococcal		
	Range	Mean	No. Samples	Range	Mean	No. Samples
Redwood Creek nr Blue Lake	1-28	14	5	3-24	12	4
Redwood Creek at Redwood Valley Bridge nr Blue Lake	<1-22	9.5	4	8-52	29	4
Redwood Creek above Panther Creek nr Orick	4-47	19	4	8-280	110	3
Redwood Creek at South Park Boundary nr Orick	<1-8	3.2	6	2-26	10	5
Redwood Creek above Harry Wier Creek nr Orick	--	1.0	1	--	11	1
Harry Wier Creek nr Orick	<1-9	3.7	3	4-190	73	3
Miller Creek nr Orick	6-30	18	2	<1-16	8.5	2
Miller Creek at Mouth nr Orick	<1-2	1.5	2	3-11	7.0	2
Hayes Creek nr Orick	--	10	1	--	6.0	1
Redwood Creek above Prairie Creek nr Orick	8-29	18	2	1-5	3.0	2
Lost Man Creek nr Orick	<1-1	1.0	2	<1-6	3.5	2
Little Lost Man Creek at site no. 2 nr Orick	<1-4	2.7	3	1-9	8.0	3
Prairie Creek nr Orick	22-220	120	2	11-750	380	2
Redwood Creek nr Orick	4-46	21	6	6-160	54	5
West Branch Mill Creek below Red Alder Campground nr Crescent City	--	3.0	1	--	4.0	1
East Fork Mill Creek nr Crescent City	--	7.0	1	--	13	1
Mill Creek nr Crescent City	--	18	1	--	4.0	1
Mill Creek at Mouth nr Crescent City	--	13	1	--	21	1
All Redwood Creek stations	<1-220	16	43	<1-750	48	39
Redwood Creek main-stem stations	<1-47	13	28	1-280	35	24
Redwood Creek tributary stations	<1-220	21	15	<1-750	70	15
Redwood Creek tributary stations (Prairie Creek excluded)	<1-30	5.4	13	<1-190	22	13
All Mill Creek stations	3-18	10	4	4-21	10	4

Benthic Invertebrates

Benthic invertebrates are the community of animals without backbones that live in or on the bottom of lakes and streams. Because benthic invertebrates are found in specific types of habitat and are sensitive to water-quality changes, they often have been used as biological indicators of the quality of the aquatic ecosystem (Hynes, 1964 and 1970, and Cummins, 1973).

The taxonomic classification and enumeration of benthic invertebrates collected from the Redwood Creek and Mill Creek basins (figs. 2, 3, and 4) have been reported by Iwatsubo and others (1975, 1976). The benthic-invertebrate community was extremely diverse and was composed of 150 taxa (table 4). Of these, 144 benthic-invertebrate taxa were identified from samples collected at Redwood Creek main-stem (above the estuary) and tributary stations, 30 taxa were identified from Redwood Creek estuary samples, and 67 taxa were identified from samples collected at Mill Creek basin stations. Of the 150 taxa identified from the samples, 79 were found only in Redwood Creek main stem and tributaries, 4 were found only in Redwood Creek estuary, and 2 were found only in the Mill Creek basin. Sixty-five were common to both drainage basins.

Taxonomic Composition

Benthic invertebrates classified in the phylum Annelida (segmented worms) composed 1 percent of the total number of benthic invertebrates collected during the study (table 5). Two classes of annelids, Oligochaeta and Polychaeta, were collected from the Redwood Creek basin. Oligochaeta (aquatic earthworms) were collected at nearly every station sampled. Aquatic oligochaetes occupy a niche similar to that occupied by terrestrial species and obtain their food by ingesting mud and organic detritus. Most aquatic oligochaetes are found in the mud substrates of lakes and slow-moving or stagnant pools of streams; however, they are also commonly found in cold mountain streams (Pennak, 1953). Polychaeta (polychaete worms) were found at only two sampling stations in the Redwood Creek estuary and represented less than 0.1 percent of the benthic invertebrates collected during the study. Polychaetes are more abundant in estuaries than in freshwater communities and occupy a niche similar to that of the oligochaetes (Reid, 1961). In the Mill Creek basin, aquatic oligochaetes were the only annelids collected, and they represented 0.8 percent of the total number of benthic invertebrates collected from the drainage basin.

Phylum Arthropoda (jointed-legs) represented 98.3 percent of the benthic invertebrates collected. Three classes of phylum Arthropoda were identified from the samples: Arachnoidea (spiders, ticks, and mites); Crustacea (crabs, shrimps, scuds, and sow bugs); and Insecta (insects).

Acari (water mites) were the only members of the class Arachnoidea sampled and represented 9.9 percent of the total benthic invertebrates collected during the study. Acari were abundant and occurred at every sampling station in the Redwood Creek and Mill Creek basins. Water mites occupy a vast range of habitats (hot springs, ponds, stagnant pools, and turbulent mountain streams); however, they are known to be especially abundant among heavy growths of aquatic vegetation (Borror and Delong, 1971, and Pennak, 1953). For example, at Copper Creek, an extensively logged drainage basin with abundant periphytic growth, 15,000 Acari per square meter were collected during the autumn 1975 sampling period.

Crustaceans (class Crustacea) occurred only in samples from the Redwood Creek basin and composed 17.9 percent of the total benthic invertebrates collected. Corophium (estuarine scud) was the dominant crustacean and represented 98.4 percent of the class; it was found only in the Redwood Creek estuary. Corophium are primarily tube-dwelling omnivores and a major source of food for fish in estuarine environments (Pennak, 1953, Kelly, 1966, and Smith and Carlton, 1975). The remaining 1.6 percent of the crustaceans collected during the study were represented by Anisogammarus and Stygobromus (freshwater scuds), Exosphaeroma (aquatic sow bug), and an unidentified group.

Insects (class Insecta) were the dominant class of arthropods and composed 70.5 percent of the total benthic invertebrates collected. Ten orders of insects were identified from the samples collected: Coleoptera (beetles); Collembola (spring tails); Diptera (two-winged flies); Ephemeroptera (mayflies); Hymenoptera (wasps); Lepidoptera (butterflies and moths); Neuroptera (dobsonflies and fishflies); Odonata (dragonflies and damselflies); Plecoptera (stoneflies); and Trichoptera (caddisflies).

In the Redwood Creek basin, insects composed 68.6 percent of the benthic invertebrates collected. Diptera was the dominant order, containing 22.0 percent of the benthic invertebrates from the basin, and was followed by: Ephemeroptera (17.7 percent); Coleoptera (13.2 percent); Trichoptera (11.3 percent); Plecoptera (4.3 percent); and Collembola, Hymenoptera, Lepidoptera, Neuroptera, and Odonata (<0.1 percent for each order). Exclusive of the estuary, the predominant insects were: Emphemeroptera (23.6 percent); Diptera (23.1 percent); Coleoptera (17.6 percent); Trichoptera (15.1 percent); Plecoptera (5.7 percent); Odonata (0.1 percent); and Collembola, Hymenoptera, Lepidoptera, and Neuroptera (<0.1 percent for each order).

In the Mill Creek basin, insects composed 91.1 percent of the benthic invertebrates collected. Ephemeroptera was the dominant order, containing 51.3 percent of the benthic invertebrates from the basin, and was followed by: Diptera (22.2 percent); Plecoptera (9.6 percent); Coleoptera (4.2 percent); Tricoptera (3.7 percent); Collembola (0.1 percent); and Hymenoptera and Odonata (<0.1 percent each).

The taxonomic composition of the insects from the Redwood Creek basin (exclusive of the estuary) and Mill Creek basin differ in that Redwood Creek had larger percentages of Coleoptera (17.6 v. 4.2 percent) and Trichoptera (15.1 v. 3.7 percent); Mill Creek had larger percentages of Ephemeroptera (51.3 v. 23.6 percent) and Plecoptera (9.6 v. 5.7 percent). In addition, Lepidoptera and Neuroptera were in Redwood Creek basin samples but not in the Mill Creek basin samples.

Benthic invertebrates representing phyla Mollusca (snails and clams), Nematoda (roundworms), and Platyhelminthes (flatworms) were collected in the Redwood Creek basin. Of these three phyla, Nematoda were the most abundant (especially in the estuary) and represented 0.7 percent of the invertebrates collected. Nematodes are highly adaptable organisms from an ecological and physiological standpoint (Pennak, 1953). For example, the same species may be found in tropical as well as alpine aquatic environments. In marine sediments, nematodes may be the most abundant metazoan present (Smith and Carlton, 1975). In the Mill Creek basin, mollusks and nematodes represented less than 1 percent of the total number of benthic organisms. Platyhelminthes were not in the Mill Creek basin samples.

TABLE 4.--Taxonomic list and occurrence of benthic invertebrates

PHYLUM CLASS Order Family Sub-family Tribe *Genus* *Sub-genus*	Redwood Creek drainage basin Main stem and tributaries	 Estuary	Mill Creek drainage basin
ANNELIDA			
OLIGOCHAETA (aquatic earthworms)	X	X	X
POLYCHAETA (polychaete worms)			
Nereidae			
Neanthes		X	
ARTHROPODA			
ARACHNOIDEA			
Acari (=Hydracarina)	X	X	X
CRUSTACEA			
Amphipoda (scuds)			
Corophiidae			
Corophium		X	
Gammaridae			
Anisogammarus	X		
Stygobromus	X		
Isopoda (aquatic sow bugs)			
Sphaeromidae			
Exosphaeroma		X	
Unknown	X		
INSECTA			
Coleoptera (beetles)			
Dytiscidae			
Agabinus	X		
Agabus	X		
Bidessus	X		
Deronectes	X	X	
Derovatellus	X		
Oreodytes	X		
Elmidae			
Ampumixis	X	X	
Heterlimnius	X	X	X
Limnius	X		
Narpus	X		X
Optioservus	X	X	X
Ordobrevia	X		X
Zaitzevia	X		X
Unknown	X		
Gyrinidae			
Gyrinus	X		
Hydraenidae (=Limnebiidae)			
Hydraena	X		
Limnebius	X		
Ochthebius	X		
Hydrophilidae			
Anacaena	X		
Berosus	X		
Cymbiodyta	X		
Helophorus	X		
Hydrochus	X		
Laccobius	X		
Paracymus	X		
Unknown	X		
Hydroscaphidae			
Hydroscapha	X		
Psephenidae			
Acneus	X		
Eubrianax	X		X
Ptilodactylidae			
Anchycteis	X		
Staphylinidae			
Emplenota	X		X
Thinusa	X		
Collembola (spring tails)	X	X	X

PHYLUM CLASS Order Family Sub-family Tribe *Genus* *Sub-genus*	Redwood Creek drainage basin Main stem and tributaries	 Estuary	Mill Creek drainage basin
Diptera (two-winged flies)			
Blephariceridae			
Blepharicera	X		
Ceratopogonidae (=Heleidae)			
Atrichopogon	X		
Bezzia	X	X	X
Forcipomyia	X		X
Palpomyia	X	X	
Unknown	X		
Chironomidae			
Chironominae			
Chironomini	X	X	X
Tanytarsini	X	X	X
Orthocladiinae and Diamesinae			
Thienemanniella	X	X	X
Other genera	X	X	X
Tanypodinae	X	X	X
Dixidae	X	X	X
Dolichopodidae	X		X
Empididae	X	X	X
Ephydridae	X		
Muscidae	X	X	X
Psychodidae			
Maruina	X		
Ptychopteridae	X		
Rhagionidae			
Atherix	X		
Simuliidae	X	X	X
Stratiomyidae			
Euparyphus	X		
Tabanidae	X		X
Tanyderidae			
Protanyderus	X		
Tipulidae			
Antocha	X		X
Dicranota	X		
Gonomyia		X	
Hexatoma	X		
Limnophila	X		
Limonia	X		
Ormosia	X	X	
Pedicia	X		
Tipula	X		
Ulomorpha	X		X
Unknown	X		
Ephemeroptera (mayflies)	X		
Baetidae			
Baetis	X	X	X
Centroptilum	X		X
Ephemerellidae			
Ephemerella	X		X
Heptageniidae			
Cinygma	X		
Cinygmula	X		X
Epeorus			
Iron	X		X
Ironodes	X		X
Ironopsis	X		X
Heptagenia	X	X	X
Rhithrogena	X		X
Leptophlebiidae			
Paraleptophlebia	X	X	X
Siphlonuridae			
Ameletus	X		X
Isonychia	X		
Tricorythidae			
Tricorythodes	X		
Hymenopters (wasps)			
Mymaridae			
Anagrus	X		X
Patasson	X		
Lepidoptera (butterflies, moths)			
Pyralidae			
Parargyractis	X		
Neuroptera (dobsonflies, fishflies)			
Corydalidae			
Dysmicohermes	X		
Sialidae			
Sialis	X		
Odonata (dragonflies, damselflies)			
Coenagrionidae			
Hyponeura	X		
Gomphidae			
Erpetogomphus			X

PHYLUM CLASS Order Family Sub-family Tribe *Genus* *Sub-genus*	Redwood Creek drainage basin Main stem and tributaries	 Estuary	Mill Creek drainage basin
Erpetogomphus			X
Gomphus	X		
Octogomphus	X		
Ophiogomphus	X		X
Plecoptera (stoneflies)			
Chloroperlidae			
Alloperla	X	X	X
Hastaperla	X		
Kathroperla	X		
Paraperla	X		X
Nemouridae			
Capnia	X		X
Leuctra	X		X
Megaleuctra	X		
Nemoura	X	X	X
Perlomyia	X		
Unknown	X		
Peltoperiidae			
Peltoperla	X		X
Perlidae			
Acroneuria	X		X
Perlodidae			
Isogenus	X		X
Isoperla	X		X
Pteronarcidae			
Pteronarcys	X		
Trichoptera (caddisflies)			
Sericostomatidae			
Sericostoma	X		X
Brachycentridae			
Micrasema	X		X
Calomoceratidae			
Heteroplectron	X		
Goeridae	X		
Hydroptilidae			
Hydroptila	X		X
Neotrichia	X		
Ochrotrichia	X		X
Oxyethira	X		X
Unknown	X		
Hydropsychidae			
Arctopsyche	X		
Cheumatopsyche	X		X
Hydropsyche	X		X
Parapsyche	X		X
Unknown	X		
Lepidostomatidae			
Lepidostoma	X	X	
Leptoceridae			
Oecetis	X		
Limnephilidae			
Dicosmoecus	X		X
Neophylax	X		X
Neothremma	X		
Oligophlebodes	X		
Pycnopsyche	X		
Radema	X		
Unknown	X		
Philopotamidae			
Wormaldia	X		X
Psychomyiidae			
Polycentropus	X		X
Unknown	X		
Rhyacophilidae			
Agapetus	X		
Glossosoma	X		X
Protoptila	X		X
Rhyacophila	X		X
Unknown	X		
MOLLUSCA			
GASTROPODA (snails)			
Ancylidae			
Lanx			X
Bythiniidae (=Bulimidae)			
Paludestrina	X		X
Planorbidae	X		
NEMATODA (roundworms)	X	X	X
PLATYHELMINTHES			
TURBELLARIA (free-living flatworms)			
Tricladida			
Planariidae			
Polycelis	X	X	

TABLE 5.--Percentage taxonomic composition of the total number of benthic invertebrates collected from the Redwood Creek and Mill Creek basins

Taxonomic classification PHYLUM Class Order	Percentage taxonomic composition[1]: Redwood Creek drainage basin: Main stem and tributaries	Redwood Creek drainage basin: Estuary	Redwood Creek drainage basin: Main stem, tributaries and estuary	Mill Creek drainage basin	Redwood Creek and Mill Creek drainage basins
ANNELIDA	1.2	0.6	1.0	0.8	1.0
ARTHROPODA	98.8	96.5	98.2	99.1	98.3
Arachnoidea	13.4	0.4	10.1	8.0	9.9
Crustacea	0.1	76.9	19.5	0.0	17.9
Insecta	85.3	19.2	68.6	91.1	70.5
Coleoptera	17.6	0.2	13.2	4.2	12.5
Collembola	<0.1	<0.1	<0.1	0.1	<0.1
Diptera	23.1	18.9	22.0	22.2	22.0
Ephemeroptera	23.6	0.1	17.7	51.3	20.5
Hymenoptera	<0.1	0.0	<0.1	<0.1	<0.1
Lepidoptera	<0.1	0.0	<0.1	0.0	<0.1
Neuroptera	<0.1	0.0	<0.1	0.0	<0.1
Odonata	0.1	0.0	<0.1	<0.1	<0.1
Plecoptera	5.7	0.1	4.3	9.6	4.7
Trichoptera	15.1	0.0	11.3	3.7	10.6
MOLLUSCA	<0.1	0.0	<0.1	<0.1	<0.1
NEMATODA	<0.1	2.9	0.7	<0.1	0.7
PLATYHELMINTHES	<0.1	<0.1	<0.1	0.0	<0.1

[1]Summation of the underlined phylum percentage figures equaled 100 percent prior to rounding.

Variations of Benthic-Invertebrate Numbers

The variations in the number of benthic invertebrates collected during the study primarily reflected seasonal changes (table 6). Benthic-invertebrate data from the 1973 samples should not be compared with the 1974 and 1975 data because different techniques were used to separate benthic invertebrates from sample detritus. As previously discussed, the invertebrates from the 1973 samples were sorted from sample detritus in the field; whereas the 1974 and 1975 samples were sorted in the laboratory. Field sorting resulted in a lower number of benthic invertebrates reported for each sampling station.

The number of benthic invertebrates collected from the Redwood Creek basin during autumn 1973 were quite variable. Along the Redwood Creek main stem, the number of benthic invertebrates collected ranged from 330 to 3,600 inverts/m^2. Redwood Creek above Panther Creek had the largest number of benthic invertebrates collected (3,600 inverts/m^2); whereas Redwood Creek below Elam Creek had the smallest number collected (330 inverts/m^2). The number of benthic invertebrates collected from Redwood Creek tributaries ranged from 90 to 4,400 inverts/m^2. Samples from Little Lost Man Creek (control drainage basin) had the largest number of benthic invertebrates (4,400 inverts/m^2); whereas Miller Creek at Mouth (logged drainage basin) had the smallest number (90 inverts/m^2).

In 1973, samples were collected after the first major storm of the winter in order to assess the effect of the storm on benthic-invertebrate densities.

On October 23, 1973, 6.18 inches of rain was recorded at the Orick Prairie Creek precipitation station just north of Orick, Calif. (U.S. National Oceanic and Atmospheric Administration, 1973). Stream discharges at Redwood Creek near Blue Lake, at South Park Boundary, and at Orick peaked at 5,070, 10,800, and 16,200 ft^3/s, respectively, on October 23, 1973 (U.S. Geological Survey, 1974). Because of increased water discharge, benthic-invertebrate samples could not be collected from the Redwood Creek main-stem stations after the October 1973 storm; however, six tributaries were resampled. The results indicated a marked decrease of benthic invertebrates in the samples collected after the storm. Percentage decreases ranged from 24 at Hayes Creek to 93 at Little Lost Man Creek and averaged 64. Streams with the control-basin classification (Hayes Creek and Little Lost Man Creek) that were resampled after the October 23, 1973, storm had a mean decrease of 58 percent in the number of benthic invertebrates collected. Streams with the logged-basin classification (Harry Wier Creek, Tom McDonald Creek, and Miller Creek at Mouth) had a mean decrease of 61 percent. Lost Man Creek was the only stream with the regenerating-basin classification that was resampled following the storm, and it had an 81-percent decrease in the number of benthic invertebrates.

The variations in the number of benthic invertebrates collected from the Redwood Creek basin in 1974 and 1975 primarily reflected seasonal changes (table 6). Benthic-invertebrate samples were collected in the spring of each year after high winter streamflows had subsided. The invertebrates in these samples represented individuals that were able to overwinter, as well as a few recently hatched individuals. During autumn, when streamflows were lowest, benthic-invertebrate samples were collected again. The invertebrates collected during the autumn sampling represented those organisms that had grown and not emerged throughout the summer and included the additional individuals from newly hatched eggs. At almost every sampling station, autumn samples contained larger numbers of benthic invertebrates than did the spring samples.

Bridge Creek and Harry Wier Creek were the only two streams that had greater numbers of benthic invertebrates per sample during spring than during autumn sampling (1975). Just prior to the collection of autumn samples at Bridge Creek, an input of sediment into the stream was caused by the removal of logging and assorted debris upstream from the sampling station and on timber company property (Steve Veirs, written commun., December 24, 1975). Extensive sedimentation of the streambed in autumn was observed in the sampling area as compared to the condition of the streambed during spring sampling. The autumn 1975 samples collected at Bridge Creek contained only 22 inverts/m^2; whereas the spring samples contained about 1,400 inverts/m^2. At Harry Wier Creek, autumn 1975 samples contained 1,000 inverts/m^2; whereas spring samples contained 1,100 inverts/m^2. This slight decrease in the number of benthic invertebrates per square meter in autumn may be related to an increase in sedimentation of the streambed between spring and autumn sampling. The source of sediment may have been the construction of a road approach to a bridge upstream from the sampling station.

Spatial variations in the number of benthic invertebrates collected from the Redwood Creek main stem (excluding estuary) during spring 1974 and 1975 were low (table 6). There was little difference between the number of benthic invertebrates collected from the upstream and downstream reaches of Redwood Creek. In contrast, the autumn 1974 and 1975 samples showed a wide variation in numbers of benthic invertebrates collected from the Redwood Creek main stem, ranging from 8,300 to 50,000 inverts/m^2.

In March 1975, a major storm in the study area resulted in flood discharges and attendant degradation and aggradation of the streambeds in the Redwood Creek basin. The peak discharge for Redwood Creek at Orick of 50,200 ft^3/s nearly equaled the record flood peak discharge of 50,500 ft^3/s on December 22, 1964. The number of benthic invertebrates collected in the samples during spring 1975 was low and similar to the number in spring 1974 samples, when the peak winter discharge reached 24,800 ft^3/s. The benthic-invertebrate density in Redwood Creek samples significantly increased by autumn 1975 sampling. This dramatic increase in benthic invertebrates following a major spring storm illustrates the ability of the benthic-invertebrate community to recolonize a stream. Benthic-invertebrate densities in Redwood Creek tributaries showed similar responses in recolonization following the March 1975 flood. However, benthic-invertebrate densities were more variable than in the Redwood Creek main stem. Samples collected from the tributaries in autumn 1975 contained greater numbers of benthic invertebrates than did spring 1975 samples, except for Bridge Creek and Harry Wier Creek, both of which were previously discussed.

Benthic-invertebrate densities were variable in their seasonal and spatial patterns in the Redwood Creek estuary during spring and autumn of 1974 (table 6). The number of benthic invertebrates per square meter was greater in autumn than in spring. Spatial patterns showed that during spring the number of benthic invertebrates was greater, on the average, in the original Redwood Creek channel (fig. 3, line 3, natural stream channel) than in the channelized Redwood Creek (fig. 3, lines 1 and 2). During autumn sampling, the distribution pattern was reversed.

During 1974, seasonal variations in the number of collected benthic invertebrates from the Mill Creek basin were similar to those of the Redwood Creek basin (table 6). Benthic-invertebrate densities were greater during autumn sampling than during spring sampling. As in the Redwood Creek basin, the benthic invertebrates collected during spring from the Mill Creek basin probably represented those invertebrates that were able to overwinter in the stream, while the benthic invertebrates collected in autumn represented the invertebrates that had grown and not emerged throughout the summer and included additional organisms from eggs that had hatched since spring.

Spatial variations of benthic-invertebrate densities in the Mill Creek basin are difficult to assess because of the limited number of samples collected. The data indicate, however, that the West Branch Mill Creek below Red Alder Campground had the highest densities during 1974 spring and autumn sampling, whereas the East Fork Mill Creek station had the lowest densities. The Mill Creek main-stem station, located just below the confluence of the west branch and east fork of Mill Creek, had intermediate densities relative to the invertebrate densities of the two upstream stations. The Mill Creek at Mouth station was sampled only during the spring and had a benthic-invertebrate density similar to the East Fork Mill Creek station.

Functional Groups

The functional group concept, as presented by Cummins (1973, 1974), describes a stream ecosystem in terms of the ecological function of the benthic invertebrates. Cummins classified benthic invertebrates into four major functional groups based on feeding mechanisms: (1) shredders, which reduce coarse particulate organic matter (CPOM) greater than 1 mm in diameter, such as leaves, twigs, bark, and flowers, into fine particulate organic matter (FPOM) less than 1 mm in diameter; (2) collectors, which feed on FPOM (especially fecal matter excreted by the shredders); (3) grazers (scrapers), which feed on periphyton; and (4) predators, which feed on other animals in the stream. In addition to these four major functional group categories of Cummins (1974), six other groups were established for this study, based on feeding mechanisms (Merritt and Cummins, 1978, and James R. Sedell, oral commun., 1976): (1) collector-grazer; (2) collector-predator; (3) collector-shredder; (4) grazer-shredder; (5) micro-predator; and (6) unknown. Cummins' (1974) functional group scheme was initially designed for northeastern streams. He noted a similarity between detritus processing, however, in New Hampshire (Fisher and Likens, 1973) and Oregon (Sedell and others, 1973) streams.

TABLE 6.--Number of benthic invertebrates in samples collected at the Redwood Creek and Mill Creek stations

[Number of individuals per square meter]

Station name	1973 Autumn	1973 After first storm	1974 Spring	1974 Autumn	1975 Spring	1975 Autumn
Redwood Creek above Hwy 299	1,400	--	310	50,000	--	--
Redwood Creek near Blue Lake	1,900	--	250	22,000	590	33,000
Redwood Creek at Redwood Valley Bridge near Blue Lake	3,200	--	280	34,000	--	--
Redwood Creek at Lower End Redwood Valley	830	--	190	15,000	--	--
Redwood Creek above Panther Creek near Orick	3,600	--	370	35,000	--	--
High Slope Schist Creek near Orick	180	--	970	2,200	1,100	1.200
Redwood Creek above Copper Cr.	--	--	180	29,000	--	--
Copper Creek near Orick	1,800	--	1,500	38,000	1,200	51,000
Redwood Creek below Copper Cr.	1,300	--	--	--	--	--
Slide Creek near Orick	610	--	1,400	7,700	--	--
Redwood Creek at South Park Boundary near Orick	740	--	430	13,000	910	39,000
Bridge Creek near Orick	980	--	1,100	9,500	1,400	22
Harry Wier Creek near Orick	320	110	1,800	3,800	1,100	1,000
Redwood Cr. below Harry Wier Cr.	450	--	430	17,000	--	--
Redwood Cr. above Tom McDonald Cr.	--	--	420	15,000	560	19,000
Tom McDonald Creek near Orick	1,400	380	1,200	9,300	600	8,200
Redwood Cr. below Tom McDonald Cr.	380	--	--	--	--	--
Redwood Creek above Miller Creek	450	--	420	12,000	--	--
Miller Creek near Orick	--	200	4,400	5,500	6,000	13,000
Miller Creek at Mouth near Orick	90	52	580	2,300	1,200	4,500
Cloquet Creek near Orick	520	--	3,500	10,000	--	--
Redwood Creek below Oscar Larson Creek	1,100	--	990	21,000	--	--
Elam Creek near Orick	440	--	1,000	1,300	--	--

TABLE 6.--Number of benthic invertebrates in samples collected at the Redwood Creek and Mill Creek stations--Continued

Station name	1973 Autumn	1973 After first storm	1974 Spring	1974 Autumn	1975 Spring	1975 Autumn
Redwood Creek below Elam Creek	330	--	670	15,000	1,100	8,400
Redwood Creek above Hayes Creek	--	--	2,000	34,000	960	8,300
Hayes Creek near Orick	150	120	1,200	14,000	5,000	9,200
Redwood Creek below Hayes Creek	720	--	--	--	--	--
Lost Man Creek near Orick	530	100	1,000	7,000	4,100	6,300
Little Lost Man Creek at Site #2 near Orick	--	--	4,100	15,000	6,900	26,000
Little Lost Man Creek near Orick	4,400	290	4,200	--	--	--
Geneva Creek near Orick	--	--	1,800	--	--	--
Redwood Creek Estuary Line 1A near Orick	--	--	2,800	--	--	--
Redwood Creek Estuary Line 1B near Orick	--	--	2,300	79,000	--	--
Redwood Creek Estuary Line 1C near Orick	--	--	1,700	--	--	--
Redwood Creek Estuary Line 2A near Orick	--	--	15,000	--	--	--
Redwood Creek Estuary Line 2B near Orick	--	--	1,900	68,000	--	--
Redwood Creek Estuary Line 2C near Orick	--	--	1,100	--	--	--
Redwood Creek Estuary Line 3A near Orick	--	--	11,000	--	--	--
Redwood Creek Estuary Line 3B near Orick	--	--	2,900	45,000	--	--
Redwood Creek Estuary Line 3C near Orick	--	--	26,000	--	--	--
West Branch Mill Creek below Red Alder Campground near Crescent City	--	--	21,000	36,000	--	--
East Fork Mill Creek near Crescent City	--	--	5,500	5,800	--	--
Mill Creek near Crescent City	--	--	7,800	13,000	--	--
Mill Creek at Mouth near Crescent City	--	--	5,900	--	--	--

A list of the functional group categories for the benthic invertebrates collected during the study is given in table 7. This list is based on the best information available at the time of writing. Most of the placement of the benthic invertebrates into functional group categories was taken from Cummins (1973, 1974) and James R. Sedell (oral commun., 1976); however, other sources of benthic-invertebrate life histories, such as Usinger (1956), Hynes (1970), and general entomology texts, were used. Although some benthic invertebrates can be classified in different functional group categories at different life stages, no attempt was made to determine these different functional roles. Another limitation in using the functional group concept is that the functional role of many benthic-invertebrate species has not been determined. As additional studies are made and more taxonomic and life history information becomes available, the functional group concept will doubtlessly become a more meaningful tool in the evaluation of ecosystems.

Despite the limitations pertaining to classifying benthic invertebrates into functional group categories, the functional group concept is useful in assessing a stream environment in terms of size and habitat stability for the benthic-invertebrate community.

The functional group percentages of the benthic invertebrates collected from the Redwood Creek and Mill Creek basins are shown in table 8. The majority of the benthic invertebrates collected during the study were of the predator, micro-predator, collector, and collector-predator categories.

In the Redwood Creek basin, spatial and seasonal changes in percentage composition of the benthic-invertebrate functional groups occurred (table 8). Along the Redwood Creek main stem during spring 1974 and 1975 sampling, the predator category was the dominant functional group; however, downstream from the Redwood Creek below Elam Creek station (estuary included), the collector category was the dominant functional group. In the downstream direction of the Redwood Creek main stem, the number of predators collected at each sampling station remained relatively the same, whereas the number of collectors increased (table 8). The Redwood Creek at South Park Boundary station was the only exception in the upstream area where the benthic-invertebrate samples were consistently dominated by collectors rather than predators.

During autumn sampling of 1974 and 1975, the collector category was the dominant functional group of the benthic invertebrates collected at the sampling stations along the Redwood Creek main stem (estuary included). The predator category was the second most abundant functional group.

Benthic-invertebrate samples from the Redwood Creek tributaries during both spring and autumn revealed that the collector category was the dominant functional group (table 8). Unlike the upper reaches of the Redwood Creek main stem, dominance by the predator functional group during spring sampling rarely occurred in the tributaries. The abundance of the shredder functional group was low. Seasonal variations in the percentage composition of the functional groups for Redwood Creek tributaries were minimal. Percentages of grazers, however, increased from spring to autumn sampling as algal production increased. There were only small differences between percentage composition of the functional groups of benthic invertebrates collected from logged and unlogged tributary drainage basins.

The collector functional group dominated the benthic-invertebrate samples collected from Redwood Creek estuary during spring and autumn 1974, with percentages greater than 90 at every sampling station (table 8). The high percentages of collectors probably were related to the type of food and streambed substrates. *Corophium* and chironomid larvae were the most numerous collectors. Percentages of predator and micro-predator groups were larger than the other remaining functional groups of benthic invertebrates collected from the estuary.

The functional grouping of benthic invertebrates from the Mill Creek basin was more consistent with the functional grouping in Redwood Creek tributaries than with the Redwood Creek main stem (table 8). The reason for this consistency of functional groups between Mill Creek and Redwood Creek tributaries was similarity of environmental factors such as streambed stability and percentage of streamside canopy. The collector category was the dominant functional group in every benthic-invertebrate sample collected from the Mill Creek basin and was followed by the micro-predator functional group. The largest seasonal percentage increases of grazer, collector-grazer, and micro-predator functional groups occurred at the Mill Creek near Crescent City sampling station. As in the Redwood Creek basin, there was a low concentration of benthic invertebrates in the shredder functional group.

Diversity of Benthic Invertebrates

The diversity index was calculated for each benthic-invertebrate sample collected during the study from the following equation (Wilhm and Dorris, 1968):

$$\bar{d} = -\sum_{i=1}^{s} \frac{n_i}{n} \log_2 \frac{n_i}{n} \qquad (1)$$

where $\bar{d}$ = diversity index,
n_i = number of individuals per taxa,
n = total number of individuals, and
s = total number of taxa in the sample of the community.

The diversity index is a mathematical expression that can be used to assess the variety of organisms found in a sample and includes both the number of taxa and the distribution or equability of individuals among the various taxa. The results of the diversity-index equation are used only as relative values. A sample with a low diversity-index value indicates that the composition of the sampled community contains few taxa, whereas a sample with a high diversity-index value indicates that the sampled community contains a large number of taxa.

TABLE 7.--Functional group categories for benthic invertebrates collected from the Redwood Creek and Mill Creek basins

List of taxa[1]

Functional group category	Order	Family	Genus
Micro-Predator	Acari	-	-
Predator	Coleoptera	Dytiscidae	*Agabus*
	Coleoptera	Dytiscidae	*Bidessus*
	Coleoptera	Dytiscidae	*Deronectes*
	Coleoptera	Dytiscidae	*Derovatellus*
	Coleoptera	Dytiscidae	*Oreodytes*
	Coleoptera	Gyrinidae	*Gyrinus*
	Diptera	Ceratopogonidae	*Bezzia*
	Diptera	Ceratopogonidae	*Palpomyia*
	Diptera	Chironomidae	*Tanypodinae* (SF)
	Diptera	Dolichopodidae	-
	Diptera	Empididae	-
	Diptera	Rhagionidae	*Atherix*
	Diptera	Tabanidae	-
	Diptera	Tipulidae	*Dicranota*
			Hexatoma
			Limnophila
			Pedicia
	Hemiptera	Corixidae	-
	Hemiptera	Saldidae	*Ioscytus*
	Neuroptera	Corydalidae	*Dysmicohermes*
	Neuroptera	Sialidae	*Sialis*
	Odonata	Coenagrionidae	*Hyponeura*
	Odonata	Gomphidae	*Erpetogomphus*
	Odonata	Gomphidae	*Gomphus*
	Odonata	Gomphidae	*Octogomphus*
	Odonata	Gomphidae	*Ophiogomphus*
	Plecoptera	Chloroperlidae	*Alloperla*
	Plecoptera	Chloroperlidae	*Hastaperla*
	Plecoptera	Chloroperlidae	*Paraperla*
	Plecoptera	Perlidae	*Acroneuria*
	Plecoptera	Perlodidae	*Isogenus*
	Plecoptera	Perlodidae	*Isoperla*
	Trichoptera	Leptoceridae	*Oecetis*
	Trichoptera	Psychomyiidae	*Polycentropus*
	Trichoptera	Rhyacophilidae	*Rhyacophila*
Collector	Annelida (P)	Hirudinea (C)	*Piscicolidae* (F)
	Annelida (P)	Oligochaeta (C)	-
	Annelida (P)	Polychaeta (C)	*Neanthes*
	Amphipoda	Corophiidae	*Corophium*
	Amphipoda	Gammaridae	*Anisogammarus*
	Amphipoda	Gammaridae	*Stygobromus*
	Isopoda	Sphaeromidae	*Exosphaeroma*
	Coleoptera	Elmidae	*Ampumixis*
	Coleoptera	Elmidae	*Heterlimnius*
	Coleoptera	Elmidae	*Limnius*
	Coleoptera	Elmidae	*Narpus*
	Coleoptera	Elmidae	*Optioservus*
	Coleoptera	Elmidae	*Ordobrevia*
	Coleoptera	Elmidae	*Zaitzevia*

[1]Other taxonomic level; P = Phylum; C = Class; F = Family; SF = Subfamily; T = Tribe; SG = Subgenus.

TABLE 7.--Functional group categories for benthic invertebrates collected from the Redwood Creek and Mill Creek basins--Continued

List of taxa[1]

Functional group category	Order	Family	Genus
	Coleoptera	Hydraenidae	*Hydraena*
	Coleoptera	Hydraenidae	*Limnebius*
	Coleoptera	Hydraenidae	*Ochthebius*
	Coleoptera	Hydrophilidae	*Anacaena*
	Coleoptera	Hydrophilidae	*Berosus*
	Coleoptera	Hydrophilidae	*Cymbiodyta*
	Coleoptera	Hydrophilidae	*Helophorus*
	Coleoptera	Hydrophilidae	*Hydrochus*
	Coleoptera	Hydrophilidae	*Laccobius*
	Coleoptera	Hydrophilidae	*Paracymus*
	Coleoptera	Hydroscaphidae	*Hydroscapha*
	Coleoptera	Psepheridae	*Acneus*
	Coleoptera	Psepheridae	*Eubrianax*
	Collembola	-	-
	Diptera	Ceratopogonidae	*Atrichopogon*
	Diptera	Ceratopogonidae	*Forcipomyia*
	Diptera	Chironomidae	*Chironomini* (T)
	Diptera	Chironomidae	*Tanytarsini* (T)
	Diptera	Orthocladiinae (SF)	*Thienemanniella*
	Diptera	and Diamesinae (SF)	Other genera
	Diptera	Dixidae	-
	Diptera	Ephydridae	-
	Diptera	Muscidae	-
	Diptera	Psychodidae	*Maruina*
	Diptera	Ptychopteridae	-
	Diptera	Simuliidae	-
	Diptera	Stratiomyidae	*Euparyphus*
	Ephemeroptera	Baetidae	*Baetis*
	Ephemeroptera	Baetidae	*Centroptilum*
	Ephemeroptera	Heptageniidae	*Cinygma*
	Ephemeroptera	Leptophlebiidae	*Paraleptophlebia*
	Ephemeroptera	Siphlonuridae	*Ameletus*
	Ephemeroptera	Siphlonuridae	*Isonychia*
	Ephemeroptera	Tricorythidae	*Tricorythodes*
	Plecoptera	Nemouridae	*Capnia*
	Plecoptera	Nemouridae	*Leuctra*
	Plecoptera	Nemouridae	*Megaleuctra*
	Plecoptera	Nemouridae	*Perlomyia*
	Trichoptera	Philopotamidae	*Wormaldia*
	Nematoda (P)	-	-
	Platyhelminthes	Planariidae	*Polycelis*
Shredder	Coleoptera	Ptilodactylidae	*Anchycteis*
	Diptera	Tanyderidae	*Protanyderus*
		Tipulidae	*Antocha*
			Gonomyia
			Limonia
			Ormosia
			Tipula
			Ulomorpha
	Plecoptera	Peltoperlidae	*Peltoperla*
		Pteronarcidae	*Pteronarcys*
	Trichoptera	Brachycentridae	*Micrasema*
		Calamoceratidae	*Heteroplectron*
		Goeridae	-

[1]Other taxonomic level; P = Phylum; C = Class; F = Family; SF = Subfamily; T = Tribe; SG = Subgenus.

TABLE 7.--Functional group categories for benthic invertebrates collected from the Redwood Creek and Mill Creek basins--Continued

List of taxa[1]

Functional group category	Order	Family	Genus
	Trichoptera	Limnephilidae	*Dicosmoecus*
	Trichoptera	Limnephilidae	*Neophylax*
	Trichoptera	Limnephilidae	*Neothremma*
	Trichoptera	Limnephilidae	*Oligophlebodes*
	Trichoptera	Limnephilidae	*Pycnopsyche*
	Trichoptera	Limnephilidae	*Radema*
Grazer	Diptera	Blephariceridae	*Blephari cera*
	Lepidoptera	Pyralidae	*Parargyractis*
	Trichoptera	Rhyacophilidae	*Agapetus*
	Trichoptera	Rhyacophilidae	*Glossosoma*
	Trichoptera	Rhyacophilidae	*Protoptila*
	Gastropoda (C)	Ancylidae	*Lanx*
	Gastropoda (C)	Bythiniidae	*Paludestrina*
	Gastropoda (C)	Planorbidae	-
Collector-Grazer	Ephemeroptera	Heptageniidae	*Cinygmula*
	Ephemeroptera	Heptageniidae	*Epeorus*
	Ephemeroptera	Heptageniidae	*Iron* (SG)
	Ephemeroptera	Heptageniidae	*Ironodes* (SG)
	Ephemeroptera	Heptageniidae	*Ironopsis* (SG)
	Ephemeroptera	Heptageniidae	*Heptagenia*
	Ephemeroptera	Heptageniidae	*Rhithrogena*
Collector-Predator	Coleoptera	Staphylinidae	*Emplenota*
	Coleoptera	Staphylinidae	*Thinusa*
	Ephemeroptera	Ephemerellidae	*Ephemerella*
	Plecoptera	Chloroperlidae	*Kathroperla*
	Trichoptera	Sericostomatidae	*Sericostoma*
	Trichoptera	Hydropsychidae	*Arctopsyche*
	Trichoptera	Hydropsychidae	*Cheumatopsyche*
	Trichoptera	Hydropsychidae	*Hydropsyche*
	Trichoptera	Hydropsychidae	*Parapsyche*
Collector-Shredder	Plecoptera	Nemouridae	*Nemoura*
	Trichoptera	Lepidostomatidae	*Lepidostoma*
	Trichoptera	Hydroptilidae	*Hydroptila*
	Trichoptera	Hydroptilidae	*Neotrichia*
	Trichoptera	Hydroptilidae	*Ochrotrichia*
	Trichoptera	Hydroptilidae	*Oxyethira*
Unknown	Isopoda	Unknown	-
	Coleoptera	Elmidae	Unknown
	Coleoptera	Hydrophilidae	Unknown
	Diptera	Ceratopogonidae	Unknown
	Diptera	Unknown	-
	Hymenoptera	Mymaridae	*Anagrus*
	Hymenoptera	Mymaridae	*Patasson*
	Plecoptera	Nemouridae	Unknown
	Trichoptera	Hydropsychidae	Unknown
	Trichoptera	Hydroptilidae	Unknown
	Trichoptera	Limnephilidae	Unknown
	Trichoptera	Psychomyiidae	Unknown

[1]Other taxonomic level; P = Phylum; C = Class; F = Family; SF = Subfamily; T = Tribe; SG = Subgenus.

TABLE 8.--Functional group percentages of the total number of benthic invertebrates collected from the Redwood Creek and Mill Creek basins

Station Name	Date	Functional group: Predator	Micropredator	Collector	Shredder	Grazer	Collector-grazer	Collector-predator	Collector-shredder	Grazer-shredder	Unknown	Individuals per m²
Redwood Creek above Highway 299	10- 3-73	12.0	5.6	59.1	0.0	0.5	4.6	18.0	0.3	0.0	0.0	1,400
	5- 8-74	56.6	2.6	27.8	.0	.0	10.4	2.6	.0	.0	.0	310
	9-18-74	2.8	8.9	40.3	.4	.1	7.3	39.6	.0	.7	.0	50,000
Redwood Creek near Blue Lake	10- 3-73	8.7	5.3	39.1	.8	.4	8.7	35.5	.0	.0	1.7	1,900
	5- 8-74	50.2	6.3	36.8	.0	1.2	1.2	3.2	.0	.0	1.2	250
	9-18-74	2.6	10.0	28.8	.1	.7	9.5	48.2	.0	<.1	.0	22,000
	5-27-75	16.3	17.0	12.4	.0	.5	.5	52.8	.5	.0	.0	590
	9-14-75	2.4	8.0	73.6	.2	.5	.3	14.9	<.1	.2	.0	33,000
Redwood Creek at Redwood Valley Bridge near Blue Lake	10- 3-73	3.4	8.0	79.3	.1	.0	1.7	7.1	.0	.0	.4	3,200
	5- 8-74	48.0	20.3	21.0	1.8	2.8	2.1	3.9	.0	.0	.0	280
	9-18-74	2.0	11.8	60.0	.2	.2	.8	23.8	.0	1.1	.0	34,000
Redwood Creek at Lower End Redwood Valley	10- 3-73	6.3	5.2	66.1	.0	.0	4.7	16.9	.0	.0	.8	830
	5- 8-74	36.1	24.7	32.0	.0	1.5	5.7	.0	.0	.0	.0	190
	9-18-74	2.3	17.9	42.3	<.1	14.9	.3	21.5	.0	.5	.1	15,000
Redwood Creek above Panther Creek near Orick	10- 1-73	2.1	5.1	81.0	.2	.0	1.6	9.0	.0	.2	.8	3,600
	5- 9-74	47.8	15.6	25.4	2.2	.8	.8	7.4	.0	.0	.0	370
	9-19-74	2.6	11.8	67.7	<.1	.9	.7	15.9	.0	.3	.0	35,000
High Slope Schist Creek near Orick	10- 2-73	33.0	2.3	37.5	2.3	2.3	11.9	4.5	4.0	.0	2.3	180
	5-26-74	24.5	14.4	44.5	.5	.0	11.3	3.3	1.3	.0	.0	970
	9-22-74	23.8	19.1	46.0	3.9	.1	2.5	2.0	2.0	.0	.6	2,200
	5-30-75	33.2	10.2	34.2	3.4	.0	12.3	3.7	3.1	.0	.0	1,100
	9-18-75	23.8	10.0	45.0	1.6	.2	8.1	5.4	6.0	.0	.0	1,200
Redwood Creek above Copper Creek	5- 9-74	56.4	2.8	28.7	1.7	.0	4.4	6.0	.0	.0	.0	180
	9-19-74	1.9	21.7	61.6	.3	1.8	.5	11.5	<.1	.8	.0	29,000
Copper Creek near Orick	10- 4-73	1.1	6.1	85.0	.4	.2	1.8	3.2	1.8	.0	.4	1,800
	5- 9-74	7.5	5.4	55.3	.3	.0	27.5	3.2	.7	.0	.0	1,500
	9-19-74	2.0	16.0	49.2	.5	.2	.2	29.9	1.1	1.0	<.1	38,000
	5-28-75	6.7	9.1	81.6	.0	.0	.2	2.4	.0	.0	.0	1,200
	9-15-75	2.7	29.4	58.4	.4	1.0	.2	4.9	2.2	1.0	.0	51,000
Redwood Creek below Copper Creek	10- 4-73	5.6	5.7	71.9	.3	.0	6.3	9.5	.0	.0	.5	1,300
Slide Creek near Orick	10- 1-73	11.6	1.1	61.6	.0	.7	2.5	17.7	4.8	.0	.0	610
	5- 9-74	16.3	.8	55.5	.2	.0	12.2	8.9	6.2	.0	.0	1,400
	9-13-74	10.0	5.3	77.0	<.1	.1	.5	2.1	4.9	<.1	.0	7,700
Redwood Creek at South Park Boundary near Orick	10- 1-73	1.6	3.9	69.6	1.5	1.5	5.3	16.1	.5	.0	.0	740
	5- 9-74	29.7	23.4	32.6	.0	.0	5.6	6.3	.7	.0	.7	430
	9-13-74	2.7	18.6	59.8	<.1	2.0	.5	16.1	<.1	.1	.0	13,000
	6- 3-75	23.5	23.0	41.8	.7	5.6	.0	5.5	.0	.0	.0	910
	9-15-75	1.3	4.9	84.8	.2	1.6	<.1	6.2	<.1	.8	.0	39,000
Bridge Creek near Orick	9-25-73	3.4	14.3	58.2	0.0	0.4	3.7	18.6	1.1	0.0	0.4	980
	5-13-74	15.7	4.4	74.7	.5	.9	2.5	1.5	.7	.0	.0	1,100
	9-16-74	4.6	10.2	68.3	<.1	.5	2.1	4.2	1.1	9.0	.0	9,500
	6- 1-75	11.3	3.4	83.5	.2	.0	.0	.4	1.1	.0	.0	1,400
	9-16-75	50.0	.0	50.0	.0	.0	.0	.0	.0	.0	.0	22
Harry Wier Creek near Orick	9-26-73	28.2	.0	41.5	3.4	6.8	11.1	3.4	5.6	.0	.0	320
	10-31-73	26.6	.0	16.5	.0	3.7	12.8	36.7	3.7	.0	.0	110
	5-13-74	15.5	7.1	62.3	.2	.0	8.1	3.7	3.1	.0	.0	1,800
	9-16-74	8.4	7.9	74.6	.0	1.0	.3	.7	6.1	<.1	.9	3,800
	6- 1-75	20.8	3.7	58.8	.3	.0	7.6	6.3	5.5	.0	.0	1,100
	9-16-75	3.5	21.6	67.1	.0	1.9	1.1	1.9	2.9	.0	.0	1,000
Redwood Creek below Harry Wier Creek	9-26-73	5.8	5.6	85.9	.9	.0	.9	.9	.0	.0	.0	450
	5-13-74	29.0	41.8	17.9	.0	.0	.0	10.7	.7	.0	.0	430
	9-16-74	6.7	17.8	68.2	.7	2.0	<.1	3.9	<.1	.5	.0	17,000
Redwood Creek above Tom McDonald Creek	5-14-74	56.1	4.5	29.5	1.4	.5	2.8	5.0	.0	.0	.2	420
	9-24-74	5.4	22.7	57.2	.7	9.1	.0	3.8	<.1	1.1	<.1	15,000
	5-30-75	38.6	15.7	24.6	.0	9.8	.2	11.1	.0	.0	.0	560
	9-16-75	8.1	12.0	66.7	.2	3.4	<.1	7.8	<.1	1.8	.0	19,000
Tom McDonald Creek near Orick	9-27-73	6.2	1.5	54.3	6.4	10.7	6.4	12.1	1.5	.0	.8	1,400
	10-31-73	12.5	.0	51.9	2.9	15.8	4.7	10.1	1.0	.0	1.0	380
	5-14-74	11.8	7.8	58.1	.5	.0	15.4	4.5	1.9	.0	.0	1,200
	9-24-74	5.5	17.2	60.0	.8	1.3	5.3	4.3	5.2	.5	.0	9,300
	5-30-75	23.1	18.3	44.6	1.8	.0	7.7	1.8	2.7	.0	.0	600
	9-16-75	3.1	2.2	68.0	3.6	2.7	.8	8.6	11.1	.0	.0	8,200
Redwood Creek below Tom McDonald Creek	9-27-73	6.8	.0	91.0	.0	1.1	.0	1.1	.0	.0	.0	380
Redwood Creek above Miller Creek	9-27-73	5.4	21.2	63.2	7.4	.0	1.6	.0	.0	.0	.9	450
	5-14-74	77.1	6.4	12.4	.7	1.2	.7	.7	.7	.0	.0	420
	9-17-74	5.6	12.6	72.2	.2	1.2	<.1	7.9	<.1	.2	<.1	12,000
Miller Creek near Orick	11- 2-73	15.9	.0	12.4	4.0	3.5	35.3	21.4	5.5	.0	2.0	200
	5-10-74	5.5	.1	75.9	.4	.0	4.6	1.1	12.4	.0	.0	4,400
	9-17-74	7.9	3.1	61.9	.3	2.6	4.4	.9	18.1	.0	.8	5,500
	5-31-75	2.8	.7	44.3	<.1	1.1	5.9	.1	45.0	.0	.0	6,000
	9-21-75	2.0	1.0	62.5	.0	.2	1.5	4.4	28.3	.0	.0	13,000

TABLE 8.--Functional group percentages of the total number of benthic invertebrates collected from the Redwood Creek and Mill Creek basins--Continued

Station Name	Date	Functional group										Individuals per m²
		Predator	Micropredator	Collector	Shredder	Grazer	Collector-grazer	Collector-predator	Collector-shredder	Grazer-shredder	Unknown	
Miller Creek at Mouth near Orick	9-27-73	35.6	.0	27.8	4.4	4.4	7.8	20.0	.0	.0	.0	90
	10-31-73	.0	.0	36.6	.0	.0	7.7	50.0	7.7	.0	.0	52
	5-14-74	36.9	6.5	26.0	.0	.0	20.2	3.6	6.8	.0	.0	580
	9-17-74	10.6	9.6	66.6	.1	.0	1.8	5.4	5.8	.1	.0	2,300
	5-31-75	14.7	4.0	56.1	.5	.0	6.4	.7	17.4	.0	.0	1,200
	9-21-75	5.5	1.5	70.1	.4	.0	1.6	15.0	5.9	.0	.0	4,500
Cloquet Creek near Orick	9-27-73	12.3	.8	42.9	.0	4.2	23.3	11.0	5.6	.0	.0	520
	5-14-74	11.4	9.1	58.9	.2	.2	7.0	4.0	9.2	.0	.0	3,500
	9-21-74	6.2	4.5	72.9	1.4	1.9	1.7	2.1	9.3	.0	.0	10,000
Redwood Creek below Oscar Larson Creek	9-28-73	8.1	6.6	78.6	0.0	3.8	0.4	0.6	0.4	0.0	1.6	1,100
	5-15-74	52.6	7.1	31.6	1.3	.5	1.6	5.0	.0	.0	.3	990
	9-21-74	4.4	22.4	64.6	.3	.6	.2	5.5	<.1	1.9	.0	21,000
Elam Creek near Orick	9-28-73	14.9	.0	51.0	.0	.9	26.4	.9	5.7	.0	.0	440
	5-15-74	13.4	9.9	60.5	.3	1.6	2.1	5.3	6.9	.0	.0	1,000
	9-21-74	14.1	13.1	70.9	.0	.2	.0	.8	.8	.0	.0	1,300
Redwood Creek below Elam Creek	9-28-73	19.1	10.9	56.7	8.8	2.1	.0	1.2	.0	.0	1.2	330
	5-15-74	28.2	8.5	56.5	.9	.6	1.3	3.6	.1	.0	.3	670
	9-21-74	6.8	20.6	63.8	.1	.2	<.1	3.7	<.1	4.6	<.1	15,000
	5-29-75	42.2	13.1	23.1	<.1	7.3	1.0	12.8	.2	<.1	.0	1,100
	9-19-75	11.0	15.4	50.2	<.1	1.8	.5	20.7	<.1	.2	.0	8,400
Redwood Creek above Hayes Creek	5-15-74	12.4	7.0	73.3	.3	.2	2.3	4.3	.1	.0	.2	2,000
	9-14-74	3.2	21.4	72.5	.1	<.1	<.1	1.7	<.1	1.0	.0	34,000
	5-28-75	18.4	12.5	54.0	.2	7.3	.7	6.7	.1	.0	.0	960
	9-19-75	3.0	39.5	25.0	<.1	5.6	<.1	21.4	<.1	5.3	.0	8,300
Hayes Creek near Orick	9-28-73	27.9	.0	47.4	.0	9.1	7.8	.0	11.7	.0	2.6	150
	11- 1-73	24.8	.0	40.2	.0	3.4	18.8	6.8	6.0	.0	.0	120
	5-15-74	18.6	1.6	45.7	.9	.0	11.9	5.8	15.5	.0	.0	1,200
	9-14-74	9.0	6.4	56.5	.3	.0	12.4	<.1	14.2	.0	1.1	14,000
	5-29-75	15.5	3.8	62.6	.6	.0	2.4	.1	15.0	.0	.0	5,000
	9-20-75	10.5	8.7	71.1	.5	.2	3.1	.2	5.8	.0	.0	9,200
Redwood Creek below Hayes Creek	9-28-73	10.3	32.0	47.7	1.9	1.5	.0	1.5	.6	.0	4.5	720
Lost Man Creek near Orick	9-25-73	33.1	6.0	34.0	2.6	7.3	8.1	8.1	.8	.0	.0	530
	11- 1-73	11.0	4.0	44.0	4.0	7.0	22.0	8.0	.0	.0	.0	100
	5-10-74	17.8	2.3	48.0	.0	.0	21.0	5.9	4.9	.0	.0	1,000
	9-15-74	14.4	10.2	54.3	1.0	3.0	3.6	9.4	3.0	.0	1.1	7,000
	6- 2-75	5.3	1.6	48.6	.0	8.4	13.1	3.8	19.2	.0	.0	4,100
	9-17-75	11.7	6.6	29.7	.5	30.8	2.9	10.0	7.8	.0	.0	6,300
Little Lost Man Creek at Site #2 near Orick	5-10-74	9.8	7.8	60.3	.7	.3	8.1	8.6	4.4	.0	.0	4,100
	9-14-74	7.1	20.8	47.1	3.0	1.4	2.8	14.6	2.3	.9	.0	15,000
	6- 2-75	10.9	12.7	53.7	.4	1.6	1.2	2.3	17.3	.0	.0	6,900
	9-20-75	8.2	8.6	57.9	1.1	3.3	2.2	12.5	5.4	.8	.0	26,000
Little Lost Man Creek near Orick	10- 4-73	5.4	6.6	59.6	5.6	.1	6.4	4.9	7.2	.0	4.1	4,400
	11- 1-73	.0	.0	56.7	26.3	.0	7.6	2.8	3.8	.0	2.8	290
	5-10-74	8.0	11.9	60.2	2.7	.3	1.4	9.9	5.5	.0	<.1	4,200
Geneva Creek	5-18-74	18.9	.3	52.6	.0	.0	7.9	.6	19.8	.0	.0	1,800
Redwood Creek Estuary Line 1A	5-17-74	7.2	.5	92.3	.0	.0	.0	.0	.0	.0	.0	2,800
Redwood Creek Estuary Line 1B	5-17-74	3.2	.6	95.5	.0	.0	.0	.0	.6	.0	.0	2,300
	9-20-74	.0	.0	99.9	.0	.0	<.1	.0	.0	.0	.0	79,000
Redwood Creek Estuary Line 1C	5-17-74	8.7	0.9	90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,700
Redwood Creek Estuary Line 2A	5-17-74	1.4	0.4	98.1	.0	.0	.0	.0	.1	.0	.0	15,000
Redwood Creek Estuary Line 2B	5-17-74	5.5	3.1	90.5	.8	.0	.0	.0	.0	.0	.0	1,900
	9-20-74	<.1	.0	99.9	.0	.0	.0	.0	.0	.0	.0	68,000
Redwood Creek Estuary Line 2C	5-17-74	1.3	1.3	97.3	.0	.0	.0	.0	.0	.0	.0	1,100
Redwood Creek Estuary Line 3A	5-17-74	.6	.6	98.6	.0	.0	.0	.0	.3	.0	.0	11,000
Redwood Creek Estuary Line 3B	5-17-74	2.0	1.5	96.4	.0	.0	.0	.0	.0	.0	.0	2,900
	9-20-74	.0	.9	99.1	.0	.0	.0	.0	.0	.0	.0	45,000
Redwood Creek Estuary Line 3C	5-17-74	1.5	.7	97.8	<.1	.0	.0	.0	.0	.0	.0	26,000
West Branch Mill Creek below Red Alder Campground near Crescent City	5-21-74	12.8	2.8	72.8	.1	<.1	6.5	2.4	2.5	.0	.0	21,000
	9-12-74	9.6	5.8	74.9	.1	.3	7.5	.3	1.5	.0	.0	36,000
East Fork Mill Creek near Crescent City	5-21-74	10.5	10.4	54.2	1.6	.2	3.2	2.5	17.2	<.1	.0	5,500
	9-12-74	3.6	10.6	68.4	1.8	2.6	3.3	5.6	3.8	.2	<.1	5,800
Mill Creek near Crescent City	5-20-74	3.8	5.9	82.1	1.0	.3	2.3	1.0	3.6	.0	.0	7,800
	9-12-74	2.3	15.2	54.0	1.1	9.9	15.3	.3	1.1	.8	.0	13,000
Mill Creek at Mouth near Crescent City	5-20-74	2.5	22.2	61.8	.2	.3	3.1	2.7	7.3	.0	.0	5,900

The benthic-invertebrate diversity-index values were variable among Redwood Creek main-stem stations and ranged from 1.76 (Redwood Creek at Redwood Valley Bridge) to 3.68 (Redwood Creek at South Park Boundary) (table 9). The majority of the diversity-index values were between 2.50 and 3.50.

The benthic-invertebrate diversity-index values for tributary sampling stations ranged from 1.00 (Bridge Creek) to 4.09 (High Slope Schist Creek)(table 9). Bridge Creek had the largest range of diversity-index values (1.00 to 3.37), whereas High Slope Schist Creek had the narrowest range (3.81 to 4.09). The benthic-invertebrate diversity-index values for 1975 sampling were substantially lower in the tributaries than 1974 values, which probably was the result of the major flood that occurred on March 18, 1975. In contrast, there was no apparent decrease in the 1974 to 1975 diversity-index values for Redwood Creek main-stem sampling stations. However, Redwood Creek tributary sampling stations had a slightly higher mean diversity-index value than the main-stem stations.

In comparing diversity-index values of benthic invertebrates from Redwood Creek tributary sampling stations to different land-use activities, the two-tailed nonparametric Wilcoxon-Mann-Whitney test (U.S. Army, 1969) was used. This particular test was used to see if the mean benthic-invertebrate diversity-index value for the control tributary basins differed from the mean diversity-index value for the logged tributary basins. The 1974 and 1975 spring and autumn benthic-invertebrate diversity-index values of the control basins, basins being logged, and regenerating tributary basins are in table 10. The control tributary basins had diversity-index values ranging from 2.98 to 4.09, with an increase in values from spring to autumn. The logged tributary basins had diversity-index values that were lower than the control basins and ranged from 1.00 to 3.77. An increase from spring to autumn in diversity-index values occurred in 1974; however this increase did not occur in 1975 for the logged tributary basins. The result of the Wilcoxon-Mann-Whitney test indicated that the mean diversity-index value from the control tributary basins was significantly larger ($\alpha<0.01$) than the mean diversity-index value from the logged tributary basins.

Benthic-invertebrate diversity-index values of the regenerating basins ranged from 3.19 to 4.02 and increased from spring to autumn, with the exception of Tom McDonald Creek (1975). The result of the Wilcoxon-Mann-Whitney test indicated no significant difference ($\alpha>0.20$) between the mean benthic-invertebrate diversity-index values of the control and regenerating tributary basins. When the test was applied to compare the mean diversity-index values of the logged and regenerating tributary basins to one another, the result was no significant difference ($\alpha>0.20$).

In the Redwood Creek estuary, benthic-invertebrate diversity-index values ranged from 1.29 to 2.90 during the spring 1974 sampling period and were variable between the sampling stations (table 9). Autumn 1975 diversity-index values were substantially lower than spring 1974 values and ranged from 0.03 to 0.50. The decrease in diversity-index values from spring to autumn 1974 was due to the dominance of saltwater-tolerant species in the estuary resulting from saltwater intrusion into the mouth of Redwood Creek.

TABLE 9.--Diversity indexes of benthic invertebrates

Station name	Date	Diversity index
Redwood Creek above Highway 299	10-03-73	3.03
	05-05-74	3.27
	09-18-74	3.48
Redwood Creek near Blue Lake	10-03-73	3.37
	05-08-74	3.52
	09-18-74	2.89
	05-27-75	2.47
	09-14-75	3.55
Redwood Creek at Redwood Valley Bridge near Blue Lake	10-03-73	1.76
	05-08-74	3.61
	09-18-74	3.26
Redwood Creek at Lower End Redwood Valley	10-03-73	2.92
	05-08-74	3.20
	09-18-74	3.43
Redwood Creek above Panther Creek near Orick	10-11-73	2.56
	05-09-74	3.52
	09-19-74	3.30
High Slope Schist Creek near Orick	10-02-73	3.82
	05-26-74	3.92
	09-22-74	3.95
	05-30-75	3.99
	09-18-75	4.09
Redwood Creek above Copper Creek	05-09-74	2.77
	09-19-74	3.52
Copper Creek near Orick	10-04-73	2.75
	05-09-74	3.06
	09-19-74	3.12
	05-28-75	2.36
	09-15-75	2.91
Redwood Creek below Copper Creek	10-04-73	3.12
Slide Creek near Orick	10-01-73	2.80
	05-09-74	2.89
	09-13-74	3.48

TABLE 9.--Diversity indexes of benthic invertebrates--Continued

Station name	Date	Diversity index
Redwood Creek at South Park Boundary near Orick	10-01-73	2.75
	05-09-74	3.68
	09-13-74	3.18
	06-03-75	3.59
	09-15-75	2.42
Bridge Creek near Orick	09-25-73	2.93
	05-13-74	2.47
	09-16-74	3.37
	06-01-75	1.42
	09-16-75	1.00
Harry Wier Creek near Orick	09-26-73	3.70
	10-31-73	2.84
	05-13-74	3.46
	09-16-74	3.77
	06-01-75	3.37
	09-16-75	3.06
Redwood Creek below Harry Wier Creek	09-26-73	2.67
	05-13-74	3.25
	09-16-74	3.12
Redwood Creek above Tom McDonald Creek	05-14-74	2.69
	09-24-74	3.44
	05-30-75	3.48
	09-16-75	3.57
Tom McDonald Creek near Orick	09-27-73	3.56
	10-31-73	3.18
	05-14-74	3.19
	09-24-74	3.58
	05-30-75	3.70
	09-16-75	3.21
Redwood Creek below Tom McDonald Creek	09-27-73	2.51
Redwood Creek above Miller Creek	09-27-73	3.06
	05-14-74	2.35
	09-17-74	2.80
Miller Creek near Orick	11-02-73	3.40
	05-10-74	2.34
	09-17-74	3.59
	05-31-75	2.38
	09-21-75	2.30

TABLE 9.--Diversity indexes of benthic invertebrates--Continued

Station name	Date	Diversity index
Miller Creek at Mouth near Orick	09-27-73	3.13
	10-31-73	2.17
	05-14-74	3.67
	09-17-74	3.74
	05-31-75	3.30
	09-21-75	3.11
Cloquet Creek near Orick	09-27-73	3.52
	05-14-74	3.42
	09-21-74	3.37
Redwood Creek below Oscar Larson Creek	09-28-73	2.48
	05-15-74	3.22
	09-21-74	3.07
Elam Creek near Orick	09-28-73	3.73
	05-15-74	3.78
	09-21-74	3.38
Redwood Creek below Elam Creek	09-28-73	3.29
	05-15-74	2.99
	09-21-74	3.28
	05-29-75	3.61
	09-19-75	3.38
Redwood Creek above Hayes Creek	05-15-74	2.21
	09-14-74	2.95
	05-28-75	3.03
	09-19-75	3.54
Hayes Creek near Orick	09-28-73	3.34
	11-01-73	3.53
	05-15-74	3.27
	09-14-74	3.77
	05-29-75	2.98
	09-20-75	2.98
Redwood Creek below Hayes Creek	09-28-73	3.29
Lost Man Creek near Orick	09-25-73	3.93
	11-01-73	3.06
	05-10-74	3.82
	09-15-74	4.02
	06-02-75	3.04
	09-17-75	3.63

TABLE 9.--Diversity indexes of benthic invertebrates--Continued

Station name	Date	Diversity index
Little Lost Man Creek at Site #2 near Orick	05-10-74	3.56
	09-14-74	3.80
	06-02-75	3.46
	09-20-75	3.87
Little Lost Man Creek near Orick	10-04-73	3.72
	11-01-73	2.84
	05-10-74	3.68
Geneva Creek	05-18-74	3.20
Redwood Creek Estuary Line 1A	05-17-74	2.35
Redwood Creek Estuary Line 1B	05-17-74	1.79
	09-20-74	.03
Redwood Creek Estuary Line 1C	05-17-74	1.29
Redwood Creek Estuary Line 2A	05-17-74	1.82
Redwood Creek Estuary Line 2B	05-17-74	2.90
	09-20-74	.50
Redwood Creek Estuary Line 2C	05-17-74	2.02
Redwood Creek Estuary Line 3A	05-17-74	2.18
Redwood Creek Estuary Line 3B	05-17-74	2.55
	09-20-74	.48
Redwood Creek Estuary Line 3C	05-17-74	1.72
West Branch Mill Creek below Red Alder Campground near Crescent City	05-21-74	2.06
	09 12-74	3.58
East Fork Mill Creek near Crescent City	05-21-74	2.99
	09-12-74	3.88
Mill Creek near Crescent City	05-20-74	1.73
	09-12-74	3.51
Mill Creek at Mouth near Crescent City	05-20-74	2.62

TABLE 10.--Comparison of the benthic-invertebrate diversity-index values of the control basins versus logged basins and regenerating tributary basins

Drainage basin classification and sampling station	Diversity index			
	1974		1975	
	Spring	Autumn	Spring	Autumn
Control				
High Slope Schist Creek near Orick	3.93	3.95	3.99	4.09
Hayes Creek near Orick	3.27	3.77	2.98	2.98
Little Lost Man Creek at Site No. 2 near Orick	3.56	3.80	3.46	3.87
Being logged				
Copper Creek near Orick	3.05	3.12	2.36	2.91
Bridge Creek near Orick	2.47	3.37	1.42	1.00
Harry Wier Creek near Orick	3.46	3.77	3.37	3.06
Miller Creek near Orick	2.34	3.59	2.38	2.30
Miller Creek at Mouth near Orick	3.67	3.74	3.30	3.11
Regenerating (including less extensively logged)				
Tom McDonald Creek near Orick	3.19	3.58	3.70	3.21
Lost Man Creek near Orick	3.82	4.02	3.04	3.63
Geneva Creek near Orick	3.20	--	--	--

In the Mill Creek basin, benthic-invertebrate diversity-index values ranged from 1.73 to 2.99 during spring 1974 sampling and from 3.51 to 3.88 during autumn sampling (table 9). As in the Redwood Creek basin, diversity-index values for Mill Creek basin samples increased seasonally from spring to autumn in 1974. Benthic-invertebrate samples were not collected in 1975, and the effect of the March 18, 1975, flood on the benthic-invertebrate community could not be assessed. Moreover, because of the limited number of benthic-invertebrate samples collected, diversity-index values could not be related to land-use activities in the Mill Creek basin.

Similarity of Taxonomic Composition

A comparison, between stations, of the taxonomic similarity of the benthic invertebrates provides information useful in evaluating water-quality changes and describing the community structure. Similarity index was calculated for the benthic invertebrates collected during the study from the Sorenson Index (Odum, 1971):

$$S = \frac{2C}{A+B} \qquad (2)$$

where S = similarity index
A = number of species in sample A,
B = number of species in sample B, and
C = number of species common to both samples.

Similarity-index values range from 0, when no taxa are common to both samples, to 1, when all taxa are common to both samples. The similarity-index concept is based only on presence-absence information. There can be considerable changes in taxa abundance with no change in the similarity-index value.

A similarity-index matrix comparing all the stations sampled in 1973 is in table 11. The values ranged from 0.19 to 0.78. Low similarity-index values were calculated between Redwood Creek below Elam Creek and Hayes Creek (0.19); Redwood Creek below Harry Wier Creek and Hayes Creek (0.20); and Copper Creek when compared with Miller Creek at Mouth (0.20). The highest similarity-index values were between Redwood Creek near Blue Lake and Redwood Creek below Copper Creek (0.78); Redwood Creek at Redwood Valley Bridge and Redwood Creek at lower end Redwood Valley (0.77); and Redwood Creek at lower end Redwood Valley when compared with Redwood Creek near Blue Lake and Redwood Creek below Copper Creek (0.76), respectively. The majority of the similarity-index values in autumn 1973 samples were greater than 0.5.

The October 23, 1973, storm increased water discharge and velocities to the point of moving streambed materials in the Redwood Creek basin. Regardless of the effect of this storm, the similarity-index values remained relatively high after the storm, indicating that the storm had no discernible effect on the similarity of benthic invertebrates in the samples collected (table 12), even when comparing drainage basins of different land-use activities (control versus logged). For example, when Hayes Creek, a control drainage basin, is compared with Harry Wier Creek, a logged drainage basin, the similarity index is 0.64. A high similarity-index value, 0.71, also occurs when benthic invertebrates from Miller Creek, another logged drainage basin, are compared with those from Hayes Creek.

TABLE 11.--Similarity-index matrix for autumn 1973 benthic invertebrates collected from Redwood Creek main stem and selected tributary sampling stations

AUTUMN 1973	Redwood Creek above Highway 299	Redwood Creek near Blue Lake	Redwood Creek at Redwood Valley Bridge near Blue Lake	Redwood Creek at Lower End Redwood Valley	Redwood Creek above Panther Creek near Orick	High Slope Schist Creek near Orick	Copper Creek near Orick	Redwood Creek below Copper Creek	Slide Creek near Orick	Redwood Creek at South Park Boundary near Orick	Bridge Creek near Orick	Harry Wier Creek near Orick	Redwood Creek below Harry Wier Creek	Tom McDonald Creek near Orick	Redwood Creek below Tom McDonald Creek	Redwood Creek above Miller Creek	Miller Creek at Mouth near Orick	Cloquet Creek near Orick	Redwood Creek below Oscar Larson Creek	Elam Creek near Orick	Redwood Creek below Elam Creek	Hyaes Creek near Orick	Redwood Creek below Hayes Creek	Lost Man Creek near Orick	Little Lost Man Creek near Orick
Redwood Creek above Highway 299	-	.59	.74	.76	.71	.33	.51	.74	.55	.65	.54	.40	.63	.44	.59	.43	.30	.52	.49	.42	.56	.37	.54	.50	.50
Redwood Creek near Blue Lake		-	.71	.60	.68	.47	.54	.78	.61	.62	.57	.44	.56	.55	.62	.60	.42	.55	.56	.50	.55	.37	.61	.57	.66
Redwood Creek at Redwood Valley Bridge near Blue Lake			-	.77	.75	.31	.50	.74	.49	.65	.58	.33	.69	.47	.59	.46	.33	.36	.48	.30	.56	.23	.47	.44	.42
Redwood Creek at Lower End Redwood Valley				-	.68	.29	.43	.76	.51	.57	.50	.32	.65	.45	.61	.39	.31	.44	.50	.33	.53	.27	.45	.47	.40
Redwood Creek above Panther Creek near Orick					-	.43	.54	.71	.61	.54	.52	.36	.56	.40	.52	.38	.26	.43	.48	.38	.41	.28	.43	.49	.52
High Slope Schist Creek near Orick						-	.36	.45	.60	.42	.38	.54	.24	.48	.36	.32	.41	.58	.49	.62	.34	.53	.38	.55	.50
Copper Creek near Orick							-	.51	.59	.55	.47	.38	.40	.43	.41	.36	.20	.51	.43	.35	.39	.34	.47	.49	.57
Redwood Creek below Copper Creek								-	.55	.65	.59	.40	.68	.48	.65	.57	.30	.52	.53	.47	.62	.32	.63	.50	.57
Slide Creek near Orick									-	.59	.51	.56	.39	.54	.57	.40	.45	.70	.56	.59	.49	.50	.51	.61	.59
Redwood Creek at South Park Boundary near Orick										-	.68	.52	.63	.64	.59	.46	.47	.51	.52	.50	.56	.40	.53	.62	.57
Bridge Creek near Orick											-	.45	.61	.58	.50	.43	.36	.49	.55	.47	.53	.30	.56	.56	.51
Harry Wier Creek near Orick												-	.32	.57	.39	.34	.56	.49	.50	.52	.26	.54	.45	.64	.51
Redwood Creek below Harry Wier Creek													-	.38	.55	.53	.24	.35	.49	.34	.45	.20	.55	.40	.38
Tom McDonald Creek near Orick														-	.44	.43	.54	.57	.53	.51	.51	.38	.44	.65	.60
Redwood Creek below Tom McDonald Creek															-	.55	.50	.55	.56	.53	.60	.28	.56	.51	.43
Redwood Creek above Miller Creek																-	.34	.47	.44	.46	.57	.29	.65	.41	.42
Miller Creek at Mouth near Orick																	-	.48	.44	.47	.38	.48	.36	.57	.46
Cloquet Creek near Orick																		-	.59	.67	.51	.53	.54	.55	.62
Redwood Creek below Oscar Larson Creek																			-	.48	.58	.39	.65	.60	.55
Elam Creek near Orick																				-	.33	.63	.42	.49	.53
Redwood Creek below Elam Creek																					-	.19	.59	.39	.45
Hayes Creek near Orick																						-	.36	.35	.46
Redwood Creek below Hayes Creek																							-	.51	.50
Lost Man Creek near Orick																								-	.59
Little Lost Man Creek near Orick																									-

TABLE 12.--Similarity-index matrix for benthic-invertebrate samples collected from selected Redwood Creek tributaries following the October 23, 1973, storm

AUTUMN 1973 (after the storm)	Harry Wier Creek	Tom McDonald Creek	Miller Creek	Miller Creek at Mouth	Hayes Creek	Lost Man Creek	Little Lost Man Creek
Harry Wier Creek	-	.55	.62	.50	.64	.38	.48
Tom McDonald Creek		-	.51	.32	.53	.33	.41
Miller Creek			-	.45	.71	.37	.45
Miller Creek at Mouth				-	.57	.35	.38
Hayes Creek					-	.38	.40
Lost Man Creek						-	.46
Little Lost Man Creek							-

The spring and autumn 1974 similarity-index values for the Redwood Creek main stem and selected tributary sampling stations are shown in table 13. The similarity-index values again were relatively high and frequently exceeded 0.5, with many values greater than 0.6. In the spring, 1974, low values were revealed when comparing samples from Redwood Creek above Highway 299 with those from Cloquet Creek (0.27); Redwood Creek above Copper Creek with Redwood Creek above Miller Creek (0.27); and Redwood Creek at lower end Redwood Valley with Little Lost Man Creek (0.30). High similarity-index values were noted when comparing Redwood Creek above Highway 299 with Harry Wier Creek (0.77) and Cloquet Creek with Little Lost Man Creek (0.75), Redwood Creek below Elam Creek with Little Lost Man Creek at Site No. 2 (0.75), and Hayes Creek with Lost Man Creek (0.75). A similarity-index value 0.41 was calculated between the uppermost main-stem station (Redwood Creek above Highway 299) and the lowermost main-stem station above the estuary (Redwood Creek above Hayes Creek).

In 1974, autumn similarity-index values were higher than the values calculated for the spring samples. These higher similarity values were attributed to an increase in both number of types and number of individuals collected during the autumn sampling period. The lowest autumn similarity-index value was calculated when comparing Redwood Creek at Redwood Valley Bridge with High Slope Schist Creek (0.41); whereas the highest similarity-index value occurred when comparing Redwood Creek above Highway 299 with Redwood Creek near Blue Lake (0.87). The similarity-index value calculated for benthic invertebrates collected from Redwood Creek above Highway 299 and Redwood Creek above Hayes Creek, the uppermost and lowermost main-stem stations above the estuary, was 0.70.

Similarity-index values for benthic-invertebrate samples collected during spring and autumn 1975 are shown in table 14. During spring sampling, the lowest similarity-index value occurred when samples from Redwood Creek near Blue Lake were compared with the samples from Miller Creek near Orick (0.32). The highest similarity-index value occurred when samples from Redwood Creek below Elam Creek were compared with samples from Redwood Creek above Hayes Creek (0.78). The similarity-index value for Redwood Creek near Blue Lake and Redwood Creek above Hayes Creek, the uppermost and lowermost main-stem stations above the estuary, was 0.57.

During 1975 autumn sampling, the lowest similarity-index value for benthic invertebrates occurred when the samples from Bridge Creek were compared with those from Miller Creek (0.00). During spring 1975 sampling, these two stations had a similarity-index value of 0.47. Upstream activities involving the removal of logging and assorted debris from the Bridge Creek stream channel resulted in an input of sediment, which caused a drastic decrease in the number of types and individuals of benthic invertebrates collected. Similarity-index values comparing Bridge Creek and the other sampling stations were all low (table 14). The highest similarity-index value occurred when comparing samples from Redwood Creek near Blue Lake with Redwood Creek above Tom McDonald Creek (0.87). The similarity-index value calculated from benthic-invertebrate samples collected from Redwood Creek near Blue Lake and Redwood Creek above Hayes Creek, the uppermost and lowermost sampling stations above the estuary, was 0.69.

The spring and autumn 1975 benthic-invertebrate samples are important from the standpoint of assessing the effect of a major flood (March 18, 1975) on the benthic-invertebrate communities in basins with different histories of land-use activity. The 1975 benthic-invertebrate samples had similarity-index values similar to the values calculated from the 1974 samples. Therefore, no major differences in benthic-invertebrate community structure appear to have occurred between sampling stations following this major flood. The result of this similarity-index comparison illustrates the ability of the benthic-invertebrate community to recolonize a stream. Bridge Creek was the only tributary where land-use activities (removal of debris from the stream channel) drastically reduced the number of types and individuals of benthic invertebrates. This land-use activity resulted in significant decreases in the calculated autumn 1975 similarity-index values between Bridge Creek station and other sampling stations in the Redwood Creek basin.

In correlating similarity-index values of benthic invertebrates collected from Redwood Creek tribuary sampling stations with different land-use activities, the Wilcoxon-Mann-Whitney test was used. Benthic-invertebrate similarity-index values calculated for tributaries with the control-basin classification (table 2) were compared with values from selected tributaries in the "logged and regenerating (less extensively logged)" basin classification. Table 15 shows seasonal and year to year comparisons of the benthic-invertebrate similarity-index values calculated for the individual tributaries. The control tributaries had similarity-index values greater than 0.6, with the exception of Hayes Creek (0.55). The range in similarity-index values for the control tributaries was 0.55 to 0.79. Tributaries logged had smaller similarity-index values, mostly under 0.6, and a wider range of values (0.09 to 0.71). Regenerating tributary basins had a narrow range of similarity-index values (0.54 to 0.69). The result of the test comparing control and logged basins indicated that the mean similarity-index value of control tributaries was larger ($\alpha<0.01$) than the mean value from tributaries logged. The tests, control versus regenerating and logged versus regenerating tributary basins, revealed no significant differences ($\alpha>0.05$) between the mean similarity-index values.

TABLE 13.--Similarity-index matrix for spring and autumn 1974 benthic invertebrates collected from Redwood Creek main stem and selected tributary sampling stations

SPRING 1974	Redwood Creek above Highway 299	Redwood Creek near Blue Lake	Redwood Creek at Redwood Valley Bridge near Blue Lake	Redwood Creek at Lower End Redwood Valley	Redwood Creek above Panther Creek near Orick	High Slope Schist Creek near Orick	Redwood Creek above Copper Creek	Copper Creek near Orick	Slide Creek near Orick	Redwood Creek at South Park Boundary near Orick	Bridge Creek near Orick	Harry Wier Creek near Orick	Redwood Creek below Harry Wier Creek	Redwood Creek above Tom McDonald Creek	Tom McDonald Creek near Orick	Redwood Creek above Miller Creek	Miller Creek near Orick	Miller Creek at Mouth near Orick	Cloquet Creek near Orick	Redwood Creek below Oscar Larson Creek	Elam Creek near Orick	Redwood Creek below Elam Creek	Redwood Creek above Hayes Creek	Hayes Creek near Orick	Lost Man Creek near Orick	Little Lost Man Creek at Site No. 2 near Orick	Little Lost Man Creek near Orick	Geneva Creek near Orick
Redwood Creek above Highway 299	-	.56	.56	.61	.54	.43	.65	.39	.44	.49	.59	.77	.61	.43	.59	.59	.36	.44	.27	.67	.60	.50	.41	.53	.48	.55	.41	.43
Redwood Creek near Blue Lake		-	.62	.68	.62	.50	.56	.48	.52	.57	.57	.45	.68	.63	.61	.57	.51	.52	.49	.64	.54	.60	.57	.56	.47	.64	.44	.38
Redwood Creek at Redwood Valley Bridge near Blue Lake			-	.68	.71	.46	.61	.43	.48	.57	.70	.54	.63	.59	.49	.57	.55	.43	.49	.60	.50	.60	.54	.52	.51	.54	.44	.34
Redwood Creek at Lower End Redwood Valley				-	.61	.35	.60	.40	.60	.50	.55	.52	.63	.58	.51	.61	.37	.50	.49	.55	.39	.51	.35	.57	.44	.52	.30	.34
Redwood Creek above Panther Creek near Orick					-	.48	.65	.50	.59	.68	.68	.68	.67	.65	.60	.70	.53	.45	.47	.67	.48	.58	.59	.54	.62	.59	.49	.40
High Slope Schist Creek near Orick						-	.45	.44	.31	.52	.41	.60	.57	.47	.67	.44	.54	.70	.62	.48	.60	.55	.51	.59	.58	.59	.57	.58
Redwood Creek above Copper Creek							-	.53	.53	.58	.47	.50	.55	.42	.59	.27	.43	.47	.49	.48	.45	.45	.44	.52	.62	.54	.43	.31
Copper Creek near Orick								-	.63	.58	.38	.56	.51	.38	.47	.36	.46	.63	.51	.46	.48	.54	.49	.54	.65	.59	.52	.45
Slide Creek near Orick									-	.58	.50	.70	.56	.57	.63	.50	.49	.67	.54	.54	.52	.54	.46	.65	.69	.59	.49	.49
Redwood Creek at South Park Boundary near Orick										-	.54	.63	.70	.68	.63	.68	.56	.58	.58	.58	.52	.68	.65	.65	.69	.69	.62	.53
Bridge Creek near Orick											-	.59	.56	.45	.47	.50	.60	.42	.51	.58	.59	.51	.46	.62	.49	.52	.43	.41
Harry Wier Creek near Orick												-	.69	.61	.63	.60	.32	.59	.62	.41	.67	.65	.62	.66	.65	.66	.60	.58
Redwood Creek below Harry Wier Creek													-	.58	.61	.72	.46	.51	.56	.68	.61	.59	.53	.60	.55	.64	.50	.41
Redwood Creek above Tom McDonald Creek														-	.46	.57	.48	.45	.53	.67	.51	.72	.71	.53	.52	.67	.58	.44
Tom McDonald Creek near Orick															-	.60	.50	.55	.65	.69	.67	.55	.53	.65	.62	.69	.66	.54
Redwood Creek above Miller Creek																-	.49	.36	.51	.71	.52	.55	.49	.54	.49	.59	.53	.44
Miller Creek near Orick																	-	.56	.50	.49	.51	.53	.57	.69	.55	.60	.46	.59
Miller Creek at Mouth near Orick																		-	.60	.46	.59	.54	.49	.65	.73	.62	.49	.57
Cloquet Creek near Orick																			-	.60	.74	.60	.55	.63	.63	.70	.75	.60
Redwood Creek below Oscar Larson Creek																				-	.52	.67	.69	.68	.57	.74	.58	.49
Elam Creek near Orick																					-	.55	.58	.68	.62	.59	.51	.58
Redwood Creek below Elam Creek																						-	.71	.63	.60	.75	.64	.50
Redwood Creek above Hayes Creek																							-	.49	.64	.69	.64	.45
Hayes Creek near Orick																								-	.75	.71	.58	.72
Lost Man Creek near Orick																									-	.68	.61	.64
Little Lost Man Creek at Site No. 2 near Orick																										-	.31	.61
Little Lost Man Creek near Orick																												
Geneva Creek near Orick																												

TABLE 13.--Similarity-index matrix for spring and autumn 1974 benthic invertebrates collected from Redwood Creek main stem and selected tributary sampling stations--Continued

AUTUMN 1974	Redwood Creek above Highway 299	Redwood Creek near Blue Lake	Redwood Creek at Redwood Valley Bridge near Blue Lake	Redwood Creek at Lower End Redwood Valley	Redwood Creek above Panther Creek near Orick	High Slope Schist Creek near Orick	Redwood Creek above Copper Creek	Copper Creek near Orick	Slide Creek near Orick	Redwood Creek at South Park Boundary near Orick	Bridge Creek near Orick	Harry Wier Creek near Orick	Redwood Creek below Harry Wier Creek	Redwood Creek above Tom McDonald Creek	Tom McDonald Creek near Orick	Redwood Creek above Miller Creek	Miller Creek near Orick	Miller Creek at Mouth near Orick	Cloquet Creek near Orick	Redwood Creek below Oscar Larson Creek	Elam Creek near Orick	Redwood Creek below Elam Creek	Redwood Creek above Hayes Creek	Hayes Creek near Orick	Lost Man Creek near Orick	Little Lost Man Creek at Site No. 2 near Orick
Redwood Creek above Highway 299	-	.87	.80	.76	.76	.47	.86	.64	.53	.69	.64	.49	.73	.71	.65	.69	.50	.54	.55	.75	.48	.60	.70	.46	.52	.56
Redwood Creek near Blue Lake		-	.74	.73	.70	.51	.75	.63	.56	.71	.68	.54	.72	.70	.67	.69	.59	.61	.61	.75	.60	.59	.69	.54	.55	.59
Redwood Creek at Redwood Valley Bridge near Blue Lake			-	.67	.78	.41	.74	.62	.58	.73	.65	.52	.71	.64	.61	.65	.47	.57	.53	.71	.48	.60	.63	.51	.52	.53
Redwood Creek at Lower End Redwood Valley				-	.63	.48	.71	.65	.57	.70	.65	.62	.75	.78	.66	.70	.52	.56	.57	.68	.57	.69	.67	.51	.58	.55
Redwood Creek above Panther Creek near Orick					-	.62	.73	.59	.68	.81	.62	.58	.70	.66	.62	.72	.49	.59	.65	.75	.54	.69	.65	.53	.51	.63
High Slope Schist Creek near Orick						-	.45	.48	.64	.55	.66	.67	.54	.55	.59	.51	.67	.61	.64	.46	.60	.52	.59	.67	.63	.65
Redwood Creek above Copper Creek							-	.71	.65	.72	.64	.52	.75	.64	.63	.72	.53	.57	.55	.75	.52	.64	.72	.53	.52	.61
Copper Creek near Orick								-	.64	.73	.68	.60	.64	.63	.62	.61	.57	.59	.62	.66	.58	.64	.67	.60	.61	.70
Slide Creek near Orick									-	.74	.64	.69	.65	.57	.61	.59	.61	.73	.79	.59	.62	.67	.58	.74	.60	.75
Redwood Creek at South Park Boundary near Orick										-	.76	.67	.79	.70	.69	.77	.59	.69	.72	.77	.60	.73	.72	.62	.63	.73
Bridge Creek near Orick											-	.75	.69	.67	.74	.66	.69	.72	.67	.68	.55	.64	.69	.67	.73	.72
Harry Wier Creek near Orick												-	.63	.62	.67	.57	.61	.72	.65	.62	.59	.65	.61	.59	.73	.75
Redwood Creek below Harry Wier Creek													-	.75	.74	.69	.58	.68	.63	.74	.59	.69	.74	.58	.60	.64
Redwood Creek above Tom McDonald Creek														-	.68	.80	.57	.61	.59	.73	.54	.72	.71	.57	.56	.57
Tom McDonald Creek near Orick															-	.67	.58	.70	.65	.72	.59	.62	.72	.56	.69	.61
Redwood Creek above Miller Creek																-	.54	.58	.59	.80	.57	.73	.72	.54	.51	.65
Miller Creek near Orick																	-	.65	.67	.54	.59	.52	.65	.67	.60	.61
Miller Creek at Mouth near Orick																		-	.73	.61	.61	.57	.65	.70	.62	.68
Cloquet Creek near Orick																			-	.64	.68	.65	.70	.76	.60	.73
Redwood Creek below Oscar Larson Creek																				-	.63	.71	.79	.57	.58	.65
Elam Creek near Orick																					-	.68	.62	.59	.52	.57
Redwood Creek below Elam Creek																						-	.73	.58	.53	.67
Redwood Creek above Hayes Creek																							-	.65	.57	.68
Hayes Creek near Orick																								-	.60	.68
Lost Man Creek near Orick																									-	.72
Little Lost Man Creek at Site No. 2 near Orick																										-

TABLE 14.--Similarity-index matrix for spring and autumn 1975 benthic invertebrates collected from Redwood Creek main stem and selected tributary sampling stations

SPRING 1975	Redwood Creek near Blue Lake	High Slope Schist near Orick	Copper Creek near Orick	Redwood Creek at South Park Boundary near Orick	Bridge Creek near Orick	Harry Wier Creek near Orick	Redwood Creek at Tom McDonald Creek	Tom McDonald Creek near Orick	Miller Creek near Orick	Miller Creek at Mouth near Orick	Redwood Creek below Elam Creek	Redwood Creek above Hayes Creek	Hayes Creek near Orick	Lost Man Creek near Orick	Little Lost Man Creek at Site No. 2 near Orick
Redwood Creek near Blue Lake	-	.42	.58	.57	.46	.56	.52	.50	.32	.47	.58	.57	.38	.55	.48
High Slope Schist near Orick		-	.51	.37	.58	.50	.51	.46	.66	.63	.53	.51	.64	.53	.57
Copper Creek near Orick			-	.55	.65	.63	.58	.57	.39	.49	.67	.62	.48	.57	.54
Redwood Creek at South Park Boundary near Orick				-	.44	.62	.61	.39	.40	.49	.56	.58	.38	.57	.50
Bridge Creek near Orick					-	.47	.49	.51	.47	.48	.48	.50	.55	.48	.49
Harry Wier Creek near Orick						-	.60	.65	.55	.70	.66	.64	.62	.72	.64
Redwood Creek above Tom McDonald Creek							-	.52	.52	.53	.72	.69	.58	.59	.56
Tom McDonald Creek near Orick								-	.50	.51	.51	.53	.61	.63	.70
Miller Creek near Orick									-	.71	.48	.52	.60	.55	.52
Miller Creek at Mouth near Orick										-	.61	.63	.71	.56	.60
Redwood Creek below Elam Creek											-	.78	.56	.64	.61
Redwood Creek above Hayes Creek												-	.61	.63	.63
Hayes Creek near Orick													-	.54	.58
Lost Man Creek near Orick														-	.72
Little Lost Man Creek at Site No. 2 near Orick															-

TABLE 14.--Similarity-index matrix for spring and autumn 1975 benthic invertebrates collected from Redwood Creek main stem and selected tributary sampling stations--Continued

AUTUMN 1975	Redwood Creek near Blue Lake	High Slope Schist near Orick	Copper Creek near Orick	Redwood Creek at South Park Boundary near Orick	Bridge Creek near Orick	Harry Wier Creek near Orick	Redwood Creek at Tom McDonald Creek	Tom McDonald Creek near Orick	Miller Creek near Orick	Miller Creek at Mouth near Orick	Redwood Creek below Elam Creek	Redwood Creek above Hayes Creek	Hayes Creek near Orick	Lost Man Creek near Orick	Little Lost Man Creek at Site No. 2 near Orick
Redwood Creek near Blue Lake	-	.49	.75	.77	.09	.56	.87	.64	.54	.54	.76	.69	.63	.58	.68
High Slope Schist near Orick		-	.52	.51	.06	.53	.47	.51	.58	.63	.54	.50	.72	.59	.59
Copper Creek near Orick			-	.71	.08	.53	.76	.54	.42	.45	.65	.61	.62	.55	.67
Redwood Creek at South Park Boundary near Orick				-	.11	.62	.75	.67	.53	.58	.66	.61	.62	.61	.66
Bridge Creek near Orick					-	.08	.09	.15	.00	.06	.10	.11	.10	.06	.10
Harry Wier Creek near Orick						-	.57	.70	.56	.51	.55	.47	.57	.65	.55
Redwood Creek at Tom McDonald Creek							-	.62	.55	.46	.72	.70	.53	.51	.62
Tom McDonald Creek near Orick								-	.62	.64	.56	.60	.55	.63	.66
Miller Creek near Orick									-	.56	.52	.48	.54	.63	.52
Miller Creek at Mouth near Orick										-	.52	.42	.63	.58	.61
Redwood Creek below Elam Creek											-	.68	.59	.46	.58
Redwood Creek above Hayes Creek												-	.54	.48	.63
Hayes Creek near Orick													-	.65	.69
Lost Man Creek near Orick														-	.77
Little Lost Man Creek at Site No. 2 near Orick															-

TABLE 15.--Comparison of seasonal and yearly benthic-invertebrate similarity-index values from selected control, logged, and regenerating tributary basins

Basin classification and sampling station	Similarity-Index Value			
	Spring vs Autumn 1974	Spring vs Autumn 1975	Spring 1974 vs 1975	Autumn 1974 vs 1975
Control				
High Slope Schist Creek near Orick	0.74	0.76	0.68	0.79
Hayes Creek near Orick	.65	.61	.55	.74
Little Lost Man Creek at site no. 2 near Orick	.63	.69	.67	.75
Logged				
Copper Creek near Orick	.50	.52	.59	.71
Bridge Creek near Orick	.50	.11	.54	.09
Harry Wier Creek near Orick	.61	.70	.63	.59
Miller Creek near Orick	.58	.55	.51	.34
Miller Creek at Mouth near Orick	.62	.74	.53	.64
Regenerating (less extensively logged)				
Tom McDonald Creek near Orick	.54	.57	.69	.66
Lost Man Creek near Orick	.54	.64	.64	.68

Comparisons of the similarity-index values from the Redwood Creek estuary are shown in table 16. During the spring, similarity-index values between estuary sampling stations were high, ranging from 0.44 to 0.89, with many values greater than 0.6. In contrast, the similarity-index values during the autumn were low, with one exception (line 2b versus line 3b). The decreases that occurred in similarity-index values from spring to autumn were related to the seasonal change in the taxa of benthic invertebrates collected. The seasonal change in benthic-invertebrate composition in the autumn was attributed to the intrusion of saltwater into the estuary, which caused a dominance of invertebrates that were tolerant to increased salinity.

Similarity-index values for the Mill Creek basin, during spring and autumn 1974, are shown in table 17. During spring and autumn sampling, the calculated similarity values were high, ranging from 0.62 to 0.80. Similarity-index values for the Mill Creek basin did not vary seasonally as did the similarity-index values for the Redwood Creek basin. No correlation could be developed between similarity-index values and the different land-use activities occurring in the Mill Creek basin.

TABLE 16.--Similarity-index matrix for spring and autumn 1974 benthic invertebrates collected at Redwood Creek estuary sampling stations

SPRING 1974	Redwood Creek Estuary Line 1A	Redwood Creek Estuary Line 1B	Redwood Creek Estuary Line 1C	Redwood Creek Estuary Line 2A	Redwood Creek Estuary Line 2B	Redwood Creek Estuary Line 2C	Redwood Creek Estuary Line 3A	Redwood Creek Estuary Line 3B	Redwood Creek Estuary Line 3C
Redwood Creek Estuary Line 1A	-	.70	.67	.83	.58	.70	.73	.61	.50
Redwood Creek Estuary Line 1B		-	.75	.73	.62	.89	.70	.57	.45
Redwood Creek Estuary Line 1C			-	.60	.44	.75	.67	.63	.60
Redwood Creek Estuary Line 2A				-	.67	.64	.83	.72	.54
Redwood Creek Estuary Line 2B					-	.48	.58	.75	.55
Redwood Creek Estuary Line 2C						-	.60	.57	.45
Redwood Creek Estuary Line 3A							-	.78	.67
Redwood Creek Estuary Line 3B								-	.72
Redwood Creek Estuary Line 3C									-

AUTUMN 1974	Redwood Creek Estuary Line 1B	Redwood Creek Estuary Line 2B	Redwood Creek Estuary Line 3B
Redwood Creek Estuary Line 1B	-	.25	.20
Redwood Creek Estuary Line 2B		-	.80
Redwood Creek Estuary Line 3B			-

TABLE 17.--Similarity-index matrix for spring and autumn 1974 benthic invertebrates collected at the Mill Creek basin sampling stations

SPRING 1974	West Branch Mill Creek below Red Alder Campground near Crescent City	East Fork Mill Creek near Crescent City	Mill Creek near Crescent City	Mill Creek at Mouth near Crescent City
West Branch Mill Creek below Red Alder Campground near Crescent City	-	.71	.74	.76
East Fork Mill Creek near Crescent City		-	.74	.63
Mill Creek near Crescent City			-	.71
Mill Creek at Mouth near Crescent City				-

AUTUMN 1974	West Branch Mill Creek below Red Alder Campground	East Fork Mill Creek	Mill Creek
West Branch Mill Creek below Red Alder Campground	-	.62	.70
East Fork Mill Creek		-	.80
Mill Creek			-

Fish

Fish are important organisms in the aquatic environment. Fish are directly and indirectly affected by physical and chemical changes in the aquatic environment and are often used as biological indicators of water quality. A summary of the fish data presented in Iwatsubo and others (1976) is given in table 18. It includes species composition of all fish captured and the condition factor and length-weight relation of salmonids captured from selected sampling areas in the Redwood Creek basin.

Species Composition

In the Redwood Creek basin, 1,066 fish were captured during the study. Species composition was: steelhead trout, *Salmo gairdneri gairdneri* (69.6 percent); Humboldt sucker, *Catostomus humboldtianus* (10.6 percent); threespine stickleback, *Gasterosteus aculeatus* (10.3 percent); coastrange sculpin, *Cottus aleuticus* (5.8 percent); coho salmon, *Oncorhynchus kisutch* (3.4 percent); chinook salmon, *O. tshawytscha* (0.3 percent); and Pacific lamprey, adult and ammocete, *Entosphenus tridentatus* (observed only).

Fish species reported to inhabit the Redwood Creek basin, but not captured during the study, include: resident rainbow trout, *Salmo gairdneri*; coast cutthroat trout, *S. clarki clarki*; and eulachon, *Thaleichthys pacificus* (DeWitt, 1964). Steelhead trout is a sea-run rainbow trout; whereas the rainbow trout is a permanent resident of the freshwater environment.

Seasonal species composition of fish is shown in figure 5. The percentage composition of fish types other than steelhead trout and coastrange sculpin decreased from 1974 to 1975.

The effect of the March 18, 1975, flood on the fisheries resource of the Redwood Creek basin is not known; however, the absence of salmon fry in the 1975 samples could be attributed to the flood. Spawning activities of chinook and coho salmon generally are completed by February (California Department of Water Resources, 1965). Absence of salmon fry during the 1975 fish-inventory survey could indicate a high mortality of salmon embryos developing in the spawning gravel during the flood.

The effects of the March 18, 1975, flood on the steelhead trout population is somewhat more complex than the effect on the chinook and coho salmon populations. Total number of steelhead trout captured during the 1975 fish-inventory survey increased by 48 percent. The steelhead trout fry captured during the July 1975 survey were probably the result of the spawning activity that occurred after the March 18, 1975, flood. This hypothesis was based on field observations of recent yolk-sac absorption of the steelhead trout fry and that a large majority of the fry were captured within the depression of their redd. Survival of steelhead trout, chinook, and coho salmon fry from spawning activity prior to the March 18, 1975, flood is not known.

The only fish-inventory survey made in the Mill Creek basin was during late spring 1974. The species composition of the 61 fish captured is given in table 18. Fish species reported to inhabit the Mill Creek basin but were not captured during this study include king salmon (California Department of Water Resources, 1965) and coast cutthroat trout (Burns, 1971).

TABLE 18.--Summary of fish inventories

Sampling Area	Date	Species-type captured	Species Composition (percent)	Fork length (cm) Range	x̄	n	Weight (gm) Range	x̄	n	Condition factor[1] Range	x̄	n	Length-weight relation[1] W=aL^b a	b[2]	correlation coefficient
Redwood Cr. near Redwood Valley Bridge	8- 2-74	Steelhead trout	81	2.6-14.5	6.7	109	0.2-37.1	5.1	109	0.31-2.05	1.05	109	0.009	3.06	0.94
		Humboldt sucker	18	--	--	24	--	--	--	--	--	--	--	--	--
		Threespine stickleback	0.7	--	--	1	--	--	--	--	--	--	--	--	--
	7-25-75	Humboldt sucker	59	--	--	19	--	--	--	--	--	--	--	--	--
		Steelhead trout	41	4.3-5.8	4.9	13	--	--	--	--	--	--	--	--	--
	9-26-75	Steelhead trout	100	7.2-16.1	10.3	50	4.2-56.1	17.2	50	1.05-1.90	1.28	50	.013	3.00	--
		Humboldt sucker(observed only)	--	--	--	--	--	--	--	--	--	--	--	--	--
		Pacific lamprey-ammocete (observed only)	--	--	--	--	--	--	--	--	--	--	--	--	--
Redwood Cr. near mouth of Copper Cr.	7-24-75	Steelhead trout	100	2.8-5.6	4.4	11	--	--	--	--	--	--	--	--	--
	9-24-75	Humboldt sucker	74	--	--	14	--	--	--	--	--	--	--	--	--
		Steelhead trout	26	6.3-11.0	8.8	5	3.5-18.5	10.9	5	1.07-1.56	1.38	5	.007	3.29	.99
Copper Cr. near mouth	7-24-75	Steelhead trout	100	2.5-9.4	3.8	42	--	--	--	--	--	--	--	--	--
	9-24-75	Steelhead trout	100	4.3-7.3	5.3	40	1.0-5.1	2.4	40	1.18-2.29	1.56	40	.025	2.71	.92
Bridge Cr. near mouth	5-23-74	Coastrange sculpin	100	--	--	3	--	--	--	--	--	--	--	--	--
	7-17-75	Steelhead trout	100	2.5-13.5	6.0	16	--	--	--	--	--	--	--	--	--
	9-25-75	Steelhead trout	80	5.0-12.6	6.8	48	1.5-22.6	4.8	48	1.06-2.29	1.37	48	.024	2.73	.96
		Coastrange sculpin	18	--	--	11	--	--	--	--	--	--	--	--	--
		Humboldt sucker	1.7	--	--	1	--	--	--	--	--	--	--	--	--
Harry Wier Cr. near mouth	5-23-74	Steelhead trout	75	3.9-11.3	8.1	3	<1-18.0	--	3	--	--	--	--	--	--
		Coastrange sculpin	25	--	--	1	--	--	--	--	--	--	--	--	--
	7-16-75	Steelhead trout	100	3.0-4.8	3.9	16	--	--	--	--	--	--	--	--	--
	9-25-75	Steelhead trout	93	4.1-11.7	5.3	50	.5-21.4	2.2	50	.59-2.00	1.18	50	.012	2.99	.92
		Coastrange sculpin	5.6	--	--	3	--	--	--	--	--	--	--	--	--
		Humboldt sucker	1.8	--	--	1	--	--	--	--	--	--	--	--	--
Redwood Cr. below Harry Wier Cr.	7-30-74	Steelhead trout	58	4.2-9.3	6.0	60	.5-9.1	2.3	60	.36-1.32	.92	60	.003	3.61	.90
		Threespine stickleback	26	--	--	27	--	--	--	--	--	--	--	--	--
		Humboldt sucker	15	--	--	15	--	--	--	--	--	--	--	--	--
		Coastrange sculpin	.9	--	--	1	--	--	--	--	--	--	--	--	--

Sampling Area	Date	Species-type captured	Species Composition (percent)	Fork length (cm) Range	x̄	n	Weight (gm) Range	x̄	n	Condition factor[1] Range	x̄	n	Length-weight relation[1] W=aL^b a	b[2]	correlation coefficient
Tom McDonald Cr. near mouth	5-24-74	Coho salmon	78.9	3.2-4.9	3.9	15	--	<1	15	--	--	--	--	--	--
		Coastrange sculpin	15.8	--	--	3	--	--	--	--	--	--	--	--	--
		Threespine stickleback	5.3	--	--	1	--	--	--	--	--	--	--	--	--
	7-21-75	Steelhead trout	64.7	2.8-17.3	5.7	44	--	--	--	--	--	--	--	--	--
		Coastrange sculpin	27.9	--	--	19	--	--	--	--	--	--	--	--	--
		Threespine stickleback	7.4	--	--	5	--	--	--	--	--	--	--	--	--
	9-25-75	Steelhead trout	89.3	5.1-15.8	6.9	50	0.7-44.2	5.26	50	.53-1.94	1.16	50	.008	3.18	.96
		Coastrange sculpin	10.7	--	--	6	--	--	--	--	--	--	--	--	--
		Pacific lamprey-ammocete (observed only)	--	--	--	--	--	--	--	--	--	--	--	--	--
Miller Creek near mouth	7-24-74	Steelhead trout	66.7	4.7-9.5	7.1	2	<1-8.0	--	2	--	--	--	--	--	--
		Coho salmon	33.3	--	3.9	1	--	<1	1	--	--	--	--	--	--
	7-22-75	Steelhead trout	70.0	4.1-11.2	7.6	7	--	--	--	--	--	--	--	--	--
		Coastrange sculpin	30.0	--	--	3	--	--	--	--	--	--	--	--	--
Redwood Cr. near Hayes Cr.	5-22-74	Coastrange sculpin	83.3	--	--	5	--	--	--	--	--	--	--	--	--
		Coho salmon	16.7	--	5.0	1	--	--	--	--	--	--	--	--	--
	7-29-74	Threespine stickleback	37.3	--	--	59	--	--	--	--	--	--	--	--	--
		Steelhead trout	29.1	4.9-14.6	8.2	46	.6-31.0	7.7	46	.46-1.20	.89	46	.003	3.48	.99
		Humboldt sucker	24.7	--	--	39	--	--	--	--	--	--	--	--	--
		Coho salmon	5.7	5.1-9.5	6.7	9	.9-10.5	3.5	9	.64-1.22	.94	9	.002	3.97	.99
		Chinook salmon	1.9	8.0-9.6	8.7	3	5.5-10.0	7.2	3	1.02-1.13	1.07	3	.005	3.39	.99
		Coastrange sculpin	1.3	--	--	2	--	--	--	--	--	--	--	--	--
Little Lost Man Cr. near mouth	5-22-74	Steelhead trout	49.0	6.3-16.0	9.6	19	1.0-51.0	12.6	19	.31-1.37	1.04	19	.001	3.94	.94
		Coho salmon	25.5	3.9-7.7	5.3	10	<1-4	--	10	--	--	--	--	--	--
		Threespine stickleback	25.5	--	--	10	--	--	--	--	--	--	--	--	--
	7-23-75	Steelhead trout	85.7	4.6-12.7	7.0	72	--	--	--	--	--	--	--	--	--
		Threespine stickleback	8.3	--	--	7	--	--	--	--	--	--	--	--	--
		Coastrange sculpin	6.0	--	--	5	--	--	--	--	--	--	--	--	--
	9-24-75	Steelhead trout	100	6.0-23.6	8.6	39	1.4-147.3	11.7	39	.56-2.13	1.24	39	.015	2.90	.97
		Threespine stickleback(observed only)	--	--	--	--	--	--	--	--	--	--	--	--	--
		Pacific lamprey-ammocete (observed only)	--	--	--	--	--	--	--	--	--	--	--	--	--
Mill Creek near recording gauge	5-25-74	Steelhead trout	72	2.8-11.8	5.1	44	<1-21	--	44	--	--	--	--	--	--
		Pacific lamprey-ammocete	12	--	--	7	--	--	--	--	--	--	--	--	--
		Coastrange sculpin	10	--	--	6	--	--	--	--	--	--	--	--	--
		Coho salmon	7	4.2-5.5	5.0	4	<1-1.0	--	4	--	--	--	--	--	--

[1]Calculated using fork lengths (centimeters) and weights (grams)
[2]b value is equivalent to the slope of the linear regression line of the length-weight relation

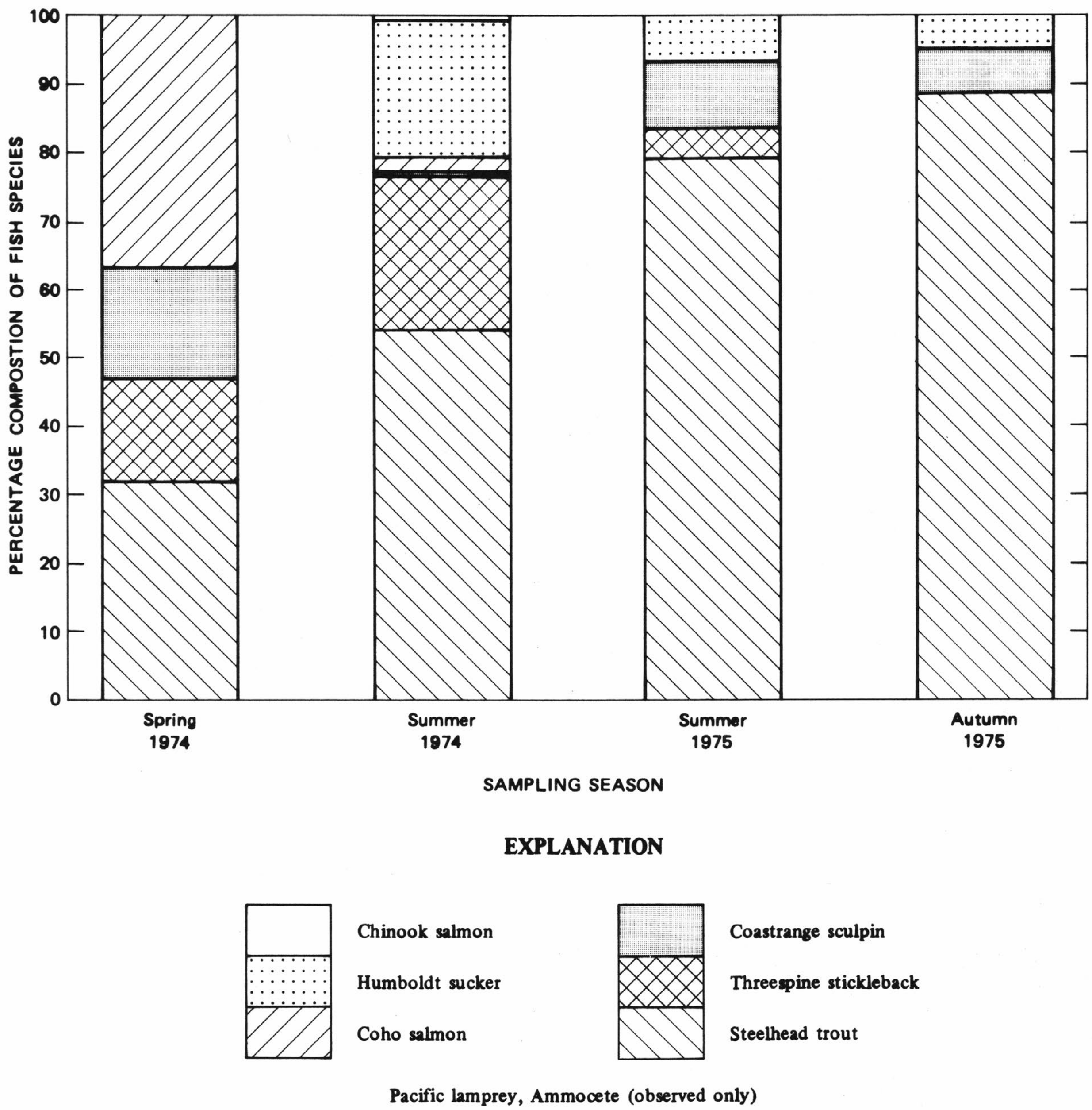


FIGURE 5.--Seasonal percentage composition of fish species captured in the Redwood Creek drainage basin.

Condition Factor

Condition factors for the majority of the salmonids collected in the Redwood Creek basin were calculated from the following equation (Lagler, 1969):

$$K = \frac{W \times 10^5}{L^3} \qquad (3)$$

where K = condition factor,
W = weight in grams, and
L = fork length in centimeters.

The condition factor can be used to indicate the relative robustness of fish and can reflect the effects of environmental changes which may improve or retard growth. Condition factors are relative values; the higher the condition factor the more robust the fish. The calculations and comparisons of condition factors for steelhead trout were based on all steelhead trout captured at each location during each sampling period. Age, sex, and size of the steelhead trout were not considered when calculating mean condition factors and when making comparisons of steelhead trout samples.

The mean condition factor for steelhead trout captured from selected areas in the Redwood Creek basin ranged from 0.89 to 1.56, with an overall mean of 1.19 (table 18). From areas located on Redwood Creek main stem, mean condition factors ranged from 0.89 to 1.38, with an overall mean of 1.10; whereas from selected Redwood Creek tributaries, the mean condition factors ranged from 1.04 to 1.56, with an overall mean of 1.26. Similar comparisons of mean condition factors for coho and chinook salmon captured from the Redwood Creek basin and all salmonids captured from the Mill Creek basin were not made because of insufficient weight data. That is, weights less than 1 gram could not be determined in the field during 1974 sampling.

The calculated mean condition factors of the steelhead trout captured from the Redwood Creek basin are shown in figure 6. The results of the summer 1974 fish-inventory survey showed a decrease in mean condition factors of captured steelhead trout in a downstream direction along Redwood Creek main stem. The results of the autumn 1975 fish-inventory survey showed that, of the selected tributaries surveyed, mean condition factors were largest for steelhead trout captured from Copper and Bridge Creeks (1.56 and 1.37) and smallest from Tom McDonald and Harry Wier Creeks (1.16 and 1.18). Steelhead trout from Little Lost Man Creek had a condition factor (1.24) just slightly less than the overall mean condition factor for steelhead trout captured from the tributaries surveyed.

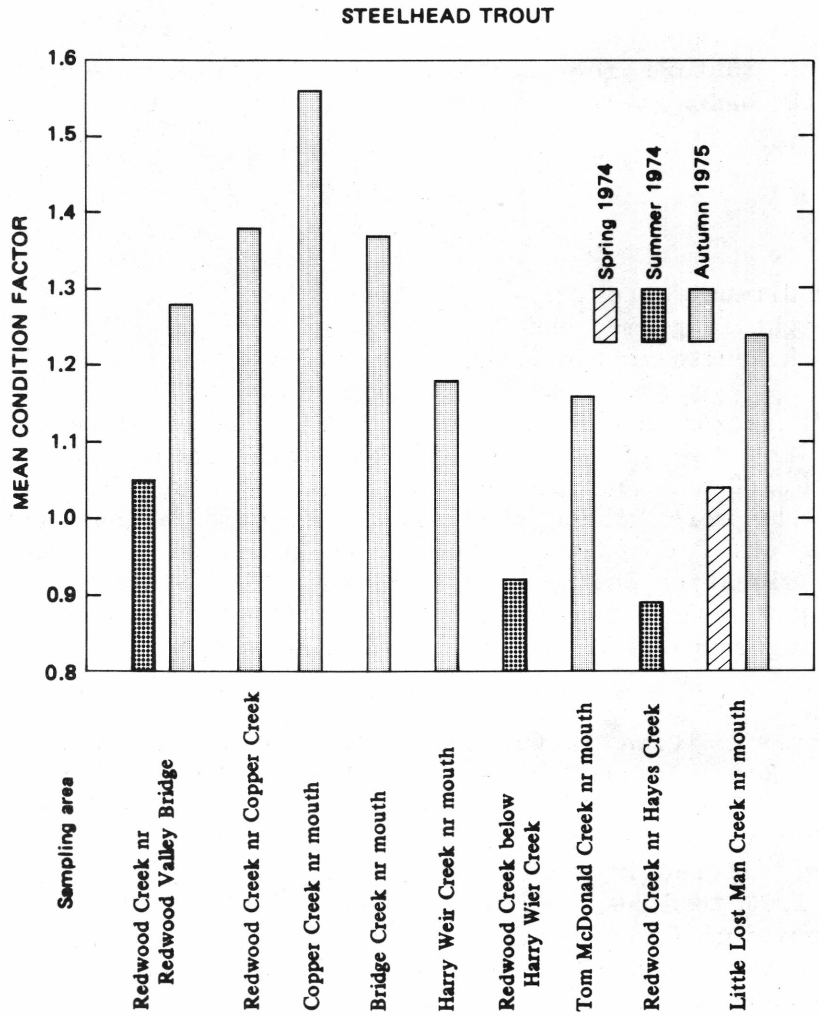


FIGURE 6.--Mean condition factors of steelhead trout.

The Wilcoxon-Mann-Whitney test (U.S. Army, 1969) was used to compare the condition factors for steelhead trout populations captured in the Redwood Creek basin. The results of the condition-factor comparisons for steelhead trout captured during summer 1974 are presented in table 19. Because of the paucity of data, comparisons could only be made between three sampling areas in Redwood Creek main stem. Condition factors for steelhead trout captured from Redwood Creek near Redwood Valley Bridge were significantly larger (α>0.01) than Redwood Creek below Harry Wier Creek and Redwood Creek near Hayes Creek. Comparisons of condition factors for steelhead trout captured from Redwood Creek below Harry Wier Creek and Redwood Creek near Hayes Creek showed no significant difference (α>0.20).

TABLE 19.--Condition-factor comparisons of steelhead trout captured during summer 1974, using the Wilcoxon-Mann-Whitney test

(Values represent significance level with < equaling a significant difference and > equaling no significant difference.)

SUMMER 1974	Redwood Creek near Redwood Valley Bridge	Redwood Creek below Harry Wier Creek	Redwood Creek near Hayes Creek
Redwood Creek near Redwood Valley Bridge	-	<.01	<.01
Redwood Creek below Harry Wier Creek		-	>.20
Redwood Creek near Hayes Creek			-

The results of the condition-factor comparisons for steelhead trout captured during the autumn 1975 fish-inventory survey are presented in table 20. Condition factors for steelhead trout captured from Redwood Creek near Redwood Valley Bridge were significantly larger ($\alpha<0.01$) than Tom McDonald Creek, Harry Wier Creek ($\alpha<0.05$), and Little Lost Man Creek ($\alpha<0.05$), and significantly smaller ($\alpha<0.01$) than Copper Creek. Condition factors for steelhead trout captured from Redwood Creek near Copper Creek were significantly larger ($\alpha<0.05$) than Tom McDonald Creek. Condition factors for steelhead trout captured from Copper and Bridge Creeks were significantly larger ($\alpha<0.01$) than the condition factors for steelhead trout captured from Harry Wier, Tom McDonald, and Little Lost Man Creeks. Comparisons of condition factors for steelhead trout captured from Harry Wier, Tom McDonald, and Little Lost Man Creeks showed no significant differences ($\alpha>0.20$).

TABLE 20.--Condition-factor comparisons of steelhead trout captured during autumn 1975, using the Wilcoxon-Mann-Whitney test

(Values represent significance level with < equaling a significant difference and > equaling no significant difference.)

	Redwood Creek near Redwood Valley Bridge	Redwood Creek near Copper Creek	Copper Creek	Bridge Creek	Harry Wier Creek	Tom McDonald Creek	Little Lost Man Creek
Redwood Creek near Redwood Valley Bridge	-	<.10	<.01	<.20	<.05	<.01	<.05
Redwood Creek near Copper Creek		-	<.20	>.20	<.10	<.05	<.20
Copper Creek			-	<.01	<.01	<.01	<.01
Bridge Creek				-	<.01	<.01	<.01
Harry Wier Creek					-	>.20	>.20
Tom McDonald Creek						-	>.20
Little Lost Man Creek							-

Length-Weight Relation

Length-weight relations for most of the salmonids collected in the Redwood Creek basin were calculated from the following equation (Lagler, 1969):

$$W = aL^b \tag{4}$$

where W = weight in grams,
L = length in centimeters,
a = constant, and
b = exponent.

A least-squares regression was derived from the logarithmic transformation of the length-weight relation of equation 4. The values of a and b were determined empirically from the actual fork lengths and weights of the salmonids captured. The slope of the regression line, b, can be used to indicate the extent of growth occurring in the salmonid fish captured. That is, the steeper the slope of the regression line the more weight the fish is gaining per unit growth in length. Generally, when the slope of the regression line is greater than 3, the fish are stout, and when the slope is less than 3, the fish are slim. Correlation coefficients also were determined to assess the length-weight of the salmonids sampled. A very strong linear relation exists when correlation coefficients values are near ±1 and there is no linear relation when values are close to zero.

During the summer 1974, three areas along Redwood Creek main stem were sampled for fish. The slopes of the length-weight regression for the steelhead trout captured during this survey ranged from 3.06 to 3.61 with a mean slope of 3.38 (table 18). During the autumn 1975 fish-inventory survey, both Redwood Creek main stem and tributaries were surveyed. The slopes of the length-weight regression for steelhead trout captured from two Redwood Creek main-stem sites were 3.00 and 3.29 with a mean slope of 3.15; whereas the slopes of the length-weight regression for steelhead trout captured from selected tributaries ranged from 2.71 to 3.18 with a mean slope of 2.90. Comparisons of length-weight relations for chinook and coho salmon captured in Redwood Creek and all salmonids captured in the Mill Creek basin were not made because of insufficient weight data; weights less than 1 gram could not be determined in the field during 1974 sampling.

Steelhead trout captured along Redwood Creek main stem during the 1974 fish-inventory survey were stout when compared to the steelhead trout captured along the main stem in 1975. Length-weight relations for steelhead trout captured from Redwood Creek main stem and tributaries during the 1975 fish-inventory survey indicated that steelhead trout from the main stem were stouter than the steelhead trout captured from the tributaries.

The length-weight relation, $W = 0.017287L^{2.768}$, for the steelhead trout captured from the Redwood Creek basin during the study was compared to the length-weight relation, $W = 0.006237L^{3.063}$, for steelhead trout populations from small coastal California streams, as described by Calhoun (1966). Graphs of the compared length-weight relations are shown in figure 7. The steelhead trout captured from the Redwood Creek basin were substantially slimmer than the steelhead trout population representative of small coastal California streams.

The correlation coefficient values (table 18) of the length-weight regressions for the salmonids captured from the Redwood Creek basin denoted that good to very strong linear relations existed between the lengths and weights of the fish.

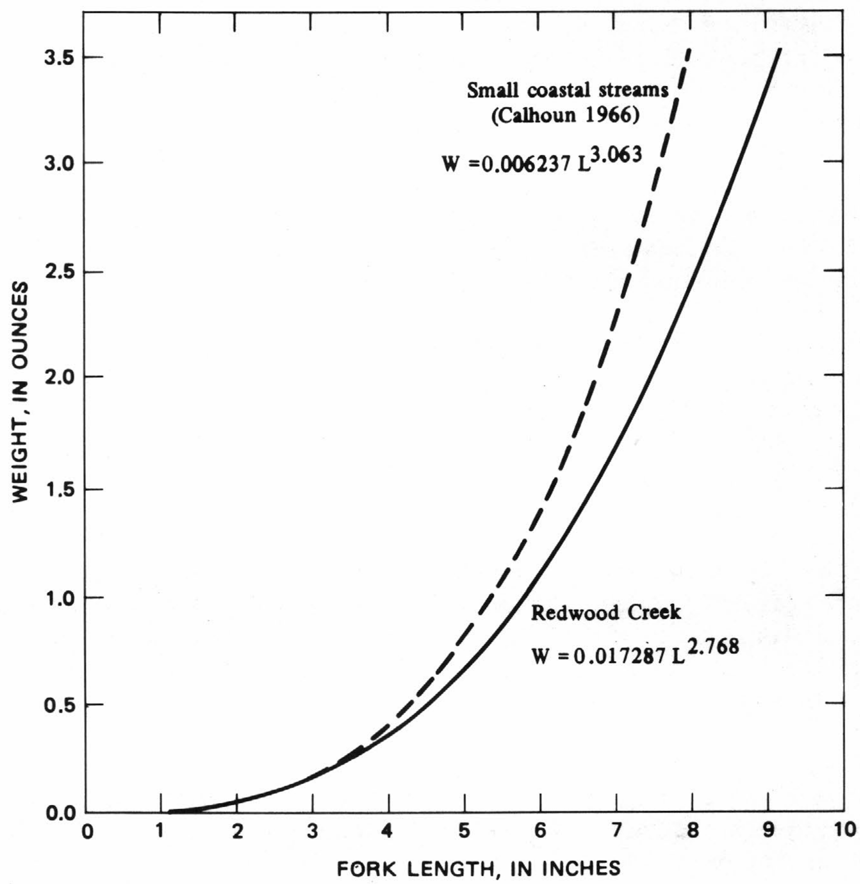


FIGURE 7.--Comparison of length-weight curves for steelhead trout.

Periphyton

Periphyton is the assemblage of organisms that attach to or live on underwater substrates and includes algae, bacteria, fungi, protozoans, rotifers, and other small organisms. Environmental influences such as insolation, streambed stability, sedimentation, nutrients, and water temperature have an effect on the abundance and diversity of the periphytic community and periphytic biomass.

The taxonomic classification and enumeration of periphyton collected from selected areas in the Redwood Creek and Mill Creek basins have been reported in Iwatsubo and others (1976). The periphyton community that colonized the artificial substrates during the study was composed of 61 taxa (table 21). Fifty taxa of periphyton colonized artificial substrates placed in selected areas of the Redwood Creek basin, 33 taxa of periphyton were identified from the Mill Creek basin samples, and 22 taxa were common in samples collected from both drainage basins.

Taxonomic Composition

Taxonomic composition of periphyton was determined for each sample collected (table 22). Diatoms (Bacillariophyceae) were the most common group in each sample. In the Redwood Creek basin, *Epithemia sorex*, *Achnanthes lanceolata*, and *Diatoma vulgare* occurred in the largest numbers; whereas in the Mill Creek basin, *Cymbella cistula*, *A. lanceolata*, and *Cocconeis placentula* were most numerous.

The percentage of green algae (Chlorophyta) was low for each periphyton sample with the exception of Bridge Creek (spring 1974) and Little Lost Man Creek at Site No. 2 (spring 1975) samples. *Chlamydomonas sp.*, *Spirogyra sp.*, and *Ulothrix sp.* were the most numerous green algae sampled from the Redwood Creek basin; whereas *Eudorina elegans*, *Scenedesmus dimorphus* and *Ankistrodesmus falcutus* (planktonic algae occurring with periphytic algae) were most numerous in the Mill Creek basin. Of the remaining groups of periphyton only the rounded-unknown nonflagellate group had a high percentage composition (East Fork Mill Creek, summer 1974).

TABLE 21.--Taxonomic list and occurrence of periphyton

DIVISION CLASS Order Suborder Family *Genus species*	Redwood Creek Drainage Basin	Mill Creek Drainage Basin
CHLOROPHYTA		
CHLOROPHYCEAE		
Chlorococcales		
Oocystaceae		
Ankistrodesmus falcutus	X	X
Selenastrum minutum	X	
Scenedesmaceae		
Crucigenia tetrapedia	X	
Scenedesmus abundans		X
Scenedesmus dimorphus	X	X
Scenedesmus sp.	X	
Ulotrichales		
Ulotrichineae		
Ulotrichaceae		
Ulothrix sp.	X	
Volcocales		
Chlamydomonadaceae		
Chlamdydomonas sp.	X	
Volcocaceae		
Eudorina elegans		X
Zygnematales		
Zygnemataceae		
Mougeotia sp.	X	
Spirogyra sp.	X	
Zygnema sp.	X	
CHRYSOPHYTA		
BACILLARIOPHYCEAE		
Centrales		
Coscinodiscineae		
Coscinodiscaceae		
Cyclotella sp.	X	
Mejosira varians	X	X
Pennales		
Achnanthineae		
Achnanthaceae		
Achnanthes lanceolata	X	X
Achnanthes minutissima	X	X
Achnanthes sp.	X	
Cocconeis placentula	X	X
Rhoicosphenia curvata	X	
Fragilarineae		
Diatomaceae		
Diatoma hiemale	X	X
Diatoma vulgare	X	
Eunotiaceae		
Eunotia pectinalis	X	
Eunotia sp.	X	
Fragilariaceae		
Fragilaria vaucheriae		X
Synedra amphicephala	X	
Synedra rumpens	X	X
Synedra ulna	X	X
Synedra sp.		X

TABLE 21.--Taxonomic list and occurrence of periphyton--Continued

DIVISION CLASS Order Suborder Family *Genus species*	Redwood Creek Drainage Basin	Mill Creek Drainage Basin
Naviculineae		
Cymbellaceae		
Cymbella cistula	X	X
Cymbella mexicanum	X	X
Cymbella sinuata	X	
Cymbella sp.		X
Ephithemia sorex	X	X
Epithemia turgida	X	
Rhopalodia gibba	X	
Gomphonemataceae		
Gomphoneis herculeana	X	
Gomphonema angustatum	X	X
Naviculaceae		
Navicula cincta		X
Navicula cryptocephala	X	X
Navicula exiqua		X
Navicula globulifera	X	X
Navicula menisculus		X
Navicula viridula	X	
Navicula sp.	X	X
Pinnularia sp.	X	X
Stauroneis sp.	X	
Surirellineae		
Nitzschiaceae		
Nitzschia acicularis	X	X
Nitzschia dissipata	X	
Nitzschia hantzschianai	X	
Nitzschia linearis	X	X
Nitzschia palea	X	X
Nitzschia romana		X
Nitzschia sp.	X	X
Surirellaceae		
Surirella angustata	X	
CYANOPHYTA		
MYXOPHYCEAE		
Chamaesiphonales		
Chamaesiphonaceae		
Chamaesiphon sp.		X
Chroococcales		
Chroococcaceae		
Merismopedia sp.	X	
Oscillatoriales		
Nostochineae		
Nostocaceae		
Anabaena sp.	X	
Oscillatorinea		
Oscillatoriaceae		
Oscillatoria sp.		X
PROTOZOA		
CILIOPHORA (subphylum)	X	
MISCELLANEOUS		
Rounded-unknown nonflagellates	X	X
Unknown flagellates	X	

TABLE 22.--Taxonomic composition of periphyton

[T = <1 cell/mm²]

Station name	Date: Installed	Date: Retrieved	Percentage composition: Chlorophyta	Chrysophyta Bacillariophycae	Cyanophyta	Unknown: Rounded nonflagellates	Unknown: Flagellates	Total: Types	Total: Cell/mm²
Redwood Creek at	5- 9-74	7-16-74	0	100	0	0	0	5	928
South Park	7-16-74	9-13-74	.4	96.1	0	3.5	0	9	489
Boundary	7-30-75	9- 5-75	0	100	0	0	0	5	49
Bridge Creek	5-13-74	7-15-74	35	60	0	0	5	8	97
	7-15-74	9-16-74	0	100	0	0	0	7	2,520
	6- 7-75	7-31-75	1	88	11	0	0	13	237
Harry Wier Creek	5-13-74	7-15-74	0	100	0	0	0	6	1,075
	7-15-74	9-16-74	0	100	0	0	0	4	1,072
	6- 1-75	7-31-75	.2	99.8	0	0	0	11	426
Miller Creek	5-10-74	7-16-74	0	100	0	0	0	2	244
	7-16-74	9-17-74	0	99.4	.3	0	0	7	573
	5-31-75	7-28-75	0	100	0	0	0	3	302
Miller Creek at	5-14-74	7-16-74	0	100	0	0	0	3	557
Mouth	7-16-74	9-17-74	0	100	0	0	0	12	125
	5-31-75	7-27-75	0	100	0	0	0	3	670
Redwood Creek	5-15-74	7-15-74	0	100	0	0	0	5	609
above Hayes	7-15-74	9-14-74	2	98	0	0	0	14	1,416
Creek	8- 1-75	9- 5-75	0	100	0	0	0	8	6,887
Hayes Creek	5-15-74	7-15-74	0	100	0	0	0	1	1,200
	7-15-74	9-15-74	0	100	T	0	0	7	11
Lost Man Creek	5-10-74	7-15-74	9	91	0	0	0	4	952
	7-15-74	9-14-74	1	99	0	0	0	10	828
	6- 2-75	7-27-75	5	95	0	0	0	8	128
Little Lost Man	5-10-74	[1]						--	--
Creek at Site	7-15-74	9-14-74	1	99	0	0	0	13	1,541
No. 2	6- 2-75	7-27-75	44	56	0	0	0	14	2,420
West Branch Mill	5-21-74	7-16-74	0	100	0	0	0	7	2,388
Creek Below Red	7-16-74	9-12-74	4	96	0	0	0	20	200
Alder Campground	6- 5-75	7-29-75	.2	99.8	0	0	0	10	2,351
East Fork	5-21-74	7-16-74	17	83	0	0	0	3	469
Mill Creek	7-16-74	9-12-74	0	56	0	44	0	8	71
	6- 5-75	7-29-75	0	100	0	0	0	5	353
Mill Creek	5-20-74	7-16-74	0	100	0	0	0	4	3,121
	7-16-74	9-12-74	.6	99.4	0	0	0	14	175
	6- 5-75	7-29-75	1	97	2	0	0	16	1,983

[1]Samplers missing July 15, 1974.

Biomass

Biomass of periphyton was determined for each sample collected during the study to obtain estimated daily rates of periphyton accrual, and organic and inorganic-material deposition. These rates do not take into consideration growth curves of periphyton at each sampling station and were computed by dividing the weights of organic and inorganic materials deposited on the samples by the number of days allowed for colonization. The results indicated that periphyton accrual was low in the Redwood Creek and Mill Creek basins (table 23).

In the spring and summer 1974, there was an increase in inorganic- and organic-material deposition on the periphyton samplers located at the lower Miller Creek stations as compared to the upper Miller Creek station (table 23). Excessive amounts of fine sediment were deposited on Miller Creek at Mouth periphyton samplers. The input of sediment into Miller Creek probably was caused by the construction of a bridge crossing located upstream and between the two sampling stations. The increases in organic material during these two sampling periods were not related so much to periphytic production but to the organic material adhered to the sediment deposited on the substrates and to the inputs of fine organic debris directly into the stream during bridge construction. No increases in organic- and inorganic-material deposition on the periphytic samplers occurred between these two stations during spring 1975 sampling. Apparently, the increases that occurred during spring and autumn 1974 sampling as a result of bridge construction were temporary. High winter streamflows flushed out the fine organic debris and sediments deposited in the stream during bridge construction in the previous year. Periphyton rate of accrual increased from spring to summer 1974 sampling at Bridge Creek, Redwood Creek above Hayes Creek, and Lost Man Creek stations. Periphyton samplers installed at Little Lost Man Creek at Site No. 2 were vandalized during spring 1974 sampling. During spring 1975 sampling the deposition of inorganic material on the periphyton samplers was greater in Bridge Creek and Harry Wier Creek than in the other streams sampled. Prior to the retrieval of the periphyton sampler installed at Bridge Creek, an input of sediment into the stream was caused by activities related to the removal of logging debris upstream from the sampling station. The cause of the increased inorganic-material deposition on the periphyton sampler installed at Harry Wier Creek may have been due to the construction of a road approach to an existing bridge.

The spring 1975 periphyton samplers installed at Redwood Creek at South Park Boundary and above Hayes Creek stations were lost. Periphyton was resampled at these two stations during summer 1975 and rates of accrual were similar to the rates of summer 1974 (table 23).

Rates of accrual of periphyton at the East Fork Mill Creek sampling station were consistently lower than at the West Branch Mill Creek and Mill Creek stations (table 23). The deposition of inorganic materials on the periphyton samplers was minimal at all Mill Creek sampling stations during the study.

TABLE 23.--Rates of accrual of periphyton

Station Number	Station Name	Date Sampler Installed	Date Sampler Removed	Colonization Period (Days)	Periphyton Dry Weight $(g/m^2)/d$	Periphyton Inorganic Wt. $(g/m^2)/d$	Periphyton Organic Wt. $(g/m^2)/d$
11482200	Redwood Creek at	5- 9-74	7-16-74	68	0.13	0.09	0.04
	South Park Boundary	7-16-74	9-13-74	59	.05	.02	.03
	near Orick	Spring 1975	samplers missing	--	--	--	--
		7-30-75	9- 5-75	37	.08	.05	.03
11482210	Bridge Creek near	5-13-74	7-15-74	63	.02	.01	.01
	Orick	7-15-74	9-16-74	63	.43	.29	.14
		6- 7-75	7-31-75	54	.59	.54	.05
11482225	Harry Wier Creek	5-13-74	7-15-74	63	.10	.07	.03
	near Orick	7-15-74	9-16-74	63	.12	.09	.03
		6- 1-75	7-31-75	60	.20	.18	.02
11482250	Miller Creek near	5-10-74	7-16-74	67	03	.02	.01
	Orick	7-16-74	9-17-74	63	.04	.03	.01
		5-31-75	7-28-75	58	.02	.02	.00
11482260	Miller Creek at	5-14-74	7-16-74	63	1.19	1.12	.07
	Mouth near	7-16-74	9-17-74	63	.92	.85	.07
	Orick	5-31-75	7-28-75	58	.03	.02	.01
	Redwood Creek above	5-15-74	7-15-74	61	.11	.10	.01
	Hayes Creek near	7-15-74	9-14-74	61	1.59	1.15	.44
	Orick	Spring 1975	samplers missing	--	--	--	--
		8- 1-75	9- 5-75	35	2.66	2.11	.55
11482330	Hayes Creek near	5-15-74	7-15-74	61	.06	.06	.00
	Orick	7-15-74	9-14-74	61	.01	.01	.00
11482450	Lost Man Creek	5-10-74	7-15-74	66	.05	.03	.02
	near Orick	7-15-74	9-15-74	62	.12	.08	.04
		6- 2-75	7-27-75	55	.05	.03	.02
11482450	Little Lost Man	Spring 1974	samplers missing	--	--	--	--
	Creek at Site #2	7-15-74	9-14-74	61	.46	.35	.11
	near Orick	6- 2-75	7-27-75	55	.01	.06	.04
11532602	West Branch Mill	5-21-74	7-16-74	56	.34	.23	.11
	Creek below Red	7-16-74	9-12-74	58	.08	.04	.04
	Alder Campground	6- 5-75	7-29-75	54	.13	.07	.06
	near Crescent City						
11532610	East Fork Mill	5-21-74	7-16-74	56	.05	.03	.02
	Creek near	7-16-74	9-12-74	58	.07	.03	.04
	Crescent City	6- 5-75	7-29-75	54	.05	.03	.02
11482620	Mill Creek near	5-20-74	7-16-74	57	.10	.05	.05
	Crescent City	7-16-74	9-12-74	58	.17	.10	.07
		6- 5-75	7-29-75	54	.10	.04	.06

Diversity Index

Diversity index was calculated for each periphyton sample collected during the study using equation 1. Periphyton collected during the study showed a wide variation in diversity-index values ranging from 0.00 to 2.76 (table 24). Diversity indexes of periphyton samples collected within the Redwood Creek basin ranged from 0.98 to 2.34 for main-stem stations and from 0.00 to 2.76 for tributary stations. Hayes Creek, a control basin, had the smallest diversity index, 0.00; whereas Bridge Creek, a logged basin, had the largest diversity index, 2.76.

The unusually small diversity index for Hayes Creek represented the community structure of periphyton collected during spring 1974 sampling; similarily, during summer 1974 sampling the periphyton diversity index was again very small at 0.06. During both sampling periods, _Achnanthes lanceolata_ was the dominant periphytic organism sampled at Hayes Creek. This diatom was reported by Geither (1927, cited in Hynes, 1970) and McIntire (1966) to be one of the first organisms to colonize newly exposed surfaces in the stream environment. The total number of periphytic organisms collected from Hayes Creek during spring and summer 1974 sampling declined from 1,200 to 11 organisms/mm^2, respectively. The reasons for this seasonal fluctuation (spring to summer) of _A. lanceolata_ are unknown, but decreases in insolation, streamflow, and the availability of nutrients are probably contributing factors. Also, grazing by larger benthic invertebrates may also cause a decrease in abundance of periphyton (Hynes, 1970).

The spring 1974 Bridge Creek samples had the largest diversity index. During this period, periphytic organisms were in the process of recolonizing stream substrates after winter discharges. The number of periphytic organisms collected at Bridge Creek was small when compared to the number of organisms collected from the other sampling stations during the same period. A substantial decrease in the diversity index of periphyton occurred at Bridge Creek from spring to summer 1974 sampling (2.76 to 0.40). This was attributed to the increase and dominance of _Epithemia sorex_, an epiphytic diatom. The increase in the number of _E. sorex_ was due to a seasonal change that was primarily associated with an increase in algal growth as a result of increased insolation and water temperatures. The dominance of _E. sorex_ occurred again during summer 1975 sampling; however, the total number was substantially smaller. Prior to the collection of summer 1975 periphyton samples, logging debris were removed from the channel of Bridge Creek (by bulldozer) upstream from the sampling station. Increased suspended sediment caused by the cleanup operation and deposition of fine sediment on the periphyton sampler probably was the principal factor influencing the decrease in total number of _E. sorex_ in the May to July 1975 samples as compared to the May to July 1974 samples.

The diversity indexes of periphyton collected from the other sampling stations in the Redwood Creek basin were related to the seasonal variability of the periphyton community structure at each station. Diversity indexes tended to be larger at the stations with greater rates of periphyton accrual (Redwood Creek above Hayes Creek, Lost Man Creek, and Little Lost Man Creek at Site No. 2 stations).

TABLE 24.--Diversity indexes of periphyton

Station Number	Station Name	Date sampler Installed	Date sampler Removed	Diversity index
11482200	Redwood Creek at South Park Boundary near Orick	5- 9-74	7-16-74	1.57
		7-16-74	9-13-74	.98
		Spring 1975	samplers missing	--
		7-30-75	9- 5-75	1.46
11482210	Bridge Creek near Orick	5-13-74	7-15-74	2.76
		7-15-74	9-16-74	.40
		6- 7-75	7-31-75	1.45
11482225	Harry Wier Creek near Orick	5-13-74	7-15-74	1.39
		7-15-74	9-16-74	.93
		6- 1-75	7-31-75	1.72
11482250	Miller Creek near Orick	5-10-74	7-16-74	.46
		7-16-74	9-17-74	1.12
		5-31-75	7-28-75	.51
11482260	Miller Creek at Mouth near Orick	5-14-74	7-16-74	.23
		7-16-74	9-17-74	1.96
		5-31-75	7-28-75	.01
	Redwood Creek above Hayes Creek near Orick	5-15-74	7-15-74	1.50
		7-15-74	9-14-74	1.40
		Spring 1975	samplers missing	--
		8- 1-75	9- 5-75	2.34
11482330	Hayes Creek near Orick	5-15-74	7-15-74	.00
		9-15-74	9-14-74	.06
11482450	Lost Man Creek near Orick	5-10-74	7-15-74	1.29
		9-15-74	9-15-74	2.18
		6- 2-75	7-27-75	1.72
11482450	Little Lost Man Creek at Site No. 2 near Orick	Spring 1974	samplers missing	--
		7-15-74	9-14-74	2.14
		6- 2-75	7-27-75	2.66
11532602	West Branch Mill Creek below Red Alder Campground near Crescent City	5-21-74	7-16-74	2.49
		9-16-74	9-12-74	2.45
		6- 5-75	7-29-75	2.14
11532610	East Fork Mill Creek near Crescent City	5-21-74	7-16-74	1.34
		7-16-74	9-12-74	2.23
		6- 5-75	7-29-75	.46
11482620	Mill Creek near Crescent City	5-20-74	7-16-74	.77
		9-16-74	9-12-74	2.57
		6- 5-75	7-29-75	2.39

The diversity indexes of periphyton collected from the Mill Creek basin were as variable as periphyton diversity indexes from the Redwood Creek basin (table 24). Diversity indexes of periphyton ranged from 0.46 (East Fork Mill Creek station) to 2.57 (Mill Creek station). The diversity indexes of periphyton collected from West Branch Mill Creek below Red Alder Campground station showed little variation throughout the study period as compared to the diversity indexes calculated from the East Fork Mill Creek and Mill Creek periphyton samples. Except during May to July 1974 sampling, periphyton diversity indexes from the East Fork Mill Creek were smaller than the diversity indexes from samples of the West Branch Mill Creek below Red Alder Campground and Mill Creek stations. The diversity indexes of periphyton from Mill Creek sampling station were as variable as the diversity indexes from East Fork Mill Creek station. The smallest diversity index of periphyton from Mill Creek sampling station occurred during May to July 1974 sampling. The dominance of Cymbella cistula, an epilithic diatom, accounted for this small diversity-index value. During June to July 1975 sampling C. cistula was present but did not dominate the periphyton community as in 1974.

Similarity Index

Similarity indexes were calculated for selected periphyton samples collected during the study using equation 4. Comparisons of the periphyton community structure between sampling areas in the Redwood Creek basin were extremely variable during the study (table 25). There were no apparent similarities in periphyton communities that could be related directly to upstream land-use activities. The variability in similarity indexes of periphyton primarily reflects the relatively small number of taxa present in each sample when compared to the total number of taxa occurring in the periphyton community sampled.

In the Mill Creek basin, periphyton similarity indexes were less variable than in the Redwood Creek basin. The similarity indexes of periphyton were consistently larger between West Branch Mill Creek below Red Alder Campground and Mill Creek sampling stations and consistently smaller between East Fork Mill Creek and Mill Creek sampling stations. The lack of similarity in community structure between East Fork Mill Creek and the West Branch Mill Creek below Red Alder Campground and Mill Creek sampling stations was influenced by the low rates of accrual of periphyton and the relatively small number of taxa that occurred in the East Fork Mill Creek samples.

TABLE 25.--Periphyton similarity-index matrix

[Number in parentheses is the number of taxa common to both samples]

REDWOOD CREEK SPRING 1974	Redwood Creek at South Park Boundary	Bridge Creek	Harry Wier Creek	Miller Creek	Miller Creek at Mouth	Redwood Creek above Hayes Creek	Hayes Creek	Lost Man Creek
Redwood Creek at South Park Boundary	-	.46(3)	.00(0)	.00(0)	.00(0)	.20(1)	.00(0)	.22(1)
Bridge Creek		-	.14(1)	.20(1)	.18(1)	.46(3)	.22(1)	.50(3)
Harry Wier Creek			-	.50(2)	.44(2)	.54(3)	.29(1)	.40(2)
Miller Creek				-	.80(2)	.57(2)	.67(1)	.67(2)
Miller Creek at Mouth					-	.50(2)	.50(1)	.57(2)
Redwood Creek above Hayes Creek						-	.33(1)	.67(3)
Hayes Creek							-	.49(1)
Lost Man Creek								-

MILL CREEK SPRING 1974	West Branch Mill Creek below Red Alder Campground near Crescent City	East Fork Mill Creek near Crescent City	Mill Creek near Crescent City
West Branch Mill Creek below Red Alder Campground near Crescent City	-	.40(2)	.54(3)
East Fork Mill Creek near Crescent City		-	.29(1)
Mill Creek near Cresent City			-

TABLE 25.--Periphyton similarity-index matrix--Continued

REDWOOD CREEK SUMMER 1974	Redwood Creek at South Park Boundary	Bridge Creek	Harry Wier Creek	Miller Creek	Miller Creek at Mouth	Redwood Creek above Hayes Creek	Hayes Creek	Lost Man Creek	Little Lost Man Creek at Site No. 2
Redwood Creek at South Park Boundary	-	.53(4)	.15(1)	.25(2)	.29(3)	.61(7)	.25(2)	.42(4)	.27(3)
Bridge Creek		-	.18(1)	.29(2)	.32(3)	.48(5)	.29(2)	.47(4)	.30(3)
Harry Wier Creek			-	.36(2)	.50(4)	.22(2)	.54(3)	.29(2)	.35(3)
Miller Creek				-	.42(4)	.29(3)	.43(3)	.35(3)	.20(2)
Miller Creek at Mouth					-	.38(5)	.42(1)	.45(5)	.48(6)
Redwood Creek above Hayes Creek						-	.38(4)	.42(5)	.67(9)
Hayes Creek							-	.24(2)	.50(5)
Lost Man Creek								-	.43(5)
Little Lost Man Creek at Site No. 2									-

MILL CREEK SUMMER 1974	West Branch Mill Creek below Red Alder Campground near Crescent City	East Fork Mill Creek near Crescent City	Mill Creek near Crescent City
West Branch Mill Creek below Red Alder Campground near Crescent City	-	.57(8)	.65(11)
East Fork Mill Creek near Crescent City		-	.45(5)
Mill Creek near Crescent City			-

TABLE 25.--Periphyton similarity-index matrix--Continued

REDWOOD CREEK SPRING 1975 SUMMER 1975	Redwood Creek at South Park Boundary	Bridge Creek	Harry Wier Creek	Miller Creek	Miller Creek at Mouth	Redwood Creek above Hayes Creek	Lost Man Creek	Little Lost Man Creek at Site No. 2
Redwood Creek at South Park Boundary[1]	-	.22(2)	.25(2)	.25(1)	.25(1)	.62(4)	.31(2)	.21(2)
Bridge Creek		-	.33(4)	.12(1)	.12(1)	.19(2)	.29(3)	.37(5)
Harry Wier Creek			-	.29(2)	.29(2)	.32(3)	.42(4)	.32(4)
Miller Creek				-	.67(2)	.18(1)	.36(2)	.24(2)
Miller Creek at Mouth					-	.18(1)	.36(2)	.24(2)
Redwood Creek above Hayes Creek[1]						-	.25(2)	.27(3)
Lost Man Creek							-	.45(5)
Little Lost Man Creek at Site No. 2								-

MILL CREEK SPRING 1975	West Branch Mill Creek below Red Alder Campground near Crescent City	East Fork Mill Creek near Crescent City	Mill Creek near Crescent City
West Branch Mill Creek below Red Alder Campground near Crescent City	-	.53(4)	.69(9)
East Fork Mill Creek near Crescent City		-	.38(4)
Mill Creek near Crescent City			-

[1]Summer 1975 sample.

Phytoplankton

Phytoplankton are the aggregate of passively drifting plant organisms in water. The abundance and taxonomic composition of phytoplankton can be used to indicate water-quality conditions.

The taxonomic classification and enumeration of phytoplankton collected from selected areas in the Redwood Creek and Mill Creek basins have been reported in Iwatsubo and others (1976). The phytoplankton community was more diverse than the periphyton community and was composed of 79 different taxa (table 26). Sixty phytoplankton taxa were identified from water samples collected from the Redwood Creek basin upstream from the estuary, 22 phytoplankton taxa were identified from samples collected exclusively from Redwood Creek estuary, and 45 phytoplankton taxa were identified from water samples collected at selected areas in the Mill Creek basin. A total of 32 phytoplankton taxa were common to both the Redwood Creek and Mill Creek basins.

Taxonomic Composition

Diatoms generally were the dominant phytoplankton group collected during the study; however, unknown flagellates and green algae were dominant at times (table 27). In the Redwood Creek basin, exclusive of the estuary, unknown flagellates, and *Gomphonema angustatum*, *Achnanthes lanceolata*, and *Cocconeis placentula* were the most numerous of the phytoplankton taxa collected. In Redwood Creek estuary, *Chlamydomonas sp.*, unknown flagellates, *Cryptomonas sp.*, and *Selenastrum minutum* were the most numerous phytoplankton; whereas unknown flagellates, and *A. lanceolata*, *G. angustatum*, and *C. placentula* were the most numerous phytoplankton taxa in samples from the Mill Creek basin.

The taxa, *G. angustatum*, *A. lanceolata*, and *C. placentula*, are not truly planktonic but epiphytic (Smith, 1950). Analysis of the life histories of the remaining phytoplankton taxa (except the dominant taxa from Redwood Creek estuary) suggests that the majority of the phytoplankton were actually periphytic algae that have become dislodged from their substrate and were passively drifting downstream when sampled. McCoy (1974) found that most of the phytoplankton sampled from two subarctic Alaskan streams were actually dislodged periphyton. In the Redwood Creek estuary, however, the dominant phytoplankton taxa, *Chlamydomonas sp.*, *Cryptomonas sp.*, and *S. minutum*, are truly planktonic. The dominance of these truly planktonic forms of phytoplankton in the Redwood Creek estuary can be related to an emergent sandbar that usually closes the mouth of Redwood Creek to the Pacific Ocean during low-flow periods. Redwood Creek estuary becomes a lentic (ponded) environment favoring phytoplankton development.

The unknown flagellate group occurred in all the phytoplankton samples collected except at Miller Creek at Mouth station during September 1974. The majority of the miscellaneous flagellates were very small, quadriflagellated and most likely zoospores; however, without culturing live material, identification was not possible (Jan B. Brocksen, written commun., 1974).

TABLE 26.--Taxonomic list and occurrence of phytoplankton

DIVISION CLASS Order Suborder Family *Genus species*	Redwood Creek drainage basin Main stem and tributaries	Redwood Creek drainage basin Estuary	Mill Creek drainage basin
CHLOROPHYTA			
CHLOROPHYCEAE			
Chlorococcales			
Micractiniaceae			
Golenkinia radiate			X
Oocystaceae			
Ankistrodesmus falcutus		X	X
Chodatella subsalsa			X
Selenastrum minutum	X	X	
Selenastrum sp.			X
Tetraedron minimum	X		
Scenedesmaceae			
Scenedesmus abundans			X
Scenedesmus bijuga		X	
Scenedesmus denticulatus			X
Scenedesmus dimorphus	X	X	X
Scenedesmus tenuispina	X	X	
Scenedesmus sp.			X
Ulotrichales			
Ulotrichineae			
Ulotrichaceae			
Ulothrix sp. (individual cells)	X		
Volvocales			
Chlamydomonadaceae			
Carteria sp.	X		X
Chlamydomonas sp. (flagellate)		X	
Zygnematales			
Desmidiaceae			
Closterium sp.	X		X
Cosmarium sp.	X		
Zygnematacede			
Spirogyra sp. (individual cells)	X		
Zygnema sp. (individual cells)	X		
CHRYSOPHYTA			
BACILLARIOPHYCEAE			
Centrales			
Coscinodiscineae			
Coscinodiscaceae			
Coscinodiscus sp.	X	X	
Cyclotella sp.	X	X	
Melosira varians	X	X	X
Pennales			
Achnanthineae			
Achnanthaceae			
Achnanthes lanceolata	X	X	X
Achnanthes minutissima	X	X	X
Cocconeis placentula	X		X
Rhoicosphenia curvata	X		X
Fragilarineae			
Diatomaceae			
Diatoma hiemale	X		
Diatoma vulgare	X		
Fragilariaceae			
Fragilaria crotonensis			X
Fragilaria sp.			X
Synedra rumpens	X		X
Synedra ulna	X		X
Synedra sp.	X		
Naviculineae			
Cymbellaceae			
Cymbella cistula	X		X
Cymbella mexicanum	X		X
Cymbella sinuata	X		X
Cymbella ventricosa	X		
Cymbella sp.	X		X
Epithemia sorex	X		X
Rhopalodia gibba	X		

DIVISION / CLASS / Order / Suborder / Family / *Genus species*	Redwood Creek drainage basin: Main stem and tributaries	Redwood Creek drainage basin: Estuary	Mill Creek drainage basin
Gomphonemataceae			
Gomphonema angustatum	X	X	X
Gomphonema sp.	X		
Naviculaceae			
Amphiprora paludosa		X	
Navicula bacillum	X		
Navicula cincta	X		
Navicula cryptocephala	X	X	X
Navicula exigua	X		X
Navicula globulifera	X		
Navicula menisculus	X		
Navicula radiosa	X		
Navicula viridula			X
Navicula sp. #1	X	X	X
Navicula sp. #2	X		
Pinnularia sp.	X		X
Surirellineae			
Nitzschiaceae			
Nitzschia acicularis	X		X
Nitzschia amphibia			X
Nitzschia dissipata	X		
Nitzschia filiformis		X	
Nitzschia frustulum	X		X
Nitzschia hantzschiana	X		
Nitzschia linearis	X		X
Nitzschia palea	X	X	X
Nitzschia romana			X
Nitzschia sp. #1	X	X	X
Nitzschia sp. #2	X		
Surirellaceae			
Surirella angustata	X		
Surirella elegans	X		
CHRYSOPHYCEAE			
Chrysomonadales			
Chromulinaceae			
Kephyrion sp.	X		X
Rhizochrysidales			
Rhizochrysidaceae			
Chrysamoeba sp.	X		X
Chrysidiastrum sp.	X	X	X
XANTHOPHYCEAE			
Heterococcales			
Centritractaceae			
Bumilleriopsis sp.			X
Pleurochloridaceae			
Botrydiopsis sp.			X
CYANOPHYTA			
MYXOPHYCEAE			
Chroococcales			
Chroococcaceae			
Merismopedia sp. (individual cells)	X		
Oscillatoriales			
Nostochineae			
Nostocaceae			
Anabaena sp. (individual cells)	X		
Oscillatorineae			
Oscillatoriaceae			
Oscillatoria sp. (individual cells)	X		X
EUGLENOPHYTA			
EUGLENOPHYCEAE			
Euglenales			
Euglenaceae			
Trachelomonas sp.	X		
PYRROPHYTA			
DINOPHYCEAE			
Peridiniales			
Glenodiniaceae			
Glenodinium sp.		X	
GROUPS OF UNCERTAIN SYSTEMATIC POSITION			
CRYPTOPHYCEAE			
Cryptomonadales			
Cryptomonadaceae			
Cryptomonas sp.	X	X	X
MISCELLANEOUS			
Unknown flagellates	X	X	X

TABLE 27.--Taxonomic composition

[T =

Station	Date	Percentage composition			
		Chlorophyta	Chrysophyta		
			Bacillariophyceae	Chrysophyceae	Xanthophyceae
Redwood Creek at South Park Boundary	7-19-74	0	40	0	0
	9-11-74	4	86	T	0
	7-31-74	13	76	T	0
	9- 5-75	T	50	0	0
Bridge Creek	7-31-75	44	41	0	0
Harry Wier Creek	7-19-74	0	41	32	0
	9-11-74	0	73	0	0
	7-31-75	T	85	0	0
Miller Creek	7-19-74	0	15	34	0
	9-11-74	0	47	40	0
	7-28-75	T	52	35	0
Miller Creek at Mouth	7-19-74	0	53	26	0
	9-11-74	0	67	33	0
	7-28-75	6	53	29	0
Hayes Creek	7-19-74	0	24	24	0
Lost Man Creek	7-19-74	0	43	0	0
	9-11-74	0	60	T	0
	7-27-75	6	19	19	0
Little Lost Man Creek at Site No. 2	7-19-74	0	37	5	0
	9-11-74	0	83	5	0
	7-27-75	0	57	4	0
Redwood Creek at Orick	7-19-74	0	70	0	0
	9-11-74	11	61	0	0
Redwood Creek Estuary Site 1B	7-25-74	19	45	0	0
	9-20-74	82	1	0	0
Redwood Creek Estuary Site 2B	7-25-74	0	20	4	0
	9-20-74	84	1	0	0
Redwood Creek Estuary Site 3B	9-20-74	81	3	0	0
West Branch Mill Creek below Red Alder Campground	8- 1-74	0	51	24	0
	9-12-74	8	67	5	0
	7-29-75	12	37	29	0
East Fork Mill Creek	8- 1-74	0	12	0	0
	9-12-74	11	43	3	0
	7-29-75	3	51	T	14
Mill Creek	8- 1-74	2	47	0	0
	9-12-74	5	63	0	0
	7-29-75	8	59	0	7

of periphyton

<1]

Cyanophyta	Euglenophyta	Pyrrophyta	Unknown flagellates	Groups of uncertain systematic positions	Total Types	Total Cells per mL
25	0	0	35	0	5	121
T	0	0	10	0	25	29
1	0	0	10	0	18	104
T	0	0	50	T	12	127
0	0	0	15	0	16	27
0	0	0	27	0	7	22
0	0	0	27	0	8	15
0	0	0	15	0	14	20
0	0	0	51	0	6	41
0	0	0	13	0	8	15
0	0	0	13	0	10	23
0	0	0	21	0	6	19
0	0	0	0	0	4	3
0	0	0	12	0	12	17
T	0	0	52	0	7	50
0	0	0	57	0	3	30
T	0	0	40	0	16	5
0	0	0	56	0	12	16
0	0	0	58	0	8	43
0	0	0	12	0	12	58
T	0	0	39	0	13	23
0	0	0	30	0	9	81
1	T	0	27	0	29	103
0	0	0	36	0	7	106
0	0	0	6	11	9	734
0	0	0	76	0	8	157
0	0	0	4	11	10	724
0	0	1	7	8	13	330
0	0	0	25	0	6	67
0	0	0	20	0	14	39
0	0	0	22	0	11	170
0	0	0	88	0	3	58
0	0	0	43	0	16	28
0	0	0	32	T	19	37
0	0	0	51	0	9	122
0	0	0	32	0	17	38
0	0	0	26	0	23	76

Diversity Index

Diversity index was calculated for each phytoplankton sample collected using equation 1. The results of the diversity-index calculations for phytoplankton showed a wide variation, ranging from 0.06 to 3.86 (table 28). In the Redwood Creek basin, phytoplankton samples had diversity indexes ranging from 2.06 to 3.86 at the main-stem stations, 1.37 to 3.18 at the tributary stations, and 1.03 to 2.43 at the estuary stations. Upstream from the estuary, diversity indexes of the phytoplankton samples were larger in the streams that received more insolation (table 2). Along Redwood Creek main stem, a downstream increase in diversity index of phytoplankton occurred. Phytoplankton samples collected at the estuary stations had smaller diversity indexes than did the samples collected at the upstream stations. The estuary phytoplankton community was primarily dominated by large concentrations of *Chlamydomonas sp*. and *Cryptomonas sp*. Both of these genera have been related to organically enriched waters (Palmer, 1969). In addition, the presence of *Cryptomonas* in large numbers has been used to indicate the completion of organic matter decomposition in the stream (Brinley, 1942).

In the Mill Creek basin, phytoplankton samples had diversity indexes ranging from 0.06 (East Fork Mill Creek) to 3.37 (Mill Creek). No explanation can be given for the small diversity index calculated for the phytoplankton sample collected at the East Fork Mill Creek station (August 1974).

Similarity Index

Similarity index was calculated for selected phytoplankton samples collected during the study from equation 2. Comparisons of the phytoplankton community structures between the sampling areas in the Redwood Creek basin varied throughout the study (table 29). Upstream from the estuary, differences in phytoplankton community structure were difficult to assess. However, phytoplankton similarity indexes did decrease from mid to late summer 1974. This decrease probably was related to the seasonal change in the species composition of phytoplankton.

Comparisons between phytoplankton samples collected at Bridge Creek and the other areas sampled during summer 1975, showed extremely low similarity indexes. The phytoplankton community of Bridge Creek was dominated by green algae; whereas diatoms dominated the phytoplankton communities of the other sampling areas. Timber-harvest activities in the Bridge Creek basin have been extensive and removal of streamside canopy has resulted in increased insolation and green algal production. The types of green algae dominating Bridge Creek phytoplankton community were actually dislodged filamentous periphyton (*Ulothrix sp*., *Spirogyra sp*., and *Zygnema sp*.).

Similarity indexes for phytoplankton collected from Redwood Creek estuary were slightly variable between sampling stations. The variability in the phytoplankton community structures probably was related to differences in water quality. The smallest similarity index occurred during midsummer 1974 sampling when salinity values were highest in the estuary. At that time, the mouth of Redwood Creek was open to the ocean and saltwater entered directly into the estuary during high-tide periods. The mouth of Redwood Creek was closed to the ocean by an emergent sandbar during late summer 1974 sampling. Saltwater again entered the estuary, but the volume was minimal because the inflow of seawater was subsurface and through the sandbar during high-tide periods. Salinity of the estuary was lower; whereas the similarity indexes were higher than the midsummer samples.

In the Mill Creek basin, phytoplankton community structures did not differ greatly between sampling areas. During 1974 sampling however, similarity indexes of phytoplankton were largest between West Branch Mill Creek below Red Alder Campground and Mill Creek sampling stations; whereas during 1975 sampling the similarity index value was largest between East Fork Mill Creek and Mill Creek sampling stations.

Seston

Seston is the particulate organic and inorganic matter suspended in water. The measurement of seston concentrations can indicate, in part, the biological productivity and potential chemical energy in the aquatic environment. The results of the seston determinations have been reported in Iwatsubo and others (1976) and are summarized in table 30.

Individual seston concentrations were extremely variable not only between stations but also at each station. The seasonal fluctuations of monthly mean percentage organic weight of seston collected in the Redwood Creek and Mill Creek basins are shown in figure 8. In Redwood Creek main stem and tributaries upstream from the estuary, a decrease in mean percentage organic weight of seston occurred between November 1973 and March 1974. This decrease indicated the reduction in organic debris being flushed from the drainage basin by winter flows, as well as aquatic productivity being at a minimum during this period. From April through September 1974, mean percentage organic weight of seston from both the Redwood Creek and Mill Creek basins increased as the aquatic productivity of these basins increased. The small peak in the mean percentage organic weight of seston that occurred in Redwood Creek tributaries (fig. 8) during May 1974 was from Elam Creek. No explanation can be given for this higher percentage of organic seston from Elam Creek.

The largest mean percentages of organic weight of seston occurred during September 1974. At the time water discharges were at a minimum, aquatic productivity was maximum, and leaf litter was starting to accumulate in the stream. These were the main factors influencing the large mean percentages of organic weight of seston during this period.

In Redwood Creek estuary the large mean percentage organic weight of seston was related to the phytoplankton population that existed in the estuary during September 1974 sampling. The mean phytoplankton density of the samples collected was 600 cells per milliliter of water.

No seston samples were collected at any of the sampling stations between September 1974 and the first storm that occurred in November 1974. Thus, no data are available to determine what level the percentage organic weight of seston would have reached prior to the first storm of the winter season. After November 1974, mean percentages of organic weight of seston again decreased as winter progressed and storms flushed organic debris from the drainage basins.

During two storms (November 6-8, 1974, and February 5-9, 1975), seston samples were collected at near hourly intervals from Harry Wier Creek (logged drainage basin) and Little Lost Man Creek (control drainage basin). Instantaneous discharge measurements and organic seston concentrations were compared between the two stations during both storms (figs. 9 and 10). Hydrographs of Harry Wier Creek during both storms displayed larger and sharper peak discharges than did the hydrographs of Little Lost Man Creek. The time-series plots of organic seston concentrations displayed larger and sharper peak concentrations of organic debris being flushed from the Harry Wier Creek basin than the Little Lost Man Creek basin.

TABLE 28.--Diversity indexes of phytoplankton

Station	Date	Diversity index
Redwood Creek at South Park Boundary	7-19-74	2.11
	9-11-74	3.47
	7-31-75	3.41
	9-05-75	2.06
Bridge Creek	7-31-75	2.99
Harry Wier Creek	7-19-75	2.43
	9-11-74	1.56
	7-31-75	2.67
Miller Creek	7-19-74	1.69
	9-11-74	2.65
	7-28-75	2.12
Miller Creek at Mouth	7-19-74	2.29
	9-11-74	1.88
	7-28-75	2.88
Hayes Creek	7-19-74	2.01
Lost Man Creek	7-19-74	1.37
	9-11-74	3.18
	7-27-75	2.35
Little Lost Man Creek at Site No. 2	7-19-74	2.04
	9-11-74	2.43
	7-27-75	2.85
Redwood Creek at Orick	7-19-74	2.75
	9-11-74	3.86
Redwood Creek Estuary site 1B	7-25-74	2.43
	9-20-74	1.36
Redwood Creek Estuary site 2B	7-25-74	1.36
	9-20-74	1.03
Redwood Creek Estuary site 3B	9-20-74	1.48
West Branch Mill Creek below Red Alder Campground	8-01-74	2.15
	9-12-74	2.75
	7-29-75	2.55
East Fork Mill Creek	8-01-74	.06
	9-12-74	2.91
	7-29-75	2.84
Mill Creek	8-01-74	2.30
	9-12-74	3.37
	7-29-75	3.05

TABLE 29.--Phytoplankton similarity-index matrix

[Number in parentheses is the number of taxa common to both samples]

REDWOOD CREEK EXCLUSIVE OF ESTUARY SUMMER 1974	Redwood Creek at South Park Boundary	Harry Wier Creek	Miller Creek	Miller Creek at Mouth	Hayes Creek	Lost Man Creek	Little Lost Man Creek at Site No. 2	Redwood Creek at Orick
Redwood Creek at South Park Boundary	-	.33(2)	.54(3)	.54(3)	.50(3)	.75(3)	.46(3)	.43(3)
Harry Wier Creek		-	.46(3)	.62(4)	.57(4)	.40(2)	.67(5)	.38(3)
Miller Creek			-	.67(4)	.62(4)	.67(3)	.71(5)	.67(5)
Miller Creek at Mouth				-	.92(6)	.67(3)	.71(5)	.40(3)
Hayes Creek					-	.60(3)	.67(5)	.38(3)
Lost Man Creek						-	.54(3)	.50(3)
Little Lost Man Creek at Site No. 2							-	.71(6)
Redwood Creek at Orick								-

LATE SUMMER 1974	Redwood Creek at South Park Boundary	Harry Wier Creek	Miller Creek	Miller Creek at Mouth	Lost Man Creek	Little Lost Man Creek at Site No. 2	Redwood Creek at Orick
Redwood Creek at South Park Boundary	-	.24(4)	.42(7)	.21(3)	.49(10)	.43(8)	.63(17)
Harry Wier Creek		-	.50(4)	.50(3)	.50(6)	.60(6)	.32(6)
Miller Creek			-	.67(4)	.50(6)	.70(7)	.27(5)
Miller Creek at Mouth				-	.30(3)	.50(4)	.18(3)
Lost Man Creek					-	.50(7)	.49(11)
Little Lost Man Creek at Site No. 2						-	.49(10)
Redwood Creek at Orick							

SUMMER 1975	Redwood Creek at South Park Boundary	Bridge Creek	Harry Wier Creek	Miller Creek	Miller Creek at Mouth	Lost Man Creek	Little Lost Man Creek at Site No. 2
Redwood Creek at South Park Boundary	-	.29(5)	.38(6)	.43(6)	.58(9)	.53(8)	.64(10)
Bridge Creek		-	.27(4)	.20(3)	.21(3)	.29(4)	.34(5)
Harry Wier Creek			-	.50(6)	.52(7)	.54(7)	.37(5)
Miller Creek				-	.78(9)	.73(8)	.43(5)
Miller Creek at Mouth					-	.87(10)	.62(8)
Lost Man Creek						-	.56(7)
Little Lost Man Creek at Site No. 2							-

TABLE 29.--Phytoplankton similarity-index matrix--Continued

REDWOOD CREEK ESTUARY SUMMER 1974	Redwood Creek Estuary Line 1B	Redwood Creek Estuary Line 2B
Redwood Creek Estuary Line 1B	-	.40(3)
Redwood Creek Estuary Line 2B		-

LATE SUMMER 1974	Redwood Creek Estuary Line 1B	Redwood Creek Estuary Line 2B	Redwood Creek Estuary Line 3B
Redwood Creek Estuary Line 1B	-	.95(9)	.73(8)
Redwood Creek Estuary Line 2B		-	.78(9)
Redwood Creek Estuary Line 3B			-

DRAINAGE BASIN MILL CREEK SUMMER 1974	West Branch Mill Creek below Red Alder Campground	East Fork Mill Creek	Mill Creek
West Branch Mill Creek below Red Alder Campground	-	.44(2)	.53(4)
East Fork Mill Creek		-	.50(3)
Mill Creek			-

LATE SUMMER 1974	West Branch Mill Creek below Red Alder Campground	East Fork Mill Creek	Mill Creek
West Branch Mill Creek below Red Alder Campground	-	.58(9)	.63(10)
East Fork Mill Creek		-	.42(7)
Mill Creek			-

SUMMER 1975	West Branch Mill Creek below Red Alder Campground	East Fork Mill Creek	Mill Creek
West Branch Mill Creek below Red Alder Campground	-	.47(7)	.41(7)
East Fork Mill Creek		-	.71(15)
Mill Creek			-

TABLE 30.--Summary of seston data

Station identification				Seston								
				Weight (mg/L)		Percentage organic	Organic weight			Percentage organic weight		
Number	Name	Date	Time	Total	Organic	weight	Range	x̄	n	Range	x̄	n
11481500	Redwood Creek near Blue Lake	1-12-74	0945	60	3.0	5.0	--	3.0	1	--	5.0	1
		2-21-74	0800	310	7.0	2.3	--	7.0	1	--	2.3	1
		7-18-74	1000	1.3	.2	15	--	.2	1	--	15	1
11482020	Redwood Creek at Redwood Valley Bridge near Blue Lake	7-18-74	1255	1.9	.2	11	--	.2	1	--	11	1
11482120	Redwood Creek above Panther Creek near Orick	7-18-74	1410	1.5	.0	.0	--	.0	1	--	.0	1
11482140	High-Slope Schist Creek near Orick	7-23-74	1145	2.9	1.1	38	--	1.1	1	--	38	1
11482160	Copper Creek near Orick	4-16-74	1400	11	.0	.0	--	.0	1	--	.0	1
11482200	Redwood Creek at South Park Boundary near Orick	11- 8-73	0815	1,700	44	2.6	--	44	1	--	2.6	1
		1-12-74	1230	92	4.5	4.9	--	4.5	1	--	4.9	1
		2-20-74	2100	230	5.0	2.2	5.0-4.0	4.5	2	2.2-1.2	1.7	2
		2-22-74	1200	320	4.0	1.2						
		3- 2-74	1615	290	6.0	2.0	--	6.0	1	--	2.0	1
		7-18-74	2400	.0	.0	.0	--					
		7-19-74	1200	.4	.0	.0	.3-.0	.1	3	38-0	12.7	3
		7-22-74	1230	.8	.3	38						
		9-11-74	1200	3.3	2.2	71	2.2-1.4	1.8	2	82-71	76.5	2
		9-13-74	1300	1.7	1.4	82						
		6- 3-75	1415	15	.5	3.3	.5-.2	.4	2	3.3-2.5	2.9	2
		6- 8-75	1145	8.1	.2	2.5						
11482210	Bridge Creek near Orick	4-26-74	1100	.0	.0	.0	--	.0	1	--	.0	1
		7-23-74	1230	.5	.2	40	--	.2	1	--	40	1
11482220	Redwood Creek above Harry Wier Creek near Orick	2-22-74	1240	200	2.0	1.0	--	2.0	1	--	1.0	1
11482225	Harry Wier Creek near Orick	11- 8-73	0900	150	5.0	3.2	--	5.0	1	--	3.2	1
		1-12-74	1800	120	13	11	13-3.3	8.2	2	16-11	13.5	2
		1-13-74	1235	20	3.3	16						
		2-21-74	0015	13	2.1	16						
		2-21-74	1200	38	3.6	9.6	3.6-.8	2.2	3	16-5.7	10.4	3
		2-22-74	0930	14	.8	5.7						
		3- 3-74	0930	8.4	.0	.0	--	.0	1	--	.0	1
		4-12-74	1530	7.3	.0	.0	--	.0	1	--	.0	1
		7-18-74	2400	.4	.0	.0	--	.0	2	--	.0	2
		7-19-74	1200	.5	.0	.0						
		9-11-74	1200	3.9	1.9	49	1.9-1.4	1.6	2	49-12	30	2
		9-16-74	1330	11	1.4	12						
		11- 7-74	0455	4.4	.4	9.1						
			0555	8.7	.4	4.6						
			0655	18	.8	4.3						
			0755	12	1.2	10						
			0855	8.1	1.7	21						
			0955	29	2.5	8.5						
			1055	90	11	12	11-.0	3.4	15	22-0	10.9	15
			1155	110	9.9	9.0						
			1255	120	7.7	6.6						
			1355	64	5.9	9.3						
			1455	32	3.7	12						
			1655	14	3.2	22						
		11- 7-74	1855	13	2.2	17						
		11- 8-74	0255	4.4	.8	18						
		11- 8-74	0655	.2	.0	.0						
		2- 6-75	1045	20	3.5	17						
		2- 7-75	1615	15	2.3	15						
		2- 8-75	2000	31	3.5	11						
			2100	56	5.9	11						
			2200	61	7.3	12						
			2300	132	9.7	7.4						
		2- 8-75	2400	226	15	6.7	15-.7	5.7	15	17-3.3	9.1	15
		2- 9-75	0100	147	12	8.2						
			0200	104	6.2	6.0						
			0300	69	5.2	7.5						
			0400	52	4.1	7.8						
			0500	50	4.1	8.2						
			0600	40	3.9	9.8						
			0800	27	1.6	6.0						
		2- 9-75	1000	21	.7	3.3						
		6- 1-75	1500	4.4	.3	6.8	.4-.3	.4	2	11-6.8	8.9	2
		6- 7-75	1330	3.6	.4	11						

TABLE 30.--Summary of seston data--Continued

Station identification: Number	Name	Date	Time	Seston Weight (mg/L): Total	Organic	Percentage organic weight	Organic weight: Range	x̄	n	Percentage organic weight: Range	x̄	n
11482230	Tom McDonald Creek near Orick	4-26-74	1335	1.2	.0	.0	--	.0	1	--	.0	1
		7-23-74	1515	.5	.1	20	--	.1	1	--	20	1
1148224	Fortyfour Creek near Orick	5- 8-74	1500	6.0	.0	.0		.0	1	--	.0	1
		7-23-74	1230	4.1	.8	20	--	.8	1	--	20	1
11482250	Miller Creek near Orick	11- 8-73	0530	370	5.0	1.4	--	5.0	1	--	1.4	1
		1-12-74	1450	30	4.0	13	--	4.0	1	--	13	1
		2-21-74	1025	100	6.5	6.4	--	6.5	1	--	6.4	1
		3- 1-74	0930	64	2.2	3.4	--	2.2	1	--	3.4	1
		4-25-74	1100	1.7	.0	.0	--	.0	1	--	.0	1
		7-18-74	2400	3.0	.0	.0	--	.0	2	--	.0	2
		7-19-74	1200	1.6	.0	.0						
		9-11-74	1200	2.2	1.7	77	1.7-.3	1	2	77-25	51	2
		9-17-74	1430	1.2	.3	25						
		5-31-75	1510	6.6	.6	9.1	.6-.5	.6	2	11.-9.1	10	2
		6- 6-75	1530	4.7	.5	11						
11482260	Miller Creek at Mouth near Orick	11- 8-73	0800	520	3.7	.7	--	3.7	1	--	.7	1
		1-13-74	0630	1,400	100	7.0	--	100	1	--	7.0	1
		2-20-74	1930	77	5.6	7.2						
		2-21-74	1050	200	12	5.8	12-.4	6.0	3	7.2-1.5	4.8	3
		2-22-74	1030	27	.4	1.5						
		3- 1-74	1030	120	7.9	6.3	--	7.9	1	--	6.3	1
		4-11-74	1600	13	.0	.0	--	.0	1	--	.0	1
		7-18-74	2400	2.0	.0	.0						
		7-19-74	1200	2.0	.1	5.0	.4-.0	.2	3	10-.0	5.0	3
		7-24-74	1030	4.0	.4	10						
		9-11-74	1300	2.1	1.2	57	1.2-.5	.8	2	57-28	42	2
		9-17-74	1200	1.8	.5	28						
		5-31-75	1150	2.7	.0	.0	.3-.0	.2	2	12-.0	6.0	2
		6- 6-75	1300	2.4	.3	12						
11482270	Bond Creek near Orick	5- 8-74	1615	4.4	.0	.0	--	.0	1	--	.0	1
11482300	Elam Creek near Orick	5 -9-74	1310	.8	.8	100	--	.8	1	--	100	1
11482310	McArthur Creek near Orick	5- 9-74	1400	2.8	.4	14	--	.4	1	--	14	1
11482320	Low-Slope Schist Creek near Orick	5-10-74	0930	1.2	.0	.0	--	.0	1	--	.0	1
11482330	Hayes Creek near Orick	11- 9-73	1155	92	.0	.0	--	.0	1	--	.0	1
		1-13-74	1300	3.3	.6	18	--	.6	1	--	18	1
		2-21-74	1845	11	.0	.0	--	.0	1	--	.0	1
		3- 2-74	1600	15	.4	2.6	--	.4	1	--	2.6	1
		4- 9-74	1330	24	.0	.0	--	.0	1	--	.0	1
		7-19-74	1150	1.3	.4	31	.4-.0	.2	2	31-0	15.5	2
		7-27-74	1430	.4	.0	.0						
11482450	Lost Man Creek near Orick	11- 8-73	0730	160	.0	.0	--	.0	1	--	.0	1
		1-13-74	0930	20	2.0	9.8	--	2.0	1	--	9.8	1
		2-21-74	1500	50	3.1	6.1	--	3.1	1	--	6.1	1
		3- 2-74	1000	26	1.6	6.2	--	1.6	1	--	6.2	1
		4- 8-74	1330	8.0	.0	.0	--	.0	1	--	.0	1
		7-18-74	2400	2.4	.0	.0						
		7-19-74	1230	.8	.0	.0	--	.0	3	--	.0	3
		7-22-74	1330	.8	.0	.0						
		9-11-74	1200	1.7	1.4	82	1.4-.8	1.1	2	89-82	86	2
		9-15-74	1100	.9	.8	89						
		6- 2-75	1130	2.2	.7	32	.7-.1	.4	2	32-7.7	19.8	2
		6- 8-75	1200	1.3	.1	7.7						
11482460	Larry Damm Creek near Orick	4- 8-74	1515	7.5	.0	.0	--	.0	1	--	.0	1
		7-27-74	1030	2.1	.4	19	--	.4	1	--	19	1
11482468	Little Lost Man Creek at Site #2 near Orick	7-18-74	2400	1.2	.2	17						
		7-19-74	1200	.6	.1	17	.2-.1	.2	3	33-17	22	3
		7-22-74	1300	.6	.2	33						
		9-11-74	1200	1.4	1.3	93	1.3-.2	.8	2	93-50	72	
		9-15-74	1400	.4	.2	50						
		11- 7-74	0535	3.5	2.4	69						
			0635	4.6	2.7	59						
			0735	4.5	.9	20						
			0835	3.2	1.4	44						
			0935	3.5	.8	23						
			1100	7.2	1.3	18						
			1200	4.1	1.2	29	3.0-.0	1.2	14	91-.0	36	14
			1300	2.4	1.2	50						
			1400	3.0	1.4	47						
			1530	1.7	.9	53						
			1730	.7	.0	.0						
			1900	3.3	3.0	91						
		11- 7-74	2100	.0	.0	.0						
		11- 8-74	0910	.0	.0	.0						

TABLE 30.--Summary of seston data--Continued

Station identification: Number	Station identification: Name	Date	Time	Seston: Weight (mg/L): Total	Weight (mg/L): Organic	Percentage organic weight	Organic weight: Range	Organic weight: x̄	Organic weight: n	Percentage organic weight: Range	Percentage organic weight: x̄	Percentage organic weight: n
		2- 5-75	1400	9.8	.7	7.1						
		2- 6-75	1330	8.3	.8	9.6						
		2- 6-75	1410	7.6	1.4	18						
		2- 6-75	2040	.8	.0	.0						
		2- 8-75	2000	7.8	3.0	38						
		2- 8-75	2300	14	2.3	16						
		2- 9-75	0110	20	3.5	17	3.5-.0	.2	13	39-.0	19	13
			0200	24	2.7	11						
			0300	18	2.9	16						
			0500	10	2.3	23						
			0700	9.5	2.3	24						
			0930	8.9	2.3	26						
		2- 9-75	1215	5.7	2.2	39						
		6- 2-75	1415	.8	.2	25	.2-.1	.2	2	25-12	18	2
		6- 8-75	1400	.8	.1	12						
11482470	Little Lost Man Creek near Orick	11- 9-73	1135	9.7	4.2	43	--	4.2	1	--	43	1
		1-13-74	1210	6.0	.0	.0	--	.0	1	--	.0	1
		2-20-74	2330	10	.0	.0						
		2-21-74	1100	8.0	.4	5.0	.8-.0	.4	3	13-.0	6.0	3
		2-22-74	1000	6.2	.8	13						
		3- 2-74	1500	7.8	.8	10	--	.8		--	10	1
		4- 9-74	1020	23	.8	3.5	--	.8		--	3.5	1
11482475	Geneva Creek near Orick	11- 9-73	1145	7.2	2.0	28	--	2.0	1	--	28	1
		1-13-74	1030	13	1.6	13	--	1.6	1	--	13	1
		2-21-74	1220	9.4	.6	6.4	--	.6	1	--	6.4	1
		3- 2-74	1715	3.8	.0	.0	--	.0	1	--	.0	1
		4- 9-74	0850	4.4	3.2	73	--	3.2	1	--	73	1
11482480	Berry Glen Creek near Orick	4-25-74	1245	7.9	1.7	22	--	1.7	1	--	22	1
11482500	Redwood Creek at Orick	1-13-74	1250	250	13	5.3	--	13	1	--	5.3	1
		2-21-74	1300	430	14	3.3	--	14	1	--	3.3	1
		7-18-74	2400	3.0	.5	17						
		7-19-74	1200	1.9	.4	21	.5-.3	.4	3	21-17	18	3
		7-24-74	1400	1.8	.3	17						
		9-11-74	1200	3.3	2.9	88	2.9-.6	1.8	2	88-50	69	2
		9-17-74	1645	1.2	.6	50						
4117341-24051302	Redwood Creek Estuary Site 1B near Orick	7-25-74	1800	1.5	.4	27	--	.4	1	--	27	1
		9-20-74	1615	1.6	.9	56	--	.9	1	--	56	1
		5-26-75	0650	17	.9	5.2	--	.9	1	--	5.2	1
		6- 2-75	1630	16	.8	5.0	.8-.4	.6	2	6.1-5.0	5.6	2
		6- 8-75	1730	6.6	.4	6.1						
4117341-24051802	Redwood Creek Estuary Site 2B near Orick	7-25-74	1845	2.5	.4	16	--	.4	1	--	16	1
		9-20-74	1615	1.0	.8	80	--	.8	1	--	80	1
		5-26-75	0755	16	.7	4.5	--	.7	1	--	4.5	1
4117321-24051802	Redwood Creek Estuary Site 3B near Orick	9-20-74	1620	1.3	.6	46	--	.6	1	--	46	1
		5-26-75	0835	11	.5	4.5	--	.5	1	--	4.5	1
11532602	West Branch Mill Creek below Red Alder Campground near Crescent City	8- 1-74	1200	.3	.1	33	--	.1	1	--	33	1
		9-12-74	1415	1.2	1.2	100	1.2-.2	.3	2	100-50	75	2
		9-23-74	1445	.4	.2	50	--					
		6- 5-75	1530	.6	.2	33	--	.2	1	--	33	1
11532610	East Fork Mill Creek near Crescent City	8- 1-74	1200	1.3	.3	23	--	.3	1	--	23	1
		9-12-74	1330	1.8	1.6	89	1.6-.3	1.0	2	89-50	70	2
		9-23-74	1300	.6	.3	50						
		6- 5-75	1315	.6	.2	33	--	.2	1	--	33	1
11532620	Mill Creek near Crescent City	8- 1-75	1200	.5	.1	20	--	.1	1	--	20	1
		9-12-74	1200	1.7	1.4	82	1.4-.3	.8	2	82-60	71	2
		9-23-74	1100	.5	.3	60						
		6- 5-74	1115	.8	.2	25	--	.2	1	--	25	1
11532630	Mill Creek at Mouth near Crescent City	8- 1-74	1220	.3	.0	.0	--	.0	1	--	.0	1

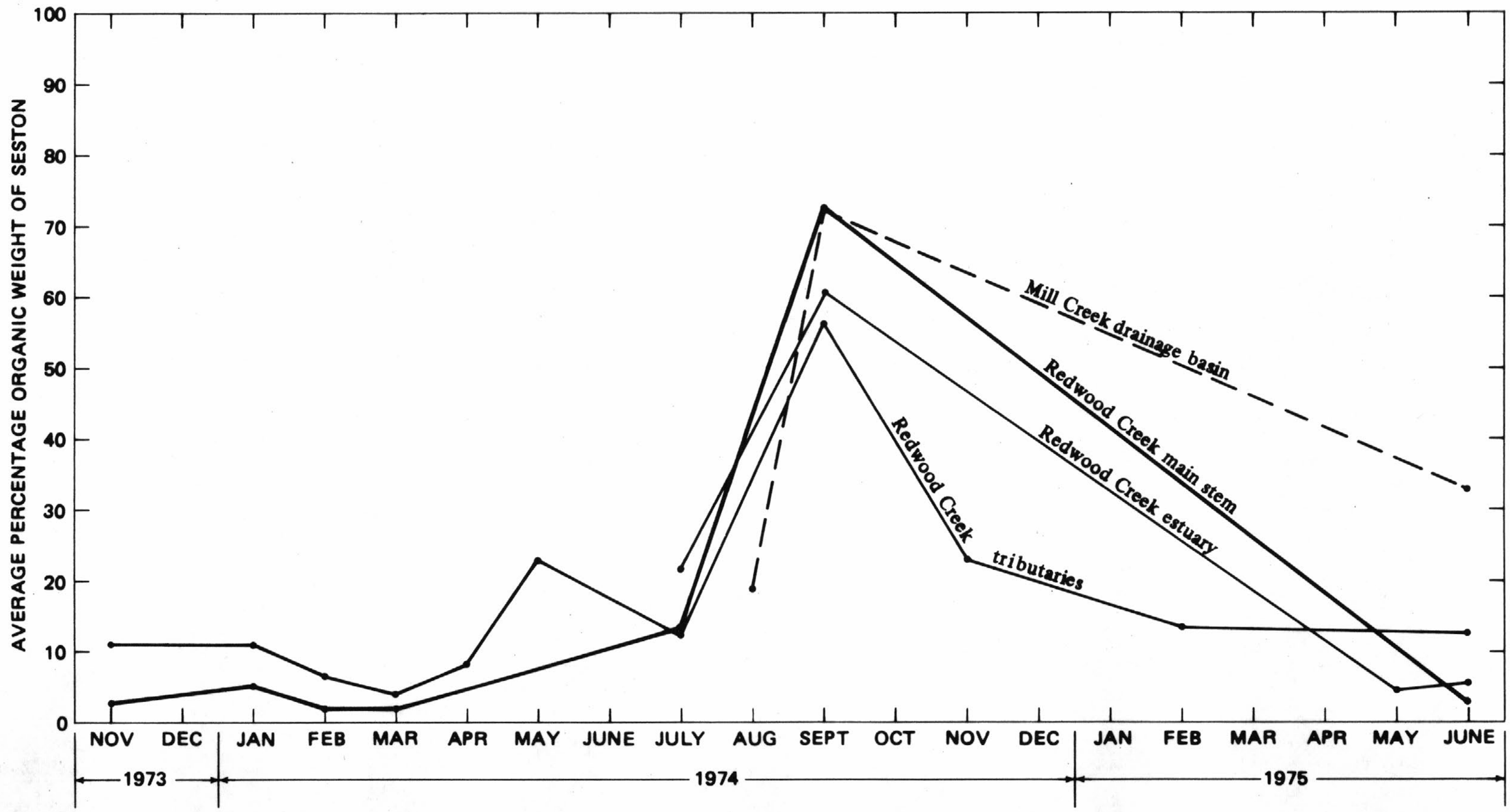


FIGURE 8.--Monthly mean percentage organic weight of seston.

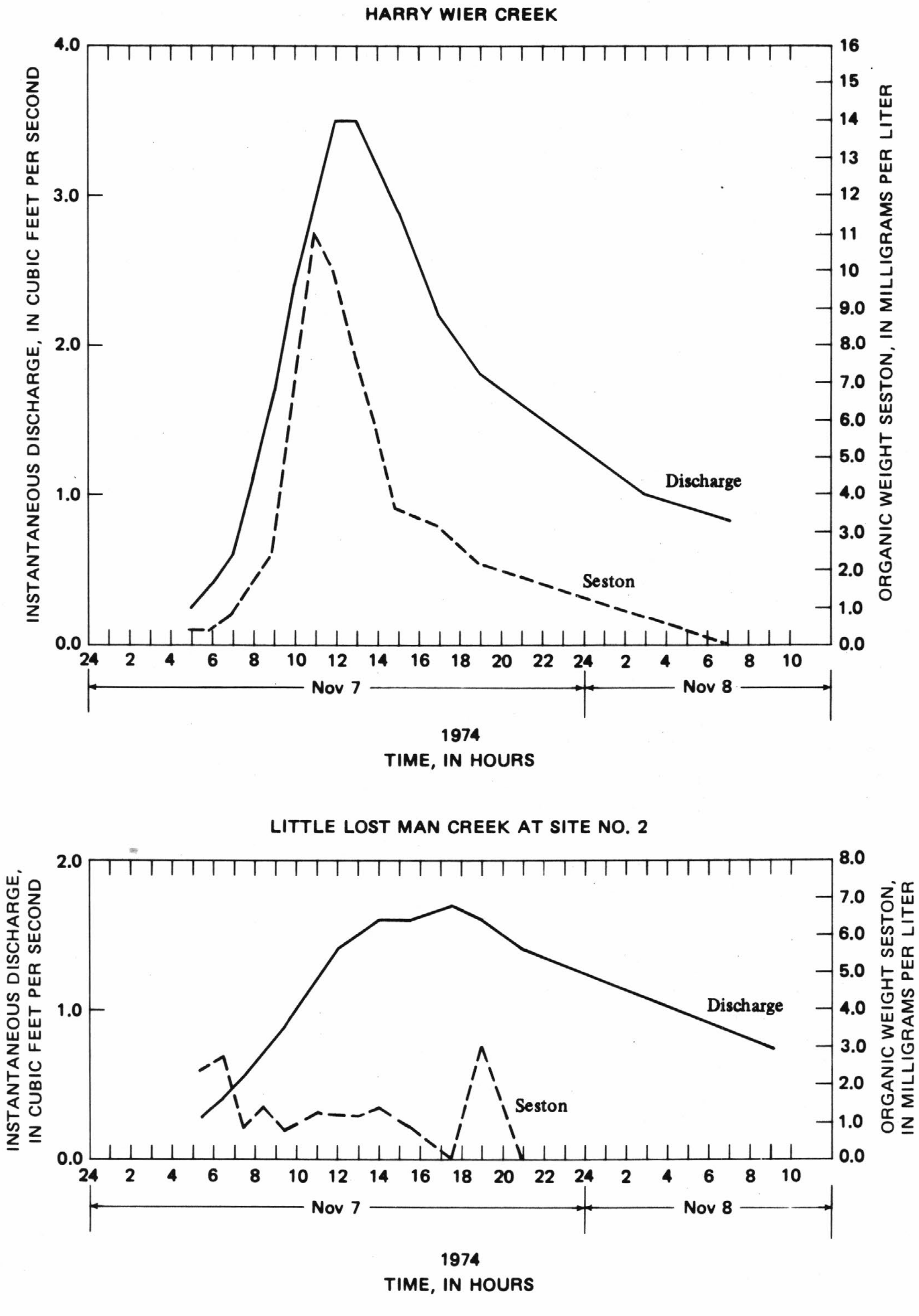
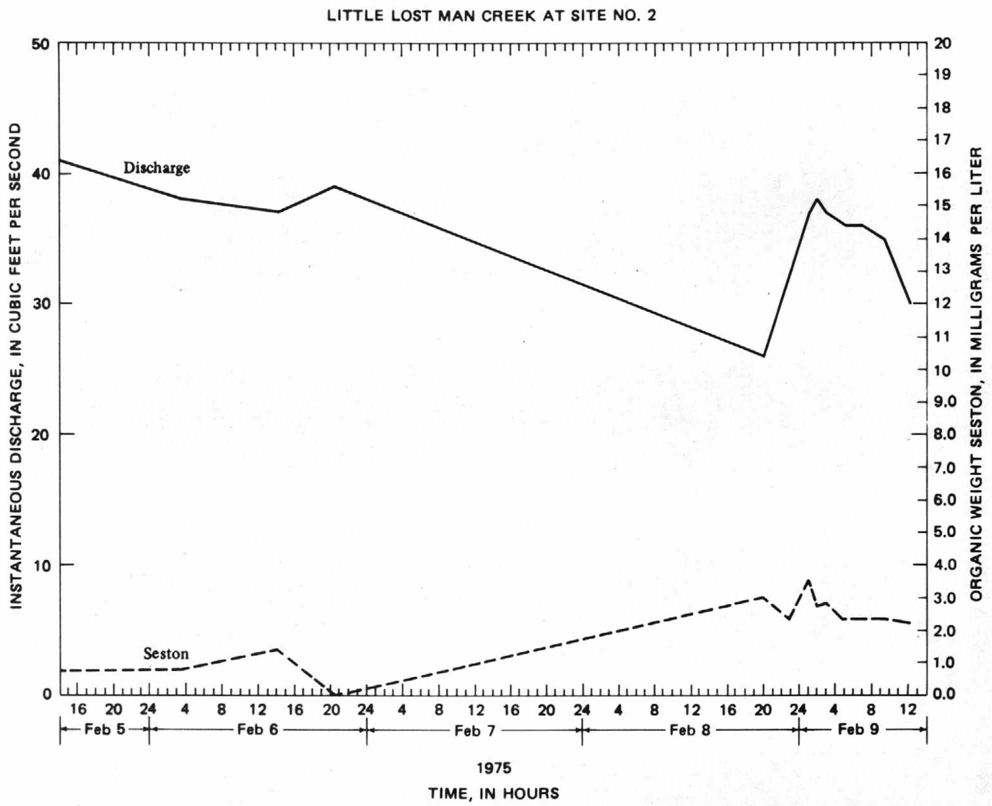


FIGURE 9.--Instantaneous discharges and organic seston concentrations from Harry Wier Creek and Little Lost Man Creek at Site No. 2 during the November 6-8, 1974, storm.



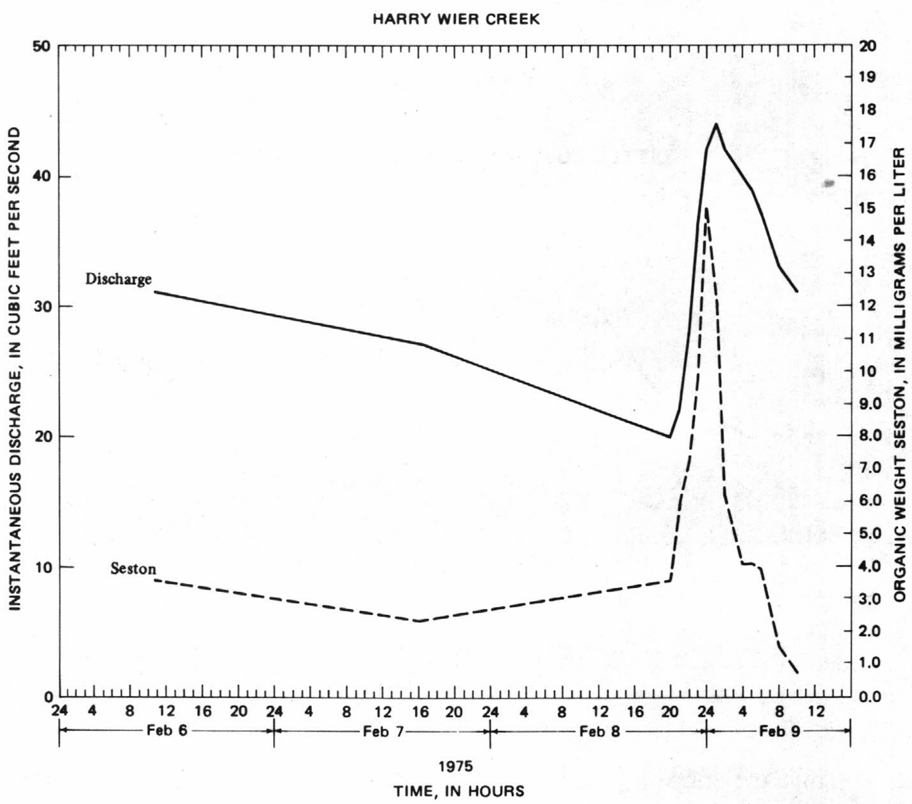


FIGURE 10.--Instantaneous discharges and organic seston concentrations from Harry Wier Creek and Little Lost Man Creek at Site No. 2 during the February 5-9, 1975, storm.

DISCUSSIONS AND CONCLUSIONS

Aquatic biota have long been used to assess the quality of water resulting from natural and man-caused activities (Hynes, 1960, 1964, and 1970). Some forms of biota, such as coliform bacteria, are indicators of direct waste contamination by man and other animals, whereas biota such as benthic invertebrates and fish may act as long-term integrators of environmental changes. Periphyton, phytoplankton, and seston often can be used as short-term indicators of aquatic enrichment; they respond rapidly to the enrichment of water by organic waste material and attendant plant nutrients, such as nitrogen and phosphorus.

In this study of the aquatic biota of the Redwood Creek and Mill Creek basins, the types of organisms inhabiting the streams were identified and an attempt was made to relate these organisms and specific characteristics, such as taxonomic composition, abundance, and ecological roles, to land-use practices in the basins. Both the Redwood Creek and Mill Creek basins have received little attention from the standpoint of aquatic biological studies. In addition, there is little biological information in the literature on other streams in northwestern California. The available information is primarily descriptive and provides little quantitative insight to the status of the aquatic community. Therefore, the study had to be designed and started without an idea of what to expect in the way of sampling difficulty, seasonal variation in organism abundance, and taxonomic composition and with little knowledge of the physical and chemical factors that control the abundance and distribution of aquatic biota in the two basins. Since 1973, however, the Redwood Creek and Mill Creek basins have been under intensive study with respect to their physical, chemical, and aquatic biological features. This report provides information that can be considered in the management of Redwood National Park resources and provides guidance for additional studies on specific aspects of the aquatic ecosystems in northwestern California. Although the findings of the study were presented in the results section of this report, a discussion of these findings, including their significance and limitations, follows.

Coliform bacteria densities in the Redwood Creek and Mill Creek basins indicated that fecal contamination is at a low level overall and is of little concern from a water-quality standpoint. Exceptions were Prairie Creek, where several potential sources of bacterial contamination may exist. With the exception of Prairie Creek, additional sampling for coliform bacteria densities is not necessary at this time.

The benthic-invertebrate assessments received the most emphasis in this study because of their importance as long-term integrators and indicators of water-quality changes. A number of factors affect the occurrence and abundance of benthic invertebrates, and some factors include: water velocity, insolation, water temperature, dissolved substances, the presence of algal and other vegetational types, competition between and within benthic-invertebrate species, and, in particular, the streambed material size, type, and stability (Hynes, 1970). In the Redwood Creek and Mill Creek basins, insolation, water temperatures, algal production, and streambed material size, type, and stability appeared to be the influencing factors related to distribution and abundance of benthic invertebrates.

Because of the diverse habitat types and the relatively large size of the Redwood Creek basin, a quantitative assessment of the benthic-invertebrate community was difficult to make. The findings of this study can be used to describe trend changes in numbers of benthic invertebrates along the main-stem channel and tributaries and are particularly useful in illustrating seasonal variability in benthic-invertebrate numbers and taxonomic composition. The findings also provide some insight in assessing the changes in numbers of benthic invertebrates collected from streams having different land-use histories.

Benthic-invertebrate samples collected during spring 1974 and 1975 sampling from Redwood Creek main stem (estuary excluded) showed a slight downstream increase in densities. Although variable, this increase in benthic-invertebrate density seemed to be related to streambed material size, type, and stability. The abundance of benthic invertebrates appeared to decrease as the size of streambed sediments decreased. Field observations made at the time of sampling indicated the presence of fine sediment in the streambed to be greater at the upstream sampling stations than at the downstream stations.

The autumn 1974 and 1975 samples showed a general decreasing trend in benthic-invertebrate densities in a downstream direction along Redwood Creek main stem (estuary excluded). Streambed material size, type, and stability again appeared to be related to the density of the benthic invertebrates. Field observations made at the time of sampling indicated that the amount of fine sediment in the streambed increased downstream. However, increases in insolation, water temperature, and the abundance and type of periphyton probably were additional factors related to benthic-invertebrate densities, especially in the upper reaches of Redwood Creek where the climate is not greatly influenced by the Pacific Ocean.

Changes in the benthic-invertebrate densities in the Redwood Creek basin between spring and autumn were striking. Spring samples, at most stations, contained lower numbers of benthic invertebrates than autumn samples. Seasonal density differences frequently were of several orders of magnitude. The reason for the lower density of benthic invertebrates during the spring, relative to autumn, probably was the result of the washout of benthic invertebrates during high winter streamflows, regardless of drainage basin land-use history. Washout of invertebrates is common, considering that the Redwood Creek basin, along with other north-coastal streams in California, is subjected to frequent storms with occasional high-intensity rainfall. These storms often result in high streamflows which cause extensive alteration (degradation and aggradation) of streambeds during the winter (Nolan, and others, 1976b). Periods of high streamflows have often been observed to reduce the invertebrate fauna in streams (Hynes, 1970). This phenomenon was observed following the October 23, 1973, storm when the number of benthic invertebrates in Redwood Creek tributaries was drastically reduced. Following the major storm of March 15, 1975, Redwood Creek channel had been greatly altered and the number of benthic invertebrates in the samples again was reduced.

Most noteworthy was the finding that, following the March 15, 1975, storm, the benthic-invertebrate densities in the autumn samples of 1975 were nearly as high as in the autumn 1974 samples. Although the March storm altered the stream channels in the Redwood Creek basin and reduced the number of benthic invertebrates in the spring, the autumn samples indicated that there were no long-lasting effects. Benthic invertebrates demonstrated the ability to recolonize the streambed after a major storm, provided there is a period of low-flow stability (nondisruption or sedimentation) of the streambed which allows recolonization.

Man-caused disruption of the streambed during the low-flow period can result in a drastic reduction of the benthic-invertebrate community. This was shown by spring and autumn 1975 Bridge Creek samples in which benthic-invertebrate densities decreased as a result of sediment input to the creek during the removal of logging debris upstream from the sampling station.

An explanation of the distributional patterns of the benthic-invertebrate community in Redwood Creek estuary is difficult because of the dynamic physical and chemical properties of the estuarine system and the small number of benthic-invertebrate samples collected. The higher density of benthic invertebrates found in the original Redwood Creek channel during the spring of 1974 may have been related to streamflow. The original Redwood Creek channel is not subjected to flood discharges as is the channelized part; therefore, the number of benthic invertebrates washed out during the winter may have been reduced.

Also, saltwater intrusion may have affected the benthic-invertebrate densities in the estuary. During spring 1974 sampling, the mouth of Redwood Creek estuary was open to the Pacific Ocean. However, the discharge from Redwood Creek was sufficient to prevent saltwater intrusion into the estuary. During the autumn sampling, an emergent sandbar closed the mouth of Redwood Creek estuary to the Pacific Ocean. The discharge of Redwood Creek was low and could not prevent the intrusion of saltwater through the sandbar into the estuary, especially during high-tide periods. During the autumn sampling, the benthic-invertebrate density in the channelized part of Redwood Creek was higher than in the original creek channel and appeared to be related to salinity. Salinity and water depths were greater in the channelized part of Redwood Creek than in the original Redwood Creek channel and, thus, provided a more favorable habitat for the saltwater-tolerant benthic invertebrates which dominated the samples. In addition to salinity, the continual input of organic material and nutrients from upstream reaches of Redwood Creek, during low-flow periods, provides a food supply which may have supported the larger benthic-invertebrate population in the channelized part of Redwood Creek than in the original creek channel.

In the Mill Creek basin, the streambed material size, type, and stability seemingly were not sufficiently different between stations to influence spatial variations of benthic-invertebrate densities. Little or no fine sediment was observed in the streambed at the sampling stations in the drainage basin. Algal production, however, was high at West Branch Mill Creek below Red Alder Campground sampling station and probably influenced the abundance of benthic invertebrates. Influences of the campground and related visitor activities on algal and benthic-invertebrate production cannot be determined on the basis of the limited quantity of data collected. However, chemical-quality data showed higher median concentrations of nitrogen at West Branch Mill Creek below Red Alder Campground than at the other sampling stations in the Mill Creek basin (Bradford and Iwatsubo, 1978). Benthic-invertebrate densities of East Fork Mill Creek sampling station were consistently lower than the other sampling stations in the drainage basin and increased only slightly between the spring and autumn sampling. Algal production appeared to be limited in East Fork Mill Creek due to lack of insolation, and this may have been a factor in reduced benthic-invertebrate production. Logging activities have been more extensive in this part of the drainage basin; however, without further investigations, no assessment can be made of the effect of logging activities on the aquatic biota.

The functional group concept of Cummins (1973 and 1974) was applied to the samples of benthic invertebrates collected from the Redwood Creek and Mill Creek basins. This concept is still in its infancy and suffers from a lack of knowledge of the specific roles that particular organisms undertake in the aquatic environment. Nevertheless, the functional group concept is ecologically sound and is based on the feeding mechanisms of the organisms and the concept that the dominant sources of energy or nutrient input to a stream are derived from two sources: (1) allochthonous material, which is organic material that is carried into the streams from an outside source (primarily leaves and litter from terrestrial vegetation); and (2) autochthonous material, which is organic material that is produced within the stream (primary production of algae and aquatic plants). The source of energy input to a stream can determine, to a great extent, the dominant functional groups of benthic invertebrates that can live in the stream. Streams that receive large quantities of allochthonous material generally are small cold-water streams (first- to third-order streams) with dense canopies of riparian vegetation that limit insolation and consequently the production of algae and aquatic plants. These streams can be expected to contain large populations of shredder benthic invertebrates, which convert CPOM to FPOM, and collector benthic invertebrates, which feed on the detritus that results from the activities of the shredders.

Streams with more autochthonous material generally are medium in size (fourth- to sixth-order streams) with higher water temperatures and a lesser amount of canopy-forming riparian vegetation. In these streams, algal and aquatic plant production is no longer limited by insolation and, as a result, large populations of grazer benthic invertebrates frequently are found. Collector benthic invertebrates are also present in large densities and feed on available detritus. Predatory benthic-invertebrate densities remain relatively constant in streams that derive energy from both allochthonous and autochthonous material (Cummins, 1974).

Although most of the major benthic-invertebrate functional groups given by Cummins (1973 and 1974) were present in the Redwood Creek and Mill Creek basins, the low percentages and occurrences of the shredders is of some ecological concern. Cummins (1974) discussed the importance of the shredder functional group in reducing CPOM to FPOM, especially in the low-order streams that depend upon allochthonous material as an energy source. No explanation can be given, using the available data, for the low percentages of the shredders in both drainage basins. However, shredders may have been more abundant in the upstream reaches of the drainage basins in first- and possibly second-order streams of the drainage basins that were not sampled.

In addition to shredders, the number of grazers collected at the Redwood Creek basin stations was lower than expected. Low algal production in the basin may explain, in part, the low number of grazers; however, the difficulty in defining and categorizing grazers as a functional group also is an important consideration. Scraping is the mode of feeding by grazers, and often the diet of grazers includes the nonselective ingestion of detrital material. Therefore, making a distinction between grazers and collectors is difficult. Grazers also can change their functional role, depending on the habitat in which they live. In forest areas, grazers may function as shredders, whereas in large open streams they function as grazers (James Sedell, oral commun., March 1976).

Overall, the collector functional group was dominant in both the Redwood Creek and Mill Creek basins. No clear reason can be given for this finding, but the greater abundance of collectors in the lower reaches of Redwood Creek main stem probably can be attributed to an increase in food supply (FPOM) in the downstream direction. Streambed material size and type, and the possibility that many of the collectors may have washed down from upstream reaches, especially from the tributaries, must be considered. The availability of FPOM and the stability of streambeds in Redwood Creek tributaries and the Mill Creek basin probably influenced the dominance of the collector functional group in these streams.

Diversity and similarity indexes were calculated for the benthic-invertebrate samples to provide information on community structure variability and to compare sample composition. The values from these calculations were variable, but not unlike that expected in streams that undergo somewhat regular dislodgment of streambed materials by floods. Field observations indicated that the common factor in the Redwood Creek basin that related to either the diversity- or similarity-index values was the type of streambed material at a particular sampling station.

Diversity- and similarity-index values were most variable in those tributaries being logged, or where man's activities were greatest. Bridge Creek, during autumn 1975, had the lowest diversity-index value. Prior to sample collection, logging debris upstream from the Bridge Creek sampling station was removed from the stream channel. This activity resulted in the deposition of fine sediment downstream and the reduction in benthic-invertebrate density and diversity. The similarity-index values, when comparing autumn 1975 samples from Bridge Creek to the other sampling stations, were all low. These low values, again, were related to the reduction of benthic invertebrates caused by the deposition of sediment during the removal of logging debris upstream.

Nonparametric statistical tests revealed a significant difference ($\alpha<0.01$) between the mean diversity- and similarity-index values of being logged and control tributary basins in the Redwood Creek basin. There was, however, no significant difference ($\alpha>0.05$) in the mean diversity- and similarity-index values between control tributaries and regenerating tributary basins, or between regenerating and logged tributary basins.

Fish are important inhabitants of the Redwood Creek and Mill Creek basins. Both anadromous and resident species are found in the two basins. In this study no attempt was made to sample adult salmonids on their upstream spawning migration from the sea. The species composition of juvenile anadromous and juvenile and adult resident fish was determined in Redwood Creek and Mill Creek drainages during low-flow periods. While no population estimates were made, data relative to the growth and condition factor of steelhead trout and some coho and chinook salmon captured from the Redwood Creek basin were collected.

The fish survey of the Redwood Creek basin showed a change in the proportions of species between 1974 and 1975. Steelhead trout increased in number while other species decreased. This shift in species composition is not alarming. Natural variations in fish populations are large in the north-coastal streams of California. Salmonid populations alone can vary as much as 50 percent from year to year and perhaps even higher (Burns, 1971). Siltation of spawning beds is the principal factor in determining the spawning success (survival rate from egg deposition to fry emergence) of salmonids. Streamflow is another important factor and can influence both the quality and quantity of habitat available to fish. Other factors that have an influence on controlling fish populations include water temperature, dissolved-oxygen concentrations, availability of food, disease, predation, and interspecies and intraspecies competition. In addition, Chapman (1962) showed that during abnormally high streamflows, gravel shifting may cause scour or burial of developing salmonid embryos. Slight shifting or rotating of salmonid embryos during the "tender period" can cause mortality (Leitritz, 1959). Sheridan and McNeil (1960) recorded a salmon embryo mortality of 95 percent as a result of the movement of spawning gravel. Direct burial of salmonid embryos can prevent fry emergence by blocking the route of egress. Siltation of spawning gravels can restrict the interchange of surface and intragravel water, reducing the supply of dissolved oxygen to and the removal of metabolic wastes from developing salmonid embryos (Phillips, 1970, and Cordone and Kelly, 1961).

The condition factors for steelhead trout captured from the Redwood Creek basin were quite variable. Nonparametric statistical tests revealed that condition factors of steelhead trout were significantly larger ($\alpha<0.05$) at sampling stations with more insolation (greater algal and invertebrate production), regardless of drainage basin land-use history.

The length-weight relations for steelhead trout captured from the Redwood Creek basin revealed that steelhead trout from the main stem were stouter than the trout captured from the tributaries. Productivity in the main stem at the time of sampling was greater than in the tributaries because of higher insolation.

Seasonal influences may have caused the change in growth of steelhead trout during the study. On a small coastal stream in California, Shapovalov and Taft (1954) observed that feeding activities diminished and growth rates of steelhead trout decreased during late summer, in association with the periods of maximum stream temperatures and minimum streamflow.

The influence of the March 18, 1975, flood on the growth rate of steelhead trout is not known. Extensive gravel shifting during the flood may have removed periphyton and benthic invertebrates by grinding and dislodgment, or by direct burial. A decrease in the availability of food (biomass) could easily retard the growth of fish.

Periphyton was collected from artificial substrates made of clear acrylic strips. This method of collection frequently is used and has the advantage of providing a uniform substrate at each sampling station for periphyton colonization (Slack and others, 1973). The use of artificial substrates may prevent a complete taxonomic assessment of periphyton types in the stream system by limiting colonization.

Diatoms were the most abundant periphytic algae in both the Redwood Creek and Mill Creek basins, whereas the occurrence and abundance of green algae were of little significance. According to Hynes (1970), diatoms usually dominate the species list of attached algae and, in stony streams and rivers, are the most abundant. The dominance of diatoms in the periphyton community may have been due to low insolation, as diatoms can occur as abundantly in shaded areas as in areas exposed to the sun. The dominant forms of diatoms that occurred in the periphyton samples are not only classified among the group of organisms that are first to colonize newly exposed surfaces but are species that commonly occur during the winter when light intensity and temperature are low (Hutchinson, 1975, and Hynes, 1970). These conditions occurred at the majority of the sampling stations. Green algae, unlike diatoms, require high light intensity; therefore, their abundance may have been limited by lack of insolation. Also, certain diatoms are the first to colonize newly exposed surfaces and have a competitive edge over green algae and other periphyton groups for space. Although the most numerous green algae sampled during the study period are on the list of 60 pollution-tolerant genera of algae (Palmer, 1969), the relative abundance of these algae was low and their presence does not reflect organic pollution. Gaufin and Tarzwell (1952), Patrick (1949 and 1962), and Warren (1971) have shown that organisms occurring in large numbers in organically enriched streams also occur in limited numbers in nonenriched streams and concluded that the occurrence of all organisms and their relative abundance must be considered before using them as indicators of organic enrichment of streams.

Periphyton rates of accrual were low overall in the Redwood Creek and Mill Creek basins. Much of this can be attributed to lack of insolation because of the somewhat dense forest canopy. The samples at the Miller Creek at Mouth station in the summer of 1974 contained a relatively high accrual of organic matter, but much of this was attributed to organic particulate matter settling on the artificial substrates, rather than periphyton production. The input of this organic particulate matter probably was the result of the bridge construction upstream from the sampling station.

Diversity-index values for periphyton were relatively low. This again was attributed to low insolation. For example, in Hayes Creek, a virtually closed-canopy system, the periphyton community consisted almost entirely of one species of diatom, Achnanthes lanceolata. This diatom is usually the first to colonize bare substrata (Geither, 1927, cited in Hynes, 1970, and McIntyre, 1966). The highest diversity-index value was calculated from samples collected at Bridge Creek, a stream whose drainage basin was being extensively logged during the study. Increased insolation probably provided for a greater variety of periphyton on the artificial substrates placed in Bridge Creek.

Similarity-index values were extremely variable for the periphyton samples collected from the Redwood Creek and Mill Creek basins. Differences in periphyton communities could not be related directly to the land-use activities of the streams sampled. Low productivity of periphyton due to the lack of insolation was the major factor influencing the periphyton community structure.

The presence of phytoplankton in a stream system is closely allied to the production of periphyton because many stream-type phytoplankton are actually detached periphytic algae. In the the Redwood Creek and Mill Creek basins the sampled phytoplankton community was dominated by detached periphytic diatoms. The phytoplankton community in Redwood Creek estuary, however, was dominated by true planktonic forms.

Phytoplankton diversity indexes of the the Redwood Creek and Mill Creek were low and probably typify the phytoplankton community of a low-productive northern California coastal stream. Diversity-index values were higher in the streams that received the greatest amount of insolation.

As with periphyton, the phytoplankton similarity-index values revealed wide variations in community structure between sampling stations. The variability of the phytoplankton communities could not be related to the differences in land-use history of the drainage basins sampled.

This study has defined the phytoplankton community in the Redwood and Mill Creek basins as it existed from 1973 to 1975. As the forest canopy is opened by additional logging, or closed by regeneration of logged areas, the phytoplankton (and periphyton) community will change.

The percentage of organic weight of seston from the Redwood Creek and Mill Creek basins was highly variable, but definitely increased as biological productivity increased in the summer. Much of the summer organic seston was detached periphyton and phytoplankton, especially in Redwood Creek estuary. As autumn approached, leaves, fragments from riparian vegetation, and decaying algae became major parts of the organic seston.

Organic seston concentrations during the winter were clearly related to stream discharge in both the Redwood and Mill Creek basins. Hobbie and Likens (1973), Bormann and others (1974), and Brinson (1976) have noted similar relations between increases in discharge and increases in particulate organic matter (organic debris). Peak discharges associated with overland flow of currently logged drainage basins, as described by Bradford and Iwatsubo (1978), would account for the larger concentrations of organic seston being flushed from the basins during storms. Overland flow is water which does not enter the soil but moves directly downgradient and has the ability to transport large quantities of particulate matter. Similar results in the Redwood Creek basin also revealed smaller organic seston concentrations being flushed from the Little Lost Man Creek basin (control basin) relative to the Harry Wier Creek basin (logged basin). Bradford and Iwatsubo (1978) suggested that quick-return flow was the more important part of peak discharge in an unlogged drainage basin, except during intensive rainfall periods when significant quantities of overland flow would occur. Quick-return flow is water which enters the soil, re-emerges in an extremely short period of time, and has less ability than water of overland flow to transport particulate matter because of energy dissipation during contact time with soil and vegetation.

The study of seston has established a base for future investigations and comparisons of seston concentrations, particularly of the Redwood Creek basin. Because of land-use changes and other activities, a time study of seston sources and concentrations could be started.

FUTURE MONITORING PROGRAMS

As a result of the assessment of the aquatic organisms in the Redwood Creek and Mill Creek basins, the following components might be included in future monitoring programs:

1. The high fecal coliform and fecal streptococcal bacteria colony counts in Prairie Creek could be verified with sampling conducted during the low-flow period that coincides with the tourist season.

2. Unless there is an increase in human population, additional bacterial sampling in other areas of the Redwood Creek and Mill Creek basins is unnecessary.

3. Benthic-invertebrate taxa and density fluctuations have been delineated and the functional groups described. Semiannual (spring and fall) sampling of benthic invertebrates is unnecessary in the immediate future. The establishment of benthic-invertebrate index stations would be required to monitor time-trend changes in the benthic-invertebrate community. Along Redwood Creek main stem, 4 to 6 index stations could be established; whereas along Redwood Creek tributaries, 3 to 6 index stations could be established. These index stations could be selected from the stations sampled during this study so that changes in the benthic-invertebrate community can be monitored. At each index station, 10 Surber samples could be collected each autumn prior to the first storm. Size composition of the streambed material could be determined at each index station and related to benthic-invertebrate density and taxonomic composition. The actual areas or sampling sites at each station could be randomly selected. Sampling for benthic invertebrates in the Mill Creek basin is unnecessary unless land use changes.

4. Because of the importance of fish in the stream ecosystems and their importance as a Park resource, some annual assessments of population estimates, emergence success, species composition, and length-weight relations could be considered. These parameters could be evaluated by sampling several established index stations along Redwood Creek main stem and tributaries. Sampling could occur each spring before the major downstream migration of anadromous salmonids takes place. Adult salmon and steelhead trout moving into Redwood Creek also could be enumerated. Observations made during the study indicate that a weir trap installed in the lower reaches of Redwood Creek and operated each autumn is the most feasible way to determine the use of Redwood Creek by anadromous salmonids. Salmonid fry traps could also be used to monitor spawning success. Annual stream surveys should be made to evaluate changes in fish habitats. The stream surveys currently made by the California Department of Fish and Game could be continued and possibly expanded to cover more areas in the Redwood Creek basin.

5. Variable insolation patterns made the evaluation of periphyton and phytoplankton results difficult. The major types of periphyton and phytoplankton have probably been adequately delineated in this study. Additional sampling is unnecessary at this time, except to determine the effect of insolation on periphyton and phytoplankton production.

6. The fluctuations in seasonal and spatial concentrations of seston in the Redwood Creek basin could be more accurately defined and understood. Seston samples could be collected in summer during the peak of biological productivity and in winter during peak storm discharges. Seston samples collected could be microscopically examined and the types of seston recorded (leaf fragments, periphyton, etc.). The dry weight and energy content of the seston could be determined.

REFERENCES CITED

Anderson, R. O., 1959, A modified flotation technique for sorting bottom fauna samples: Limnology and Oceanography, v. 4, no. 2, p. 223-225.

Averett, R. C., and Iwatsubo, R. T., 1975, Notes on water chemistry and aquatic biology of Redwood Creek and selected tributaries: U.S. Geological Survey open-file report., 66 p.

Bormann, F. H., Likens, G. E., Siccama, T. G., Pierce, R. S., and Eaton, J. S., 1974, The export of nutrients and recovery of stable conditions following deforestation at Hubbard Brook: Ecology Monographs, v. 44, no. 3, p. 255- 277.

Borror, D. J., and DeLong, D. M., 1971, An introduction to the study of insects [3d ed.]: New York, Holt, Rinehart, and Winston, 812 p.

Bradford, W. L., and Iwatsubo, R. T., 1978, Water chemistry of the Redwood Creek and Mill Creek basins, Redwood National Park, Humboldt and Del Norte Counties, California: Menlo Park, California, U.S. Geological Survey Water-Resources Investigations 77-115, 112 p.

Brinley, F. G., 1942, Biological studies, Ohio River pollution survey--I, Biological zones in a polluted stream: Sewage Works Journal v. 14, p. 147-159.

Brinson, M. M., 1976, Organic matter losses from four watersheds in the humid tropics: Limnology and Oceanography, v. 21, no. 4, p. 572-582.

Burns, J. W., 1971, The carrying capacity for juvenile salmonids in some northern California streams: California Fish and Game, v. 57, no. 1, p. 44-57.

Calhoun, Alex, 1966, Inland fisheries management: State of California, Department of Fish and Game, 546 p.

California Department of Water Resources, 1965, North coastal area investigation: Bulletin 136--Appendix C, Fish and Wildlife, 364 p.

California State Water Resources Control Board, 1975, Water quality control plan, north coastal region: North Coast Regional Water Quality Control Board, part 1.

Chapman, D. W., 1962, Effects of logging upon fish resources of the west coast: Journal of Forestry, v. 60, no. 8, p. 533-537.

Cordone, A. J., and Kelly, D. W., 1961, The influences of inorganic sediment on the aquatic life of streams: California Fish and Game, v. 47, no. 2, p. 189-228.

Critchfield, H. J., 1966, General climatology [2nd ed.]: Inglewood Cliffs, New Jersey, Prentice Hall, Inc., 420 p.

Cummins, K. W., 1973, Trophic relations of aquatic insects: Annual Review of Entomology, v. 18, p. 183-206.

______1974, Structure and function of stream ecosystems: Bioscience, v. 24, no. 11, p. 431-441.

DeWitt, J. W., 1964, The fish and fish habitat of the coast redwood region in Mendocino, Humboldt, and Del Norte Counties in California: Coast Redwood study, final report, National Park Service, Project NPS-WASO-11-64-(4), 31 p.

Edmondson, W. T., 1959, Fresh-water biology [2nd ed., 1st ed. by H. B. Ward and G. C. Whipple]: New York, John Wiley and Sons, 1,248 p.

Edmunds, G. F., Jr., Allen, R. K., and Peters, W. L., 1963, Annotated key to the nymphs of the families and subfamilies of mayflies (Ephemeroptera): Utah University Biology Service, v. 13, no. 1, 49 p.

Fisher, S. G., and Likens, G. E., 1973, Energy flow in Bear Brook, New Hampshire: an integrative approach to stream ecosystem metabolism, Ecology Monographs, v. 43, p. 421-439.

Gaufin, A. R., and Tarzwell, C. M., 1952, Aquatic invertebrates as indicators of stream pollution: Public Health Reports, v. 67, no. 1, p. 57-64.

______1967, Fecal coliform concepts in stream pollution: Water and Sewage Works, v. 114, reference number 1967, p. R98-R110.

Harden, D. R., 1977, Preliminary photo-interpretative map of vegetation and ground surface conditions in the Redwood Creek drainage basin, Humboldt County, California, June 1976: U.S. Geological Survey open-file report, 1 p.

Harden, D. R., Janda, R. J., Nolan, K. M., 1978, Mass movement and storms in the drainage basin of Redwood Creek, Humbolt County, California--a progress report: U.S. Geological Survey Open-File Report 78-486, 161 p.

Hobbie, J. E., and Likens, G. E., 1973, The output of phosphorus, dissolved organic carbon, and fine particulate carbon from Hubbard Brook watersheds: Limnology and Oceanography, v. 18, no. 5, p. 734-742.

Hutchinson, G. E., 1975, A treatise on limnology--volume III, Limnological botany: New York, John Wiley and Sons, 660 p.

Hynes, H. B. N., 1960, The biology of polluted waters: Liverpool, Liverpool University Press, 202 p.

______1964, The interpretation of biological data with reference to water quality in Symposium, Environmental measurements, valid data, and logical interpretation: U.S. Department of Health, Education and Welfare, p. 289-298.

______1970, The ecology of running water: Toronto, Toronto University Press, 555 p.

Iwatsubo, R. T., Nolan, K. M., Harden, D. R., Glysson, G. D., and Janda, R. J., 1975, Redwood National Park studies, data release number 1, Redwood Creek, Humboldt County, California, September 1, 1973-April 10, 1974: U.S. Geological Survey open-file report, 120 p.

Iwatsubo, R. T., Nolan, K. M., Harden, D. R., and Glysson, G. D., 1976, Redwood National Park studies, data release number 2, Redwood Creek, Humboldt County, and Mill Creek, Del Norte County, California, April 11, 1974-September 30, 1975: U.S. Geological Survey Open-File Report 76-678, 247 p.

Janda, R. J., 1975a, Recent man-induced modifications of the physical resources of the Redwood Creek unit of Redwood National Park, California, and the processes responsible for those modifications: U.S. Geological Survey open-file report, 10 p.

______1975b, Statement to the California State Board of Forestry relative to physical events and processes in Redwood National Park: U.S. Geological Survey open-file report, 7 p.

______1976, Prepared statement and responses to questions by Dr. Richard J. Janda: Hearing concerning Forest Management and Redwood National Park before a subcommittee of the Committee on Government Operations, U.S. House of Representatives, September 18, 1976, p. 403-430, 621-625.

______1977a, Oral statement and written responses to questions by Dr. Richard J. Janda: Hearing concerning Forest Management and Redwood National Park before a subcommittee of the Committee on Government Operations, U.S. House of Representatives, Part 2, February 9, 1977, p. 53-57, 69-72.

______1977b, Summary of watershed conditions in the vicinity of Redwood National Park, California: U.S. Geological Survey Open-File Report 78-25, 82 p.

Janda, R. J., Nolan, K. M., and Harden, D. R., 1975a, Graphic and tabular summaries of water and suspended-sediment discharge during eight periods of synoptic storm sampling in the lower drainage basin of Redwood Creek, Humboldt County, California: U.S. Geological Survey open-file report, 20 p.

Janda, R. J., Nolan, K. M., Harden, D. R., and Colman, S. M., 1975b, Watershed conditions in the drainage basin of Redwood Creek, Humboldt County, California, as of 1973: U.S. Geological Survey open-file report, 266 p.

Jewett, S. G., Jr., 1960, The stoneflies (Plecoptera) of California: California Insect Survey, v. 6, no. 6, p. 125-177.

Johannsen, O. A., 1969, Aquatic diptera: Los Angeles, Entomological Reprint Specialists, 369 p.

Kelly, D. W., 1966, Ecological studies of the Sacramento-San Joaquin Estuary, Part 1: Zooplankton, Zoobenthos, and Fishes of San Pablo and Suisun Bays, Zooplankton and Zoobenthos of the Delta: State of California, Department of Fish and Game, Fish Bulletin 133, 133 p.

Lagler, K. F., 1969, Freshwater fishery biology: Dubuque, Iowa, William C. Brown Company, 421 p.

Lee, K. W., Kapple, G. W., and Dawdy, D. R., 1975, Rainfall-runoff relation for Redwood Creek above Orick, California: U.S. Geological Survey open-file report, 14 p.

Leitritz, Earl, 1959, Trout and salmon culture: California Department of Fish and Game, Fish Bulletin no. 107, 169 p.

Likens, G. E., Bormann, F. H., Johnson, N. M., Fisher, D. W., and Pierce, R. S., 1970, Effects of forest cutting and herbicide treatment on nutrient budgets in the Hubbard Brook watershed ecosystem: Ecology Monographs, v. 40, p. 23-47.

Mason, W. T., Jr., 1973, An introduction--The identification of Chironomid larva: Cincinnati, Ohio, Analytical Quality Control Laboratory, National Environmental Research Center, U.S. Environmental Protection Agency, 90 p.

McCoy, G. A., 1974, Preconstruction assessment of biological quality of the Chena and Little Chena Rivers in the vicinity of the Chena Lakes flood control project near Fairbanks, Alaska: Anchorage, Alaska, U.S. Geological Survey Water-Resources Investigations 29-74, 84 p.

McIntire, C. David, 1966, Some effects of current velocity on periphyton communities in laboratory streams: Hydrobiologia, v. 27, p. 559-570.

Merritt, R. W., and Cummins, K. W., 1978, An introduction to the aquatic insects of North America: Iowa, Kendall/Hunt Publishing Company, 441 p.

Nolan, K. M., and Harden, D. R., 1976, Graphic and tabular summaries of water and suspended-sediment discharge for two periods of synoptic storm sampling during 1975 in the Mill Creek drainage basin, Del Norte County, California: U.S. Geological Survey open-file report, 13 p.

Nolan, K. M., Harden, D. R., and Colman, S. M., 1976a, Erosional landform map of the Redwood Creek drainage basin, Humboldt County, California, 1947-1974: Menlo Park, Calif., U.S. Geological Survey Water-Resources Investigations 76-42, open-file report, 1 p.

Nolan, K. M., Harden, D. R., and Janda, R. J., 1976b, Graphic and tabular summaries of recent changes in stream-channel cross sections for Redwood Creek and selected tributaries, Humboldt County, California: U.S. Geological Survey Open-File Report 76-392, 24 p.

Odum, E. P., 1971, Fundamentals of ecology: Philadelphia, W. B. Saunders Company, 574 p.

Palmer, C. M., 1969, A composite rating of algae tolerant organic pollution: Journal of Phycology, v. 5, no. 1, p. 78-82.

Patrick, Ruth, 1949, A proposed biological measure of stream conditions: Lafayette, Indiana, Purdue University Engineering Bulletin, Extension Series No. 72, p. 379-399.

______1962, Algae as indicators of pollution in Biological problems in water pollution: U.S. Public Health Service Publication No. 999-WP-25, p. 225-231.

Pennak, R. W., 1953, Fresh-water invertebrates of the United States: New York, The Ronald Press, 769 p.

Pielou, E. C., 1969, An introduction to mathematical ecology: New York, John Wiley and Sons, 286 p.

Phillips, R. W., 1970, Effects of sediment on the gravel environment and fish production in Symposium, Forest land uses and stream environment, 1971: Corvallis, Oregon State University Press, Continuing Education Publications, p. 64-74.

Pritchard, D. W., 1967, What is an estuary: Physical viewpoint in G. H. Lauff, ed., Estuaries: Washington, D. C., American Association for the Advancement of Science Publication, v. 83, p. 3-6.

Rantz, S. E., 1969, Mean annual precipitation in the California region: U.S. Geological Survey open-file report, 5 p.

Reid, G. K., 1961, Ecology of inland waters and estuaries: New York, Reinhold Book Corporation, 375 p.

Ross, H. H., 1944, The caddis flies, or Tricoptera, of Illinois: Los Angeles Entomological Reprint Specialists, 326 p.

Sedell, James R., 1976, Impacts of large organic debris on aquatic habitats in small western Oregon streams, Proposal to Water Resources Research Institute annual allotment program: Department of Fisheries and Wildlife, Oregon State University, 16 p.

Sedell, J. R., Triska, F. J., Hall, J. D., Anderson, N. H., and Lyford, J. H., 1973, Sources and fates of organic inputs in coniferous forest streams, Contribution 66, Coniferous Forest Biome, Synthesis of Coniferous Forest Biome Research Symposium, IBP Analysis of Ecosystems, 1973, Amherst, Mass: International Biological Program, Oregon State University, 23 p.

Shapovalov, Leo, and Taft, A. C., 1954, The life histories of the steelhead rainbow trout (Salmo gairdneri) and silver salmon (Oncorhynchus kisutch) with special reference to Waddell Creek, California, and recommendations regarding their management: California Department of Fish and Game, Fish Bulletin No. 98, 375 p.

Sheridan, W. L., and McNeil, W. J., 1960, Effects of logging on the productivity of pink salmon streams in Alaska in Research in fisheries, 1959: Seattle, Washington University, College of Fisheries Contribution No. 77, p. 16-17.

Slack, K. V., Averett, R. C., Greeson, P. E., and Lipscomb, R. G., 1973, Methods for the collection and analysis of aquatic biological and microbiological samples: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. A4, 165 p.

Smith, G. M., 1950, The fresh-water algae of the United States: New York, McGraw-Hill Book Co., 719 p.

Smith, R. I., and Carlton, J. T., 1975, Light's manual of intertidal invertebrates of the central California coast [3rd ed.]: Berkeley, California University Press, 716 p.

Stone, E. C., Rudolf, F. G., and Zinke, P. J., 1969, An analysis of the buffers and the watershed management required to preserve the redwood forest and associated streams in the Redwood National Park: Report prepared for the National Park Service, 106 p.

Strand, R. G., 1962, Redding sheet, in Geologic map of California, Jenkins, O. P., ed.: California Division of Mines and Geology, scale 1:250,000.

______1963, Weed sheet in Geologic map of California, Jenkins, O. P., ed.: California Division of Mines and Geology, scale 1:250,000.

Usinger, R. L., 1956, Aquatic insects of California, with keys to North American genera and California species: Berkeley, California University Press, 508 p.

U.S. Army, 1969, Engineering design handbook--Experimental statistics, Sections 1-5: Army Material Command Pamphlets AMCP 706:110-114.

U.S. Geological Survey, 1975, Water resources data for California, water year 1974. Part 1. Surface-water records, volume 1, Colorado River basin, southern Great Basin, and Pacific slope basins excluding Central Valley: U.S. Geological Survey Water-Data Report CA-74-1, 495 p.

______1976, Water resources data for California, water year 1975. Volume 2, Pacific slope basins from Arroyo Grande to Oregon State line except Central Valley: U.S. Geological Survey Water-Data Report CA-75-2, 515 p.

U.S. National Oceanic and Atmospheric Administration, 1973, Climatological data, California: v. 77, no. 10, 43 p.

______1974-75, Climatological data, California: v. 78-79 (published monthly).

Warren, C. E., 1971, Biology and water pollution control: Philadelphia, W. B. Saunders Co., 434 p.

Wilhm, J. L., and Dorris, T. C., 1968, Biological parameters for water-quality criteria: Bioscience, v. 18, p. 477-481.

Woods, P. F., 1975, Intergravel and surface water conditions in three tributaries of Redwood Creek: Arcata, California, Humboldt State University, School of Natural Resources, M.S. thesis, 68 p.