

SEASONAL ANALYSIS OF SPECIES DIVERSITY AND FUNCTIONAL GROUP
ORGANIZATION OF AQUATIC INVERTEBRATES IN TWO COASTAL STREAMS

by

TERRANCE L. STRANGE

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SEASONAL ANALYSIS OF SPECIES DIVERSITY AND FUNCTIONAL GROUP
ORGANIZATION OF AQUATIC INVERTEBRATES IN TWO COASTAL STREAMS

by

Terrance L. Strange

Approved by the Master's Thesis Committee


Douglas J. Jager, Chairman

03/27/89

Date


David R. Lauck

3/27/89

Date


Terry D. Roelofs

27 Mar. 1989

Date


Director, Natural Resources Graduate Program

Mar 27, 1989

Date

88/WM-162/03/31

Natural Resources Graduate Program Number

Approved by the Dean of Graduate Studies


John C. Hennessy

31 March 1989

Date

ABSTRACT

Seasonal patterns of species diversity and functional organization of benthic invertebrates were studied for a one year period in two coastal streams, Lost Man Creek and Prairie Creek, from March 1986 through March 1987. Invertebrates in Lost Man Creek were most abundant in summer months and least abundant in spring. Invertebrates in Prairie Creek were most abundant in autumn and least abundant in spring. Species diversity values did not change significantly between seasons in both streams. Diversity values for Lost Man Creek samples were significantly lower throughout the year compared to Prairie Creek samples, which may reflect the effects of logging activities in the Lost Man Creek watershed over 20 years earlier.

Seasonal changes in functional group had both expected and unexpected results. As predicted by the River Continuum Concept, shredders were most abundant during autumn and least abundant during the spring in both streams. Contrary to the River Continuum Concept, scraper abundance in both streams was lowest in winter. Predators were most

abundant during summer in both streams. Collectors exhibited different patterns of seasonal abundance within the two streams. Collector abundance in Lost Man Creek peaked dramatically in summer, then declined throughout the remainder of the study. Prairie Creek collectors exhibited a gradual increase in numbers from spring through autumn and then declined through winter.

The unexpected results in the functional organization of stream invertebrates in this study may be due to one or more of the following factors: coastal climate; life history patterns of stream invertebrates; quantity and quality of food resources; past logging activities in the Lost Man Creek watershed; local geology; functional group categorization; and nonrandom sampling. Future study needs in coastal streams are discussed.

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INTRODUCTION

Seasonal (temporal) and longitudinal (spatial) changes in stream invertebrate communities are well documented (Hynes 1970). Most studies dealt with taxonomic diversity of stream invertebrate community structure and provide little information on the trophic organization within stream systems. Studies by Cummins (1973,1974), Vannote et al. (1980), Cummins et al. (1981), Hawkins and Sedell (1981), Bruns et al. (1982), Hawkins et al. (1982), Molles (1982), Newbold et al. (1982), Canton and Chadwick (1983), Gray et al. (1983), Minshall et al. (1983), Benke et al. (1984), Cowan and Oswood (1984), Dudgeon (1984), and Scheiring (1985) have examined trophic organization of stream invertebrate communities and how it is affected by changing stream conditions.

Studies on headwater streams (Minshall 1968 and Vannote 1978) have shown that biological communities in most habitats can be characterized as forming a temporal sequence of synchronized species replacement. As a species completes its growth in a particular habitat, it is replaced by other

species performing essentially the same ecological function, differing principally by the season of growth (Vannote et al. 1980). Vannote et al. (1980) developed a generalized conceptual model, the River Continuum Concept (RCC), for trophic organization of invertebrate communities in lotic habitats. According to the RCC theory, seasonal changes in food resources of a stream should be accompanied by predicted changes in the functional organization of invertebrate communities.

Much remains to be discovered about how and why seasonal changes in trophic structure occur and if there is any pattern to these changes. Studies of seasonal changes in stream invertebrate functional organization in western coastal streams are lacking.

The purpose of this study was to describe seasonal changes of both invertebrate community diversity and invertebrate functional group organization in two coastal streams. Comparisons are made between seasons and between the two streams. The primary objective is to compare the results of this study with the RCC theory.

In addition, the data were intended to help evaluate the Highway 101 Biological Monitoring Program at Redwood National Park. The program is concerned with the effects of the Highway 101 Bypass construction on stream invertebrate production.

STUDY SITE

Prairie Creek drains a 104 km² watershed in Humboldt County, California (Figure 1). Janda et al. (1975) and U. S. Department of Transportation et al. (1984) have provided detailed descriptions of the Prairie Creek basin. Two sites in the basin were selected for study. The first site included the upper Prairie Creek basin above the confluence of Brown Creek. Prairie Creek is a 4th order stream at this site, based on the convention of Strahler (1957). Prairie Creek drains a series of old growth coastal redwood (Sequoia sempervirens) groves and has had minimal human impacts on its watershed above the study area.

The second site is located on Lost Man Creek approximately 1 km above its confluence with Prairie Creek. Lost Man Creek is a 6th order stream and drains a 32.2 km² basin area. Approximately 70% (22.2 km²) of the timber within the Lost Man Creek watershed above the study site was logged from the late 1950s through the mid 1960s (Hammon et al. 1967). Both sites are designated as control streams for

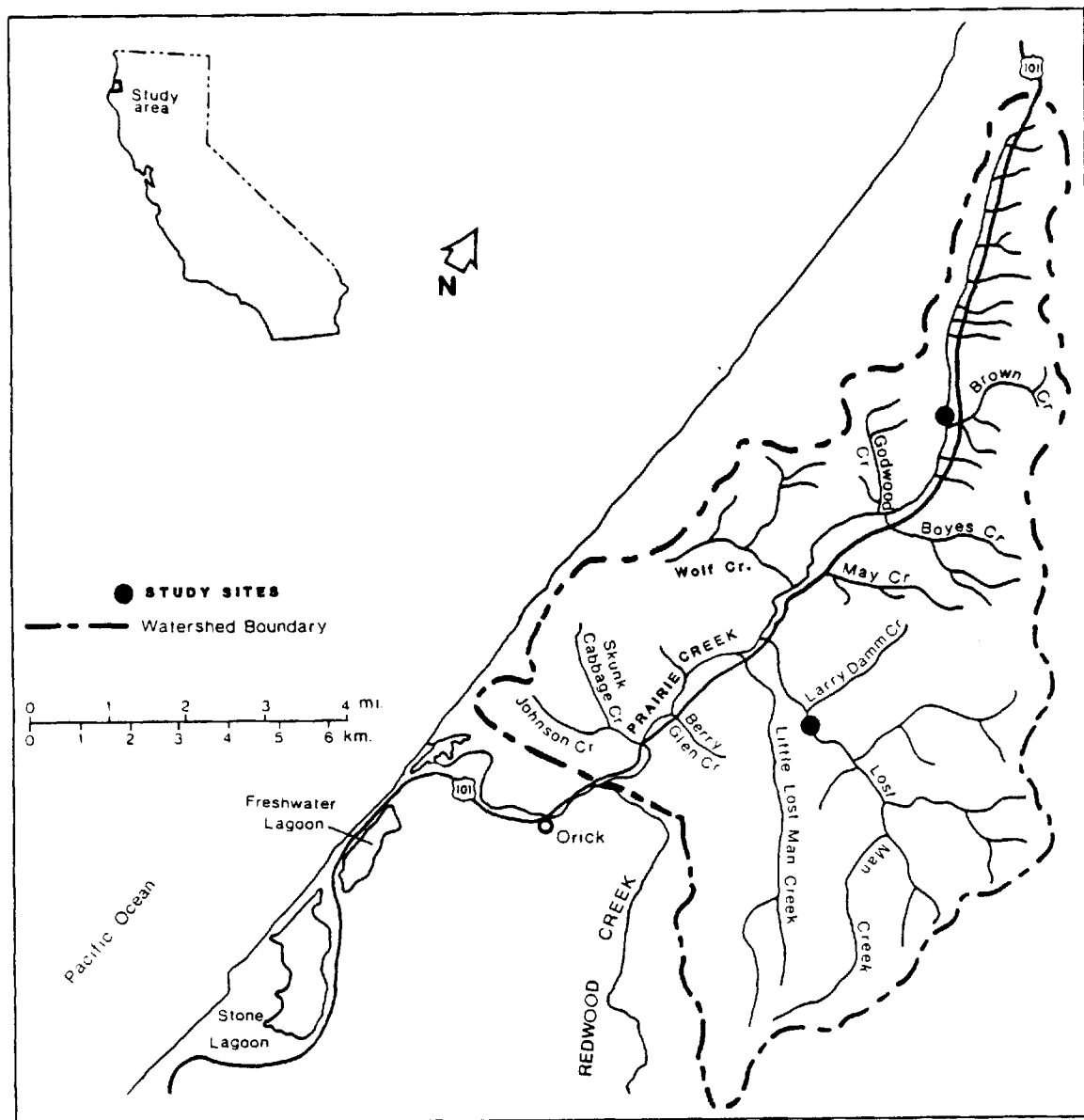


Figure 1. Prairie Creek Watershed and Study Site Locations, Humboldt County, California.

the U. S. Highway 101 Bypass Biological Monitoring Program at Redwood National Park (Harrington 1987).

Prairie Creek, which is the largest tributary of Redwood Creek, enters Redwood Creek approximately 1.6 km north of Orick. In contrast to Redwood Creek, the Prairie Creek watershed exhibits gentler hillslope gradients and a regolith that is less susceptible to erosive processes (Janda et al. 1975). Prairie Creek has an average channel gradient of approximately 12 meters per kilometer. The Prairie Creek basin upstream from the mouth of Lost Man Creek is underlain primarily by unnamed, weakly indurated coastal plain sediments (Iwatsubo et al. 1975). These sediments contain Pliocene or younger plant fossils and interfinger with Marine Pliocene St. George Formation (Janda et al. 1975). The southern Prairie Creek basin, including Lost Man Creek, is underlain by Franciscan sandstone. These Franciscan sandstones have been thrust over unnamed beds in the northern Lost Man Creek basin by geologic activities of the Grogan Fault (Janda et al. 1975).

The basin has a Coastal Mediterranean climate with mild winters and short, warm, and dry summers with frequent fog (Janda et al. 1975). The average annual rainfall is 178 cm a year at Elk Prairie in Prairie Creek Redwoods State Park and occurs predominately between October and June (Iwatsubo et al. 1976 and U. S. Department of Transportation et al. 1984). The average temperature remains nearly constant

throughout the year (low of 7°C and a high of 16°C). Stream flow is lowest between August and October, and highest between November and April.

Vegetation in the basin consist of old growth coast redwood with interspersed red alder (Alnus oregona), western hemlock (Tsuga heterphylla), Sitka spruce (Picea sitchensis), and big-leaf maple (Acer macrophyllum) trees. Shrub understory consists of Pacific rhododendron (Rhododendron macrophyllum), salal (Gaultheria shallon), red huckleberry (Vaccinium parvifolium), skunk cabbage (Veratrum californicum), and Oregon grape (Vitis californica). Common herbaceous plants include sword fern (Polystichum munitum), deer fern (Blechnum spicant), redwood sorrel (Oxalis oregana), trillium (Trillium sp.), and redwood violet (Viola sempervirens).

Salmonid species which occur in the study areas include steelhead trout (Oncorhynchus mykiss), coastal cutthroat (O. clarkii), chinook salmon (O. tshawytscha), and coho salmon (O. kisutch). Other fish include Humboldt sucker (Catostomus occidentalis humboldtianus), sculpin (Cottus sp.), three spine stickleback (Gasterosteus aculeatus), and Pacific lamprey (Lampetra tridentata). Amphibians found in the area include Pacific giant salamander (Dicamptodon ensatus), red-legged frog (Rana aurora), and tailed frog (Ascaphus truei).

The watershed is located within the Redwood National and Prairie Creek Redwoods State Parks. Management policies within the parks have been developed to protect the aesthetic quality for park visitors; therefore, recent adverse environmental activities in the area appear negligible (U. S. Department of Transportation et al. 1984).

MATERIALS AND METHODS

Benthic samples were collected at 5 week intervals from Prairie Creek and Lost Man Creek for a period of one year (March 1986 through March 1987). Each site was divided into three sample stations of approximately 300 m lengths. Alternate stations were sampled on consecutive collection dates. This system allows sufficient time for recolonization following sampling disturbance. Fifteen samples were collected at each station with a Portable Invertebrate Box Sampler (area = 0.1m^2 , mesh size = 0.5 mm) during each collection visit. Sample locations were subjectively chosen by the author to ensure that a variety of stream habitat parameters were collected. These parameters included depth, velocity, temperature, shade, and substrate size, roughness, and heterogeneity.

Samples were preserved in 100% denatured alcohol solvent in the field and sorted in the laboratory. Invertebrates were then identified to the lowest taxon possible and enumerated. Taxonomic keys used for the identification of invertebrates were those of Usinger

(1956), Edmondson (1959), Allen and Edmunds (1961a, 1961b, 1962, 1963, and 1964), Edmunds and Allen (1964), Birch (1972), Brown (1972), Hogue (1973), Mason (1973), Smith and Carlton (1975), Anderson (1976), Baumann et al. (1977), Borror et al. (1977), Wiggins (1977), Pennak (1978), Lauck (1979), Williams and Lauck (1982), Merritt and Cummins (1984), and Stewart and Stark (1984). Functional groups (feeding guilds) for insects were assigned based on tables from Merritt and Cummins (1984). Non-insect invertebrates were assigned functional groups according to life history information from Edmondson (1959), Smith and Carlton (1975), Borror et al. (1977), Pennak (1978), Cummins and Wilzbach (1985), and Brinkhurst (1986).

Diversity values, D , were calculated using Simpson's equation for nonrandom samples (Brower and Zar 1984):

$$D = 1 - \frac{\sum_{i=1}^s n_i^2}{N}$$

where : n_i = number of individuals in each taxon
 N = total number of individuals
 s = number of taxa in sample

Diversity ranges from 0 to 1, where 1 indicates maximum diversity and 0 minimum diversity. Krebs (1972) defines Simpson's D as the probability of picking two organisms at random from the entire sample that are different species.

Williams (1964), Hurlburt (1971), Brower and Zar (1984), Washington (1984), and Hellowell (1986) recommend the use of Simpson's diversity index over similar indices of community diversity.

A two-way ANOVA was used to analyze diversity values by stream and by season. SPSS PC+ V2.0 (Norusis 1988) was used to perform the calculations. Adult and larvae life stages of Coleoptera were considered as two separate species for diversity calculations. Samples collected from sand substrate were not used for diversity comparisons due to their low diversity.

Invertebrates were assigned to four general functional group categories based on feeding mechanisms (Table 1) :

1. Predators (engulfers). Carnivores which feed by engulfing whole or parts of living animal tissue.

2. Shredders. Detritivores and herbivores which process coarse particulate organic matter (CPOM) as a food source.

3. Collectors (suspension and deposit feeders). Detritivores, herbivores, and carnivores which feed by filtering suspended material or by gathering depositional material primarily consisting of decomposing fine particulate organic matter (FPOM) as a food source.

4. Scrappers (grazers). Herbivores and detritivores which feed by scraping periphyton and associated material from mineral and organic surfaces.

Table 1. Functional Group Classification (after Merritt and Cummins 1984) of Benthic Invertebrates from Lost Man Creek and Prairie Creek, March 1986-March 1987.

11

TAXA	FUNCTIONAL GROUP
Phylum Arthropoda	
Subphylum Mandibulata	
Class Insecta	
Order Ephemeroptera	
Family Baetidae	
<u>Baetis spp.</u>	COLLECTOR
Family Ephemerellidae	
<u>Attenella margarita</u>	COLLECTOR
<u>Caudatella heterocaudata</u>	COLLECTOR
<u>Ephemerella inermis</u>	COLLECTOR
<u>Ephemerella infrequens</u>	SHREDDER
<u>Ephemerella mollitia</u>	COLLECTOR
<u>Drunella coloradensis</u>	PREDATOR
<u>Drunella doddsi</u>	SCRAPER
<u>Drunella grandis</u>	PREDATOR
<u>Drunella spinifera</u>	PREDATOR
<u>Serratella levis</u>	COLLECTOR
<u>Serratella teresa</u>	COLLECTOR
<u>Serratella tibialis</u>	COLLECTOR
<u>Timpanoga hecuba</u>	COLLECTOR
Family Heptageniidae	
<u>Cinygmula sp.</u>	SCRAPER
<u>Epeorus albertae</u>	COLLECTOR, SCRAPER
<u>Epeorus longimanus</u>	COLLECTOR, SCRAPER
<u>Heptagenia sp.</u>	SCRAPER
<u>Ironodes sp.</u>	SCRAPER
<u>Rhithrogena sp.</u>	COLLECTOR, SCRAPER
Family Leptophlebiidae	
<u>Paraleptophlebia bicornuta</u>	COLLECTOR
<u>Paraleptophlebia sp.</u>	COLLECTOR
Family Siphonuridae	
<u>Ameletus sp.</u>	COLLECTOR
Family Tricorythidae	
<u>Tricorythodes sp.</u>	COLLECTOR
Order Odonata	
Family Gomphidae	
<u>Gomphus sp.</u>	PREDATOR
Order Plecoptera	
Family Capniidae	
<u>Capnia sp.</u>	SHREDDER
<u>Paracapnia angulata</u>	SHREDDER

Table 1. Functional Group Classification (after Merritt and Cummins 1984) of Benthic Invertebrates from Lost Man Creek and Prairie Creek, March 1986-March 1987. (continued) 12

TAXA	FUNCTIONAL GROUP
Family Chloroperlidae	
<u>Paraperla frontalis</u>	PREDATOR
<u>Suwallia sp.</u>	PREDATOR
Family Nemouridae	
<u>Zapada cinctipes</u>	SHREDDER
<u>Zapada oregonensis</u>	SHREDDER
Family Peltoperlidae	
<u>Yoroperla brevis</u>	SHREDDER
Family Perlidae	
<u>Calineuria californica</u>	PREDATOR
<u>Hesperoperla pacifica</u>	PREDATOR
Family Perlodidae	
<u>Cultus sp.</u>	PREDATOR
<u>Isoperla sp.</u>	PREDATOR
<u>Kogotus nonus</u>	PREDATOR
Family Pteronarcyidae	
<u>Pteronarcys californica</u>	SHREDDER
Order Hemiptera	
Family Corixidae	
<u>Sigara vandekeyi</u>	COLLECTOR
Family Gerridae	
<u>Gerris sp.</u>	PREDATOR
Order Megaloptera	
Family Corydalidae	
<u>Orohermes crepusculus</u>	PREDATOR
Family Sialidae	
<u>Sialis sp.</u>	PREDATOR
Order Trichoptera	
Family Brachycentridae	
<u>Micrasema onisca</u>	SHREDDER
Family Calamoceratidae	
<u>Heteroplectron californicum</u>	SHREDDER
Family Glossosomatidae	
<u>Agapetus taho</u>	SCRAPER
<u>Glossosoma sp.</u>	SCRAPER
Family Hydropsychidae	
<u>Arctopsyche grandis</u>	COLLECTOR
<u>Hydropsyche sp.</u>	COLLECTOR
<u>Parapsyche almota</u>	COLLECTOR

Table 1. Functional Group Classification (after Merritt and Cummins 1984) of Benthic Invertebrates from Lost Man Creek and Prairie Creek, March 1986-March 1987. (continued) 13

TAXA	FUNCTIONAL GROUP
Family Hydroptilidae	
<u>Hydroptila</u> sp.	SCRAPER
<u>Ochrotrichia</u> sp.	COLLECTOR
<u>Palaeagapetus nearcticus</u>	SHREDDER
Family Lepidostomatidae	
<u>Lepidostoma</u> sp.	SHREDDER
Family Limnephilidae	
<u>Apatania sorex</u>	SCRAPER
<u>Dicosmoecus gilvipes</u>	SCRAPER
<u>Ecclisomyia conspersa</u>	SHREDDER
<u>Hydatophylax hesperus</u>	SHREDDER
<u>Neophylax rickeri</u>	SCRAPER
<u>Onocosmoecus</u> sp.	SHREDDER
Family Philopotamidae	
<u>Wormaldia</u> sp.	COLLECTOR
Family Polycentropodidae	
<u>Polycentropus</u> sp.	PREDATOR
Family Psychomyiidae	
<u>Psychomyia lumina</u>	COLLECTOR
Family Rhyacophilidae	
<u>Rhyacophila</u> spp.	PREDATOR
Family Sericostomatidae	
<u>Gumaga griseola</u>	SHREDDER
Family Uenoidae	
<u>Farula</u> sp.	SCRAPER
Order Coleoptera (larvae)	PREDATOR
Family Anthicidae (adult)	COLLECTOR
Family Dytiscidae	
<u>Oreodytes</u> sp. (adult)	PREDATOR
<u>Oreodytes</u> sp. (larvae)	PREDATOR
Family Elmidae	
<u>Ampumixis dispar</u> (adult)	COLLECTOR
<u>Ampumixis dispar</u> (larvae)	COLLECTOR
<u>Heterlimnius koebelei</u> (adult)	COLLECTOR
<u>Heterlimnius koebelei</u> (larvae)	COLLECTOR
<u>Lara</u> sp. (larvae)	SHREDDER
<u>Narpus concolor</u> (adult)	COLLECTOR
<u>Narpus concolor</u> (larvae)	COLLECTOR
<u>Optioservus</u> sp. (adult)	COLLECTOR
<u>Optioservus</u> sp. (larvae)	SCRAPER
<u>Ordobrevia nubifera</u> (adult)	COLLECTOR
<u>Ordobrevia nubifera</u> (larvae)	COLLECTOR
<u>Zaitzevia parvula</u> (adult)	COLLECTOR
<u>Zaitzevia parvula</u> (larvae)	COLLECTOR

Table 1. Functional Group Classification (after Merritt and Cummins 1984) of Benthic Invertebrates from Lost Man Creek and Prairie Creek, March 1986-March 1987. (continued) 14

TAXA	FUNCTIONAL GROUP
Family Haliplidae	
<u>Brychius</u> <u>sp.</u> (larvae)	SCRAPER
<u>Halipus</u> <u>sp.</u> (larvae)	SHREDDER
Family Hydraenidae	
<u>Ochthebius</u> <u>sp.</u> (adult)	SCRAPER
Family Hydrophilidae	
<u>Tropisternus</u> <u>sp.</u> (larvae)	PREDATOR
Family Psephenidae	
<u>Eubrianax edwardsi</u> (larvae)	SCRAPER
Family Ptilidae (adult)	COLLECTOR
Family Ptilodactylidae	
<u>Anchytarsus</u> <u>sp.</u> (larvae)	SHREDDER
Family Salpingidae (larvae)	SCRAPER
Order Diptera	
Family Blephariceridae	
<u>Phlorus californicus</u>	SCRAPER
Family Ceratopogonidae	
<u>Bezzia</u> <u>sp.</u>	PREDATOR
<u>Atrichopogon</u> <u>sp.</u>	COLLECTOR
Family Chironomidae	
Subfamily Chironominae	
Tribe Chironomini	COLLECTOR
<u>Polypedilum</u> <u>sp.</u>	
Tribe Tanytarsini	COLLECTOR
<u>Rheotanytarsus</u> <u>sp.</u>	
<u>Stempellina</u> <u>sp.</u>	
<u>Stempellinella</u> <u>sp.</u>	
<u>Tanytarsus</u> <u>sp.</u>	
Subfamily Orthocladinae	COLLECTOR
<u>Heterotanytarsus</u> <u>sp.</u>	
<u>Krenosmittia</u> <u>sp.</u>	
<u>Lopescladius</u> <u>sp.</u>	
Subfamily Podonominae	COLLECTOR
Tribe Boreochlini	
<u>Boreochlus</u> <u>sp.</u>	
Subfamily Tanypodinae	PREDATOR
Family Culicidae	
<u>Anopheles</u> <u>sp.</u>	PREDATOR
Family Dixidae	
<u>Dixa</u> <u>sp.</u>	COLLECTOR
Family Dolichopodidae	PREDATOR
Family Empididae	
<u>Chelifera</u> <u>sp.</u>	PREDATOR
Family Muscidae	PREDATOR

Table 1. Functional Group Classification (after Merritt and Cummins 1984) of Benthic Invertebrates from Lost Man Creek and Prairie Creek, March 1986-March 1987. (continued) 15

TAXA	FUNCTIONAL GROUP
Family Pelecorhynchidae	
<u>Glutops sp.</u>	PREDATOR
Family Psychodidae	
<u>Maruina lanceolata</u>	SCRAPER
<u>Pericoma sp.</u>	COLLECTOR
Family Ptychopteridae	
<u>Ptychoptera sp.</u>	COLLECTOR
Family Sarcophagidae	PREDATOR
Family Simuliidae	
<u>Prosimulium sp.</u>	COLLECTOR
<u>Simulium sp.</u>	COLLECTOR
Family Stratiomyidae	
<u>Allognosta sp.</u>	COLLECTOR
<u>Myxosargus sp.</u>	COLLECTOR
Family Tabanidae	
<u>Tabanus sp.</u>	PREDATOR
Family Tipulidae	
<u>Antocha monticola</u>	COLLECTOR
<u>Dicranota sp.</u>	PREDATOR
<u>Hexatoma sp.</u>	PREDATOR
Class Crustacea	
Order Amphipoda	
Family Gammaridae	
<u>Anisogammarus confervicolus</u>	SHREDDER, COLLECTOR
Order Isopoda	
Family Asellidae	
<u>Asellus sp.</u>	COLLECTOR
Subphylum Chelicerata	
Class Arachnida	
Order Acari	
Suborder Hydracarina	PREDATOR
Phylum Mollusca	
Class Gastropoda	
Order Basommatophora	
Family Physidae	
<u>Physa sp.</u>	SCRAPER
Family Planorbidae	
<u>Gyraulus sp.</u>	SCRAPER

Table 1. Functional Group Classification (after Merritt and Cummins 1984) of Benthic Invertebrates from Lost Man Creek and Prairie Creek, March 1986-March 1987. (continued) 16

TAXA	FUNCTIONAL GROUP
Order Mesogastropoda	
Family Hydrobiidae	
<u>Amnicola sp.</u>	SCRAPER
Family Pleuroceridae	
<u>Juga sp.</u>	SCRAPER
Class Pelecypoda	
Order Heterodonta	
Family Sphaeriidae	
<u>Sphaerium corneum</u>	COLLECTOR
Phylum Annelida	
Class Oligochaeta	COLLECTOR
Class Adenophorea	
Order Rhabditida	COLLECTOR

When a taxon fits into more than one functional group, it was treated as a composite of these groups. For example, if a group was listed as both a collector and scraper, it was included as one-half collector and one-half scraper. This process is consistent with studies by Hawkins and Sedell (1981), Canton and Chadwick (1983), Dudgeon (1984), and Scheiring (1985).

Relative abundance of each functional group was calculated for each site. Seasonal abundance was calculated combining monthly collections as follows: spring = March 1986, April, and March 1987; summer = June, July, and August; autumn = September, October, and November; and winter = December and February (Scheiring 1985). Winter collections consisted of only two sample dates, therefore, winter numerical totals were increased by one-half for total abundance data only, to allow for comparisons with other seasons. Data used to calculate relative abundance was not modified.

RESULTS

A total of 265,955 aquatic invertebrates representing 125 taxa was collected during the study. Aquatic insects comprised 89% of the total number and the remainder was comprised of crustaceans, mollusks, and annelids. Invertebrates were generally most abundant in autumn and least abundant in winter.

Invertebrates sampled in Lost Man Creek totaled 158,127 individuals from 117 taxa. Aquatic insects made up 90% of the total invertebrate community sampled from Lost Man Creek. Species abundance for Lost Man Creek is presented in Appendix A. Invertebrates were most abundant during the summer months in Lost Man Creek and least abundant during spring. Abundance continuously increased from a low in March 1986 to peak abundance in August. Lost Man Creek invertebrate abundance decreased from September through November, increased relatively little in November, declined in February, and then increased again in March 1987 (Figure 2).

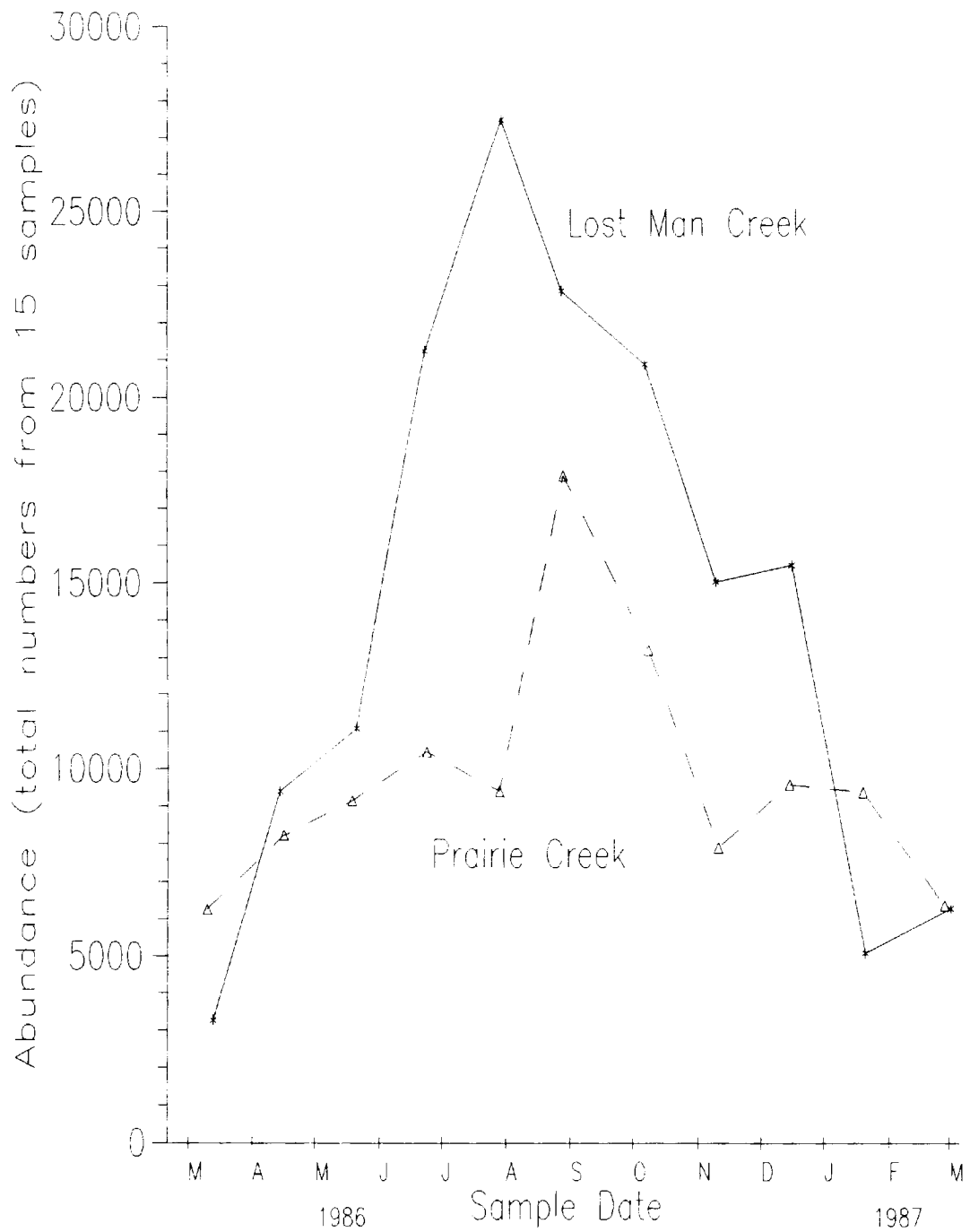


Figure 2. Total Benthic Invertebrates Sampled from Lost Man Creek and Prairie Creek, March 1986-March 1987. Each point represents collection date totals.

Invertebrates sampled in Prairie Creek totaled 107,828 individuals from 106 taxa. Aquatic insects comprised 87% of the invertebrates sampled from Prairie Creek. Species abundance for Prairie Creek is presented in Appendix B. As opposed to Lost Man Creek, invertebrates in Prairie Creek were most abundant in autumn and least abundant during spring. Total invertebrate numbers gradually increased from a low in March 1986 to July, declined somewhat in August, and increased again to peak in September. Invertebrate numbers then declined through November, increased relatively little in December, then decreased through March 1987 (Figure 2).

Diversity (D) values were calculated for each sample. Individual sample diversities in Lost Man Creek ranged from an unusual yearly low of 0.408 in the summer to a maximum of 0.942 in the spring (Table 2). Collection date means ranged from a low of 0.800 in July to a maximum of 0.918 in March of 1986.

Individual sample diversities in Prairie Creek ranged from an unusual study low of 0.396 in autumn to a maximum of 0.952 in winter (Table 3). Collection date means ranged from a low of 0.831 in November to a maximum of 0.926 in February.

The two-way ANOVA test of significance revealed no sample difference ($p > 0.10$) between seasons for both

Table 2. Values for Simpson's Species Diversity from Benthic Invertebrate Collections in Lost Man Creek, March 1986-March 1987. Diversity values on each date represent 15 total benthic samples (diversity values from samples on sand substrate were omitted).

Spring		Summer	
<u>March 26/86</u>		<u>June 4/86</u>	
0.9350	0.9280	0.8450	0.8980
0.9000	0.9330	0.8960	0.8840
0.9400	0.9350	0.9250	0.8410
0.8830	0.9140	0.9160	0.9170
0.8330	0.9150	0.9260	0.9120
0.8820	0.9420	0.9240	0.8830
	0.9130	0.9080	0.9220
monthly avg = 0.9180		monthly avg = 0.9000	
<u>March 16/87</u>		<u>July 7/86</u>	
0.9180	0.8770	0.7810	0.4080
0.8730	0.9060	0.7890	0.8150
0.9210	0.8060	0.9080	0.8750
0.8550	0.9130	0.7500	0.8070
0.8730	0.9330	0.8700	0.9180
0.8270	0.7610	0.8760	0.9150
0.9290	0.8930	0.8540	0.5700
			0.8560
monthly avg = 0.8780		monthly avg = 0.8000	
<u>April 28/86</u>		<u>Aug 13/86</u>	
0.6490	0.7870		
0.9180	0.7730	0.8580	0.9040
0.9140	0.8150	0.8380	0.8770
0.8410	0.8680	0.7660	0.8460
0.8960	0.7320	0.7390	0.8890
0.8660	0.8720	0.9000	0.8740
0.8640	0.9400	0.8270	0.8530
	0.9230	0.8980	0.8490
			0.8900
monthly avg = 0.8440		monthly avg = 0.8540	
seasonal avg = 0.8760		seasonal avg = 0.8500	

Table 3. Values for Simpson's Species Diversity from Benthic Invertebrate Collections in Prairie Creek, March 1986-March 1987. Diversity values on each date represent 15 total benthic samples (diversity values from samples on sand substrate were omitted).

Spring

March 24/86

0.9120	0.9320
0.8570	0.9440
0.6920	0.8080
0.8290	0.8700
0.9150	0.7280
0.9250	0.9070
0.9280	0.9250
	0.9210

monthly avg = 0.8730

March 13/87

0.9210	0.9430
0.9410	0.9420
0.8310	0.9050
0.9330	0.9220
0.9210	0.9430
0.9210	0.8740
	0.9260

monthly avg = 0.9170

April 30/86

0.9240	0.9220
0.9080	0.9190
0.9320	0.8770
0.9300	0.9340
0.9210	0.8990
0.9440	0.9490

monthly avg = 0.9220

seasonal avg = 0.9020

Summer

June 2/86

0.8920	0.9170
0.9070	0.9260
0.9250	0.9450
0.9320	0.9250
0.9380	0.9450
0.9220	0.8570
0.9290	0.9440

monthly avg = 0.9220

July 8/86

0.9220	0.9230
0.9190	0.9090
0.9160	0.8170
0.8190	0.9370
0.9420	0.9040
0.8960	0.8430
	0.8020

monthly avg = 0.8880

Aug 12/86

0.8080	0.8910
0.8330	0.8740
0.8870	0.8390
0.8000	0.8640
0.8990	0.8560
0.8580	0.9280
0.8890	0.8230

monthly avg = 0.8610

seasonal avg = 0.8900

Table 3. Values for Simpson's Species Diversity from Benthic Invertebrate Collections in Prairie Creek, March 1986-March 1987. Diversity values on each date represent 15 total benthic samples (diversity values from samples on sand substrate were omitted). (continued)

24

Autumn

Sept 12/86

0.8750	0.9270
0.8510	0.9270
0.8510	0.8910
0.9140	0.9080
0.8860	0.8540
0.9210	0.8750
0.8830	0.7660
	0.8970

monthly avg = 0.8820

Oct 23/86

0.9040	0.9140
0.9140	0.8510
0.9410	0.9370
0.9250	0.9160
0.8780	0.8980
0.9390	0.9000

monthly avg = 0.9100

Nov 25/86

0.9070	0.9350
0.9360	0.8650
0.9090	0.9150
0.9340	0.8870
0.6330	0.3960
0.7700	0.9090
	0.8090

monthly avg = 0.8310

seasonal avg = 0.8740

Winter

Dec 29/86

0.9190	0.9150
0.9190	0.9110
0.9040	0.9360
0.9070	0.9080
0.9490	0.9290
0.9160	0.9320
0.8940	0.8790

monthly avg = 0.9160

Feb 3/87

0.9330	0.8950
0.9220	0.9380
0.9520	0.9510
0.9500	0.8840
0.9310	0.8730
0.9190	0.9450
0.9410	0.9330

monthly avg = 0.9260

seasonal avg = 0.9210

streams (Table 4). The average diversity value for Lost Man Creek (0.864) was significantly lower ($p < 0.001$, Table 4) than Prairie Creek (0.895).

Functional group abundance of each sample is listed for Lost Man Creek (Appendix C) and for Prairie Creek (Appendix D). Seasonal changes in functional group abundance varied in both streams (Table 5). Collectors were the most abundant functional group in all seasonal samples. Scrapers were the second most abundant functional group in all seasonal collections. Predators were the third most abundant functional group in all but the adjusted winter collections from Lost Man Creek, where there were 77 fewer predators than shredders. Shredders were generally the least abundant functional group in both streams.

Lost Man Creek collectors were most abundant in summer and least abundant in spring (Figure 3). Collector abundance in Lost Man Creek was considerably larger than in Prairie Creek during summer and autumn (Table 5). Scrapers and shredders in Lost Man Creek were most abundant in autumn and least abundant in spring. Predators were most abundant in summer and least abundant in winter.

Collectors, scrapers, and shredders in Prairie Creek were most abundant in autumn and least abundant in winter (Figure 4). Percent abundance of scrapers in Prairie Creek was greater throughout the year as compared to Lost Man Creek (Figures 5,6). Percent abundance of collectors was

Table 4. Results of Two-Way Anova for Effects of Stream and Season on Simpson's Species Diversity Values for Lost Man Creek and Prairie Creek Benthic Invertebrates, March 1986-March 1987.

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Main Effects	.104	4	.026	5.012	.001
Season	.032	3	.011	2.031	.110
Stream	.072	1	.072	13.822	.000
2-Way Interactions					
Season	.023	3	.008	1.485	.219
Stream	.023	1	.088	1.485	.219
Explained	.127	7	.018	3.500	.001
Residual	1.553	299	.005		
Total	1.680	306	.005		

Table 5. Functional Group Abundance of Stream Invertebrates Collected (individuals/4.5 m²)^a from Lost Man Creek and Prairie Creek, March 1986-March 1987. (* = adjusted winter values for three sample date comparisons).

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	Predator	Collector	Scraper	Shredder
<u>Lost Man Creek</u>				
Spring	2914	11151	4188	704
Summer	7044	41780	8067	2934
Autumn	4131	38295	12800	3557
* Winter	2716	18873	6461	2793
<u>Prairie Creek</u>				
Spring	2916	10044	6746	1167
Summer	3965	13030	8856	3155
Autumn	3151	18409	13955	3506
* Winter	3129	14232	8772	2259

^a Each of the 45 samples taken with a 0.1m² benthic sampler.

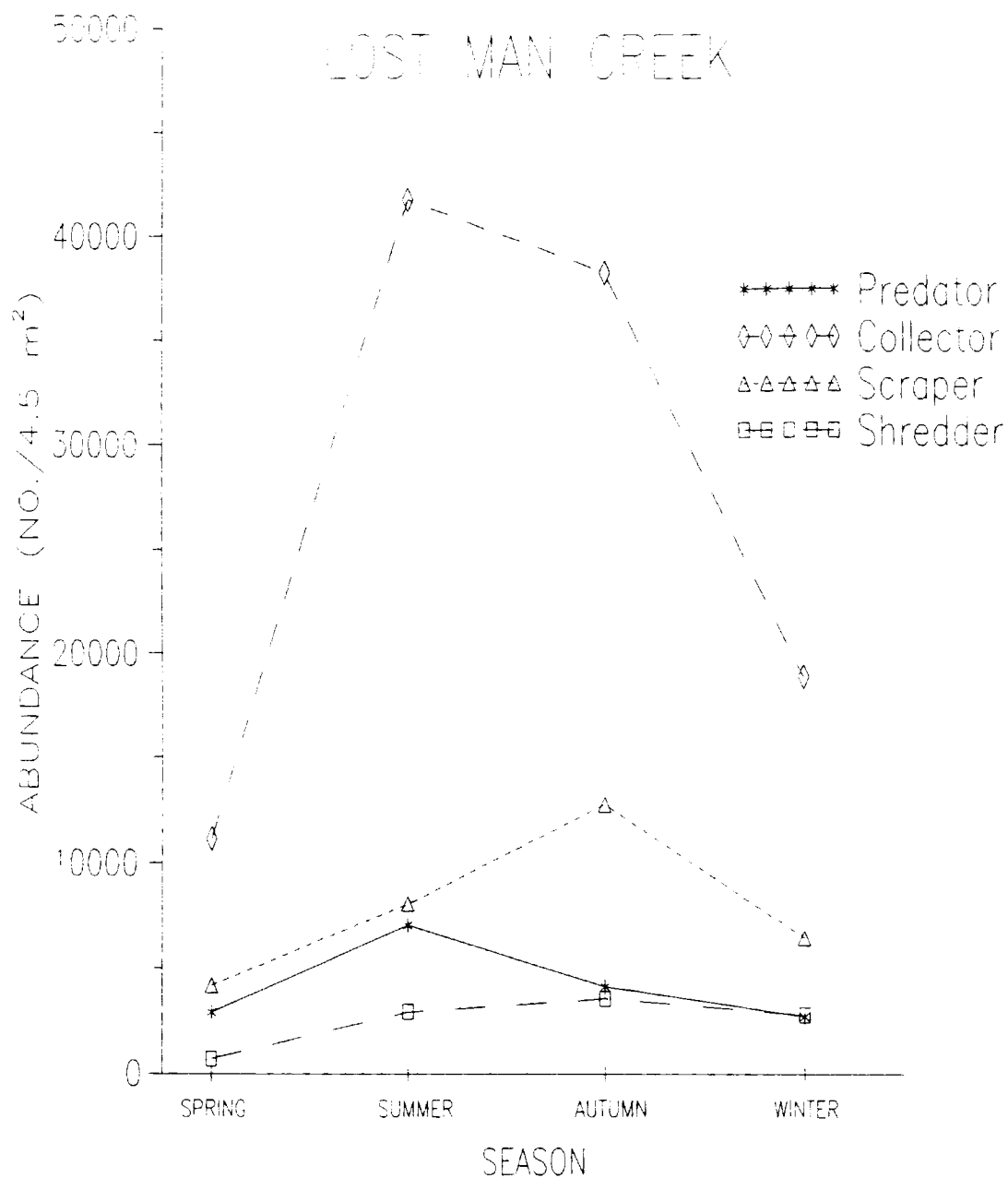


Figure 3. Seasonal Abundance of Benthic Invertebrates from Lost Man Creek, March 1986-March 1987.

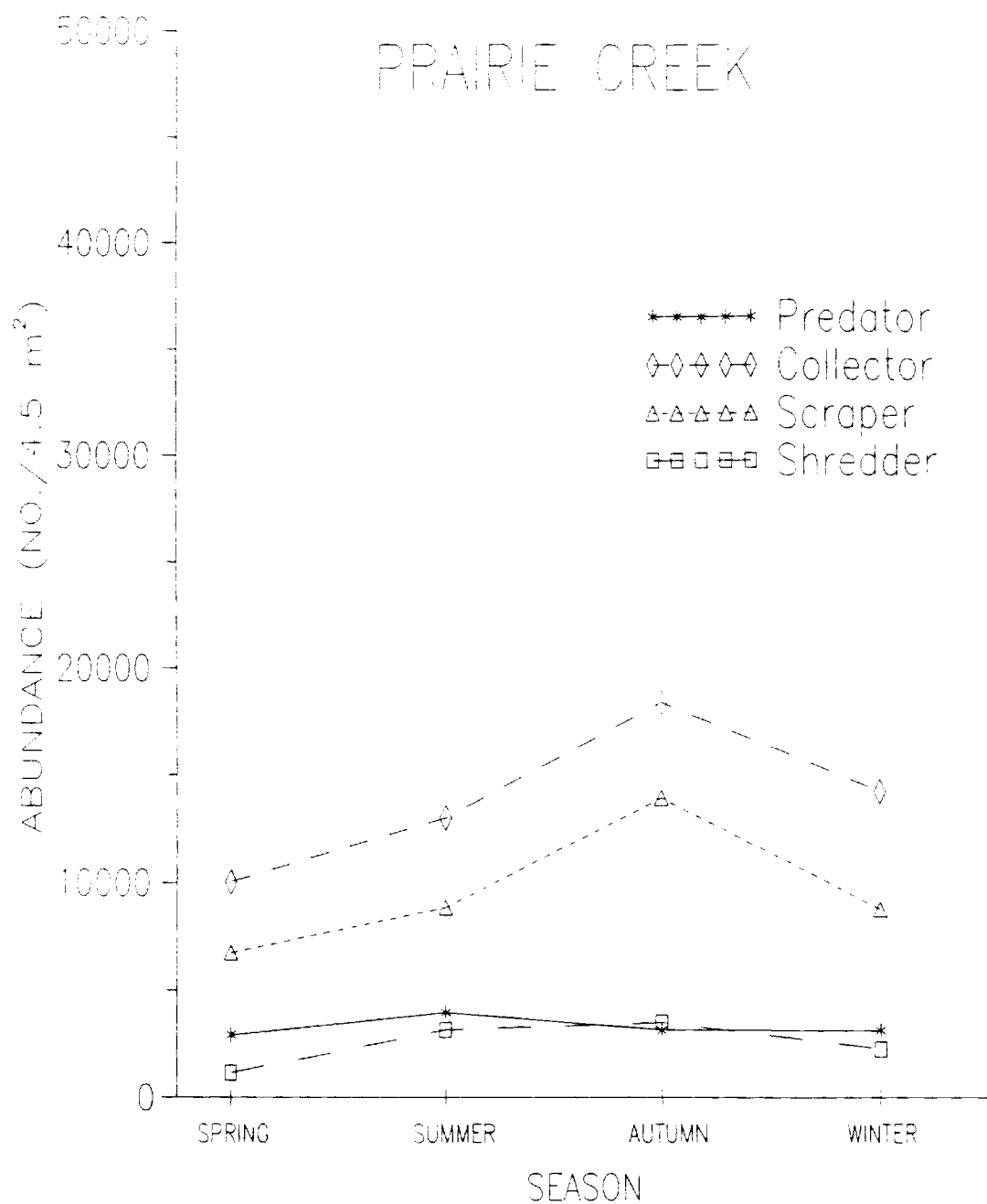


Figure 4. Seasonal Abundance of Benthic Invertebrates from Prairie Creek, March 1986-March 1987.

LOST MAN CREEK

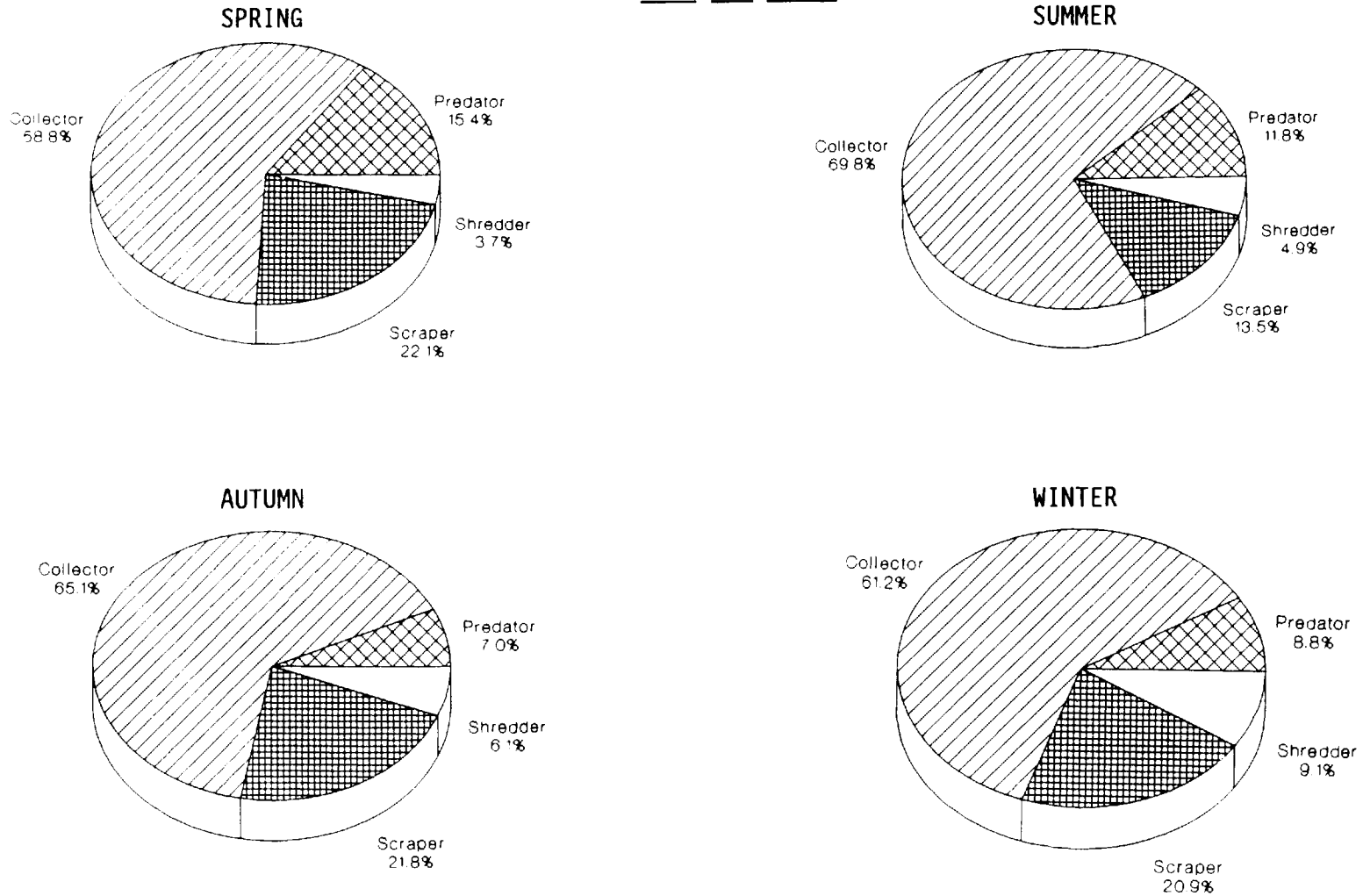


Figure 5. Relative Abundance by Season of Lost Man Creek Functional Groups, March 1986-March 1987.

PRAIRIE CREEK

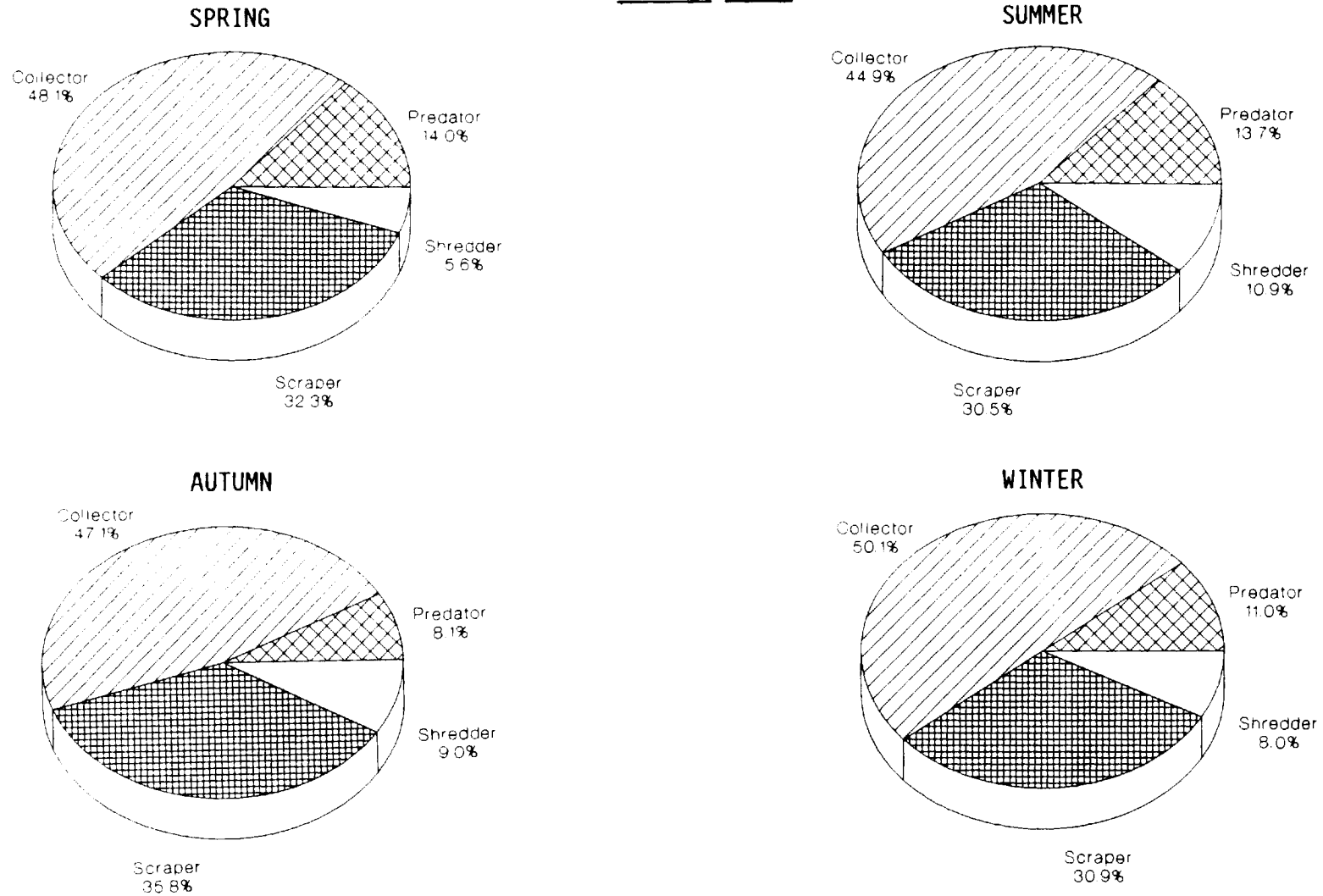


Figure 6. Relative Abundance by Season of Prairie Creek Functional Groups, March 1986-March 1987.

greater in Lost Man Creek throughout the year as compared to Prairie Creek. Prairie Creek predators were most abundant in summer and least abundant in spring (Figure 4).

Seasonal patterns of abundance percentage for each functional group varied among the two streams. Collector proportions in Lost Man Creek ranged from 58.8% in spring to 69.8% in summer (Figure 5). Scraper proportions in Lost Man Creek ranged from 13.5% in summer to 22.1% in spring. Predator proportions in Lost Man Creek ranged from 7.0% in autumn to 15.4% in spring. Shredder proportions in Lost Man Creek ranged from 3.7% in spring to 9.1% in winter.

Collector proportions in Prairie Creek ranged from 44.9% in summer to 50.1% in winter (Figure 6). Scraper proportions in Prairie Creek ranged from 30.5% in summer to 35.8% in autumn. Predator proportions in Prairie Creek ranged from 8.1% in autumn to 13.9% in spring. Shredder proportions in Prairie Creek ranged from 5.5% in spring to 10.9% in summer.

DISCUSSION

Species Diversity

Species diversity is used in comparative studies of benthic invertebrate communities. Diversity indices are single values that consider the entire community of benthic organisms. These indices are influenced by the number of taxa in a sample and the evenness of distribution among taxa. A community is considered to have high species diversity if many equally or nearly equally abundant species are present. If a community is composed of a few species, or if only a few species are abundant, then species diversity is low. In general, high species diversity indicates a highly complex community, as a greater variety of species allows for a larger array of species interactions (Washington 1984).

Seasonality and Stability

Seasonality can be considered as the amount of change between seasons and, therefore, is a measure of temporal disruption to stable conditions. Vannote et al. (1980)

suggest that stream communities strive to preserve structural and functional stability by maintaining a constant rate of energy processing even when exposed to dramatic changes in quantity and quality of energy sources. Persistent environmental variation, such as sharp seasonality, disrupt stream ecosystem stability over relatively short periods of time. In highly stable environments, community contributions to ecosystem stability may be less critical. In widely fluctuating environments; however, the biota may assume critical importance in stabilizing the entire system. Species in temperate streams with extreme environmental fluctuations are well adapted to these fluctuations and, therefore, stability of the system can be maintained.

In systems with highly stable substrates, biotic diversity may be low and yet total stability of the stream ecosystem can be maintained. In contrast, systems with a high degree of physical variation may have high species diversity or at least the function of each species may be highly complex within the community, which acts to maintain stability. For example, areas within streams with unusual changes in seasonal temperatures may have organisms exposed to suboptimum temperatures for significant periods of time, but over some range in the season each species encounters a favorable or optimum temperature range. Under these conditions an optimum temperature may occur for a larger

number of species, as opposed to areas within streams with little change in stream temperature. This same example can apply to other environmental conditions as well.

MacArthur (1972) and Wiens (1977) state that sharp seasonality in temperate areas increases diversity in animal communities. Hutchinson (1951) working with plankton, concluded that diversity was caused by perturbations brought about by seasonal change. Hughes (1978) stated that time of year is an important factor to consider when comparing diversity samples from different locations. He found that the time of year in which benthic samples were taken exerted considerable influence on diversity values as a result of changes in benthic community life cycles.

Analysis of Diversity

The results of this study revealed no significant difference in seasonal diversity values between the two streams. Other recent studies from geographic areas with sharp contrasts in seasonal climatic conditions have had similar results. Andrews and Minshall (1978) found little difference in benthic invertebrate community diversity between seasons, except for severe ice conditions at one site, in the Rocky Mountains of Idaho. Arnekleiv (1985) reported only slight seasonal trends in species diversity in

a Norwegian Boreal stream. Rosillon (1985) found minimal seasonal changes in benthic community diversity in a Belgium chalk stream.

Studies on seasonal diversity of benthic communities in streams with high water temperatures in summer should have more variation (D. R. Lauck, personal communication). Benthic samples taken during high water temperatures in summer should have significantly lower sample diversities when compared to samples taken during other periods of the year.

The statistical difference of diversity values between the two streams was unexpected, as the streams have many similar physical, biological, geographical, and hydraulic features (Janda et al. 1975, Iwatsubo et al. 1975, and U. S. Department of Transportation et al. 1984). The significant qualitative difference between the two watersheds may be the past logging activities on Lost Man Creek. The long-term impact of logging on stream invertebrates depends on the stability of the watershed. Murphy and Hall (1981) found that logged sites, where the stream remained exposed to sunlight up to 17 years after harvest, had greater biomass, density, and species richness of insects compared to old growth forest streams in the Cascade Range of Oregon. Erman et al. (1977) report that logging increased total numbers and biomass in west coast streams but decreased species

diversity. Estimates of Simpson's species diversity frequently decline in logged watersheds, because systems become dominated by a few species, even though other species may be present in remnant numbers (Gregory et al. 1987).

Diversity indices generally have both a species number component (richness) and a component which measures abundance of individuals within species (evenness). Lost Man Creek benthic samples had a greater abundance of aquatic invertebrates compared to Prairie Creek yet diversity values from Lost Man Creek were significantly less (Appendix A). Lower diversity values from Lost Man Creek benthic samples resulted from large numbers of individuals from a few taxa. These dominant taxa resulted in a low evenness component, which is reflected in the low diversity values from Lost Man Creek throughout the year.

Usefulness of Species Diversity

The use of indices of species diversity for documenting effects of pollution or environmental disturbance on invertebrate communities has been questioned by Hurlbert (1971), Margalef (1972), Pielou (1975), Hughes (1978), and Washington (1984). Pielou (1975) states that a community's diversity index is a single descriptive statistic which is not very informative by itself. Pielou suggests that the belief of many ecologists that a diversity index provides a basis for reaching a full understanding of community

structure is highly inaccurate. Hughes (1978) believed diversity indices mask considerable information by representing an entire community by a single number. Such indices cannot be depended upon to reflect subtle differences among communities. Hughes concluded that although diversity index values are useful indices of community structure in general, they cannot stand alone as indicators of environmental change. Washington (1984) stated that although a diversity index can be an important tool in assessing environmental disturbance, it cannot suffice by itself and can never replace an in-depth study of community structure. The functional organization analysis of this study provides an additional measure of benthic invertebrate community structure.

Patterns of Seasonal Abundance

Hynes (1970) stated that invertebrate abundance in temperate streams is expected to exhibit two peaks, in spring and in autumn, as the young emerge from eggs. During late spring and late summer, many species emerge as adults thus reducing invertebrate numbers to yearly lows. Invertebrate numbers tend to decline in winter as predation and climatic conditions reduce survival.

Lost Man Creek and Prairie Creek invertebrate seasonal abundance patterns (Figures 3,4) differ from the general model of seasonal fluctuation presented by Hynes (1970).

This study revealed yearly lows in total numbers of invertebrates during spring and a single peak abundance in late summer to early autumn (Figures 3,4). The decline of invertebrates in spring is likely associated with adult emergence patterns (Merritt and Cummins 1984). The increased numbers of invertebrates in summer and early fall may reflect life history patterns of shredders and collectors as a result of increased seasonal allochthonous inputs. Consistent autochthonous contributions during this same period may maintain scraper abundance as well. Thus the seasonality of invertebrate abundance in these coastal streams were somewhat different when compared to seasonal invertebrate abundance patterns from streams of more temperate areas.

Functional Organization of Stream Invertebrates

Southward (1977) stated that stream physical structure coupled with the hydrologic cycle form a template for biological responses and result in consistent patterns of community structure and function dependent on the organic matter loading, transport, utilization, and storage within a river system. Vannote et al. (1980) speculated that natural stream ecosystems should tend towards uniformity of energy flow on an annual basis. Although processing rates and efficiencies of energy use by consumer organisms are believed to approach equilibrium for the year, major organic

sources shift seasonally. In natural stream systems, both living and detrital food bases are processed continuously, but there is a seasonal shift in the relative importance of autotrophic production vs. detritus loading and processing (Vannote et al. 1980). Studies by (Minshall 1967, Coffman et al. 1971, Kaushik and Hynes 1971, MacKay and Kalff 1973, Cummins 1974, and Sedell et al. 1974) have shown the importance of allocthonous detritus in supporting autumn-winter food chains and providing a fine particulate base for consumer organisms during other times of the year. Autotrophic communities often form the major food base, especially in spring and summer months. According to theory, shredders should have maximum abundance in streams during late summer and autumn. Scraper dominance follows seasonal shifts in primary production and is maximized in winter and early spring. With a reduction in organic matter particle size, collectors should increase in importance and dominate invertebrate communities in summer and early winter.

Invertebrate functional organization in both study sites closely resembled theoretical functional group assemblages in mid-sized rivers (order 4-6) as described by Vannote et al. (1980). According to Vannote et al. (1980) predicted stream gross primary production should be in

excess of stream community respiration. Sample sites in this study had dominant numbers of scrapers and collectors throughout the year indicating that both study sites rely heavily on autochthonous primary production and organic matter transport from upstream.

Shredders

As predicted by RCC theory, shredder abundance was greatest during autumn and lowest during spring in both streams (Table 5). This pattern reflects seasonal changes in food quantity. Shredders were most abundant during increased CPOM inputs from leaf fall and woody debris accumulation.

Decreased shredder abundance in spring may reflect invertebrate life history patterns. Howe (1980) reports that shredder abundance decreased rapidly in spring with the emergence of insect adults. Increased shredder abundance in summer may be a result of hatching and growth of shredder invertebrates.

Percent abundance of shredders in autumn (Figures 5,6) was less than expected in both streams when compared to stream theory (Cummins 1974 and Vannote et al. 1980). These differences may be partly due to the unpredicted numerical dominance of collectors present at both sites. Although CPOM input does have a strong autumnal peak, this may not be

reflected in benthic organic matter biomass for three reasons (Minshall et al. 1983):

1. Timing of the inputs relative to when the samples are taken.
2. Accumulation of organic matter in relatively rare depositional areas.
3. The fact that freshly fallen leaves do not enter the storage compartment in streams as readily as weathered leaves transported into the stream in winter and spring.

The quality of CPOM may also influence shredder abundance. Studies by MacKay and Kalff (1973), Iversen (1974), Anderson (1976), and Anderson and Cummins (1979), and Cummins and Klug (1980) have shown that food quality can be as important as food quantity in limiting population abundance and growth of shredders. Triska et al. (1982) and Gregory et al. (1987) state that coniferous organic matter takes a much longer period of time to breakdown in natural systems compared to deciduous organic matter, thus organic matter from old growth redwood forests may persist in a stream system longer than originally thought. This may help to explain the high relative numbers of shredders throughout the winter months in both streams.

Scrapers

In this study, modification of food resources as a result of seasonality among the two streams did not always evoke patterns of trophic structure that were expected based on previous stream theory. Scraper abundance patterns were similar in both streams as scrapers increased from spring through autumn, but then declined in winter (Figures 3,4). These results do not follow stream theory predictions. Scraper abundance is expected to remain high during winter and early spring as direct solar radiation increases primary production as a result of reduced riparian shade (Vannote et al. 1980). Beschta et al. (1987) however, reports that winter solar radiation levels at the stream surface for coastal streams in the Pacific Northwest are typically low, regardless of canopy cover. This is a result of a combination of factors affecting the availability of direct-beam solar radiation: short days, low sun angles, and cloudy weather. During summer months when solar radiation levels are greatly increased with higher sun angles, longer days, and clear skies, shading effects of the forest canopy become significant.

Winter decreases in scraper abundance may be a result

of life history patterns. However, if most life history characteristics are adaptive and have evolved to take advantage of favorable environmental conditions (such as habitat, food, or temperature) decreasing abundance as a result of adult emergence may reflect, to some extent, the quality and quantity of food resources (Meats 1971, Wilbur et al. 1974, Stearns 1977, and Collins 1980).

Food quality may influence scraper abundance. Hawkins and Sedell (1981) state that algal species which exhibit filamentous or mat-like morphologies will not be harvested as efficiently as thin organic films on substrate surfaces. In Cascade streams with open canopies, a succession of both algal species and growth forms occur throughout the year. In shaded Cascade streams, unicellular diatoms are dominant over the entire year. Therefore, although production may be highest in open streams (Vannote et al. 1980), availability of food items that can be harvested efficiently or digested easily may be nearly as great or more predictable in moderately to heavily shaded streams. If unicellular algae are abundant in coastal streams throughout the year, an unexpected summer and autumn food source may influence scraper seasonal abundance.

Predators

Predator abundance was greatest during summer (Table 5). This may reflect life history patterns of both

prey species and predators. The increased numbers of both shredders and collectors in summer provides an increased food source for stream predators. Predator population may have adapted to take advantage of additional food supplies. The seasonal lows in relative abundance of predators during fall (Figures 5,6) may reflect adult emergence patterns.

According to stream theory, predator abundance should remain relatively constant, reflecting a consistent abundance of prey species throughout the year. Other food sources are expected to reflect seasonal increases within the stream.

Collectors

Collectors exhibited different patterns of seasonal abundance between the two streams. Lost Man Creek collector abundance peaked dramatically in summer from a yearly low the previous spring (Figure 3). Collector numbers then dropped throughout the remainder of the study. Prairie Creek collectors exhibited a more subtle increase in numbers from spring through its peak in autumn and then decreased through winter (Figure 4). Collector abundance patterns generally followed the same patterns of other functional groups. This may reflect the ability of collectors to immediately process FPOM from shredder and scraper CPOM breakdown throughout the entire year.

Organic matter cannot serve as a nutritional resource for aquatic invertebrates until it is retained within the stream channel. Gregory et al. (1987) states that material in transport in a stream channel is retained by either passively dropping out of transport and settling on the stream bottom or being actively trapped against another object. Dissolved organic material may be retained by bacterial activity. The difference in collector abundance, especially during summer and autumn, may be a result of greater organic matter accumulation or retention in Lost Man Creek.

Minshall et al. (1983) state that retention of organic matter in streams differs presumably because of various numbers and effectiveness of geomorphic and hydraulic controls affecting deposition. Also, mid-sized streams constantly undergo change as reflected by their wide range of discharges, large-scale bed movements, and lack of storage and its attendant buffering capacity in terms of food resources.

Deviations from Stream Theory Predictions

Minshall et al. (1983) stated that deviations from expected patterns in functional organization may be explainable largely on the basis of variations imposed by :

- 1) broad scale riparian vegetation,
- 2) local-specific lithologic and geomorphic features (channel braiding, block

boulders, and outcrop features), 3) tributaries, and 4) watershed climate and geology. Climatic and geologic controls can affect nutrient supply, runoff pattern and amount, and general geomorphic responses.

The mild coastal climate differs considerably with other temperate climates. The range of temperatures experienced in coastal streams is relatively low because of the maritime influence of the Pacific Ocean on the coastal climate. Coastal climates produce more rainfall on the average and have longer growing seasons (National Oceanic and Atmospheric Administration 1974). Compared with most temperate climates, sharp seasonal contrasts in temperature and growth are much less in coastal areas. If coastal climates differ significantly from Cascade and Rocky Mountain climates, benthic invertebrate communities may also reflect such differences.

Watersheds disturbed by logging activities may exhibit somewhat different invertebrate functional group organization than predicted by stream theory (Gregory et al. 1987). Increased light and nutrient levels as a result of timber harvest can increase stream primary production for 10 to 20 years. Scrapers should be most abundant in the initial period following harvest when algal production is highest. This period of enhanced primary production will last until development of the second-growth canopy results in light intensities similar to those of mature forest

conditions. The rate of recovery from logging activities is greater for moist coastal watersheds of the Pacific Northwest compared to the Cascades and Rocky Mountains (Summers 1983). On the average, 50% of each study stream was shaded within five years of harvesting and burning in the Coastal Range in western Oregon. Removal of the forest canopy by timber harvest greatly alters the quantity and quality of allocthonous organic matter in stream ecosystems (Gregory et al. 1987). The source of coarse woody debris to stream channels is often lost for more than a century. The composition of CPOM is shifted for 50 to 80 years as the coniferous material, which is relatively decay resistant, is replaced by deciduous material, which is more rapidly decomposed. Stream invertebrate functional group organization in Lost Man Creek may reflect past logging activities in the watershed as this would help to explain the proportionately larger number of shredders in Prairie Creek throughout the study when compared to Lost Man Creek.

Differences from study results and expected patterns of functional organization based on stream theory may be, in part, a result of inadequate categorization of species functional groups. Caution should be used when placing benthic invertebrates into functional categories based on published information (Platts et al. 1983). Hawkins et al. (1982) state that many taxa may be more facultative in both their feeding behavior and food requirements than authors

originally suspected. Groups such as Baetidae, Ephemerellidae, Nemouridae, and many Limnephilidae have generalized mouthparts which may function equally well in consuming large particles (CPOM), attached food, or loose particles (FPOM). Discrepancies also exist in the fact that approximations of functional categories may vary among streams, time of year, and invertebrate size or life cycle.

It is also important to understand that random selection of sample collection sites was not achieved during the study. Collection locations were arbitrarily selected by the author to represent a continuum of depth, velocity, shade, and substrate size, heterogeneity, and roughness measurements. Therefore, the results of this study may or may not represent actual conditions as they appear in nature. The author, however, believes that due to the large sample size, study results accurately estimate natural stream ecosystem conditions.

CONCLUSIONS

Seasonal shifts in stream conditions result from changes in stream discharge, bedload movement, temperature regime, and food quantity and quality. These factors are important in structuring and organizing stream invertebrate communities. In order to understand the importance of each factor, taxa should be examined from a number of perspectives. Species diversity and functional group perspectives can be useful. Seasonal changes in physical environments of streams may produce distinct shifts in species structure of invertebrate communities. Functional organization may follow different trends. Functional group classification simplifies community data, as it separates the biota into subgroups. These subgroups are easier to work with and understand than the complex interactions of the entire community. Separation of the biota into subgroups may help to reduce community variability which may

be due to structural and taxonomic complexity. Reduction in community variability enhances our ability to recognize seasonal trends and patterns and thus increase our understanding of the natural stream ecosystem.

Species diversity among the two streams exhibited unexpected results. Seasonality had less effect on species diversity in the two streams than expected. Logging activities in Lost Man Creek over 20 years ago (late 1950s to late 1960s) may be influencing species diversity of benthic invertebrates.

This study has revealed both expected and unexpected seasonal changes in the functional organization of stream invertebrates. The unexpected results in stream invertebrate functional organization may be due to one or more of the following factors:

Coastal climate; life history patterns of stream invertebrates; quantity and quality of food resources; past logging activities in the Lost Man Creek watershed; local geology; functional group categorization; and nonrandom sampling.

Further studies in coastal streams are needed to develop an accurate understanding of the effects that maritime climates may have on seasonal functional organization of stream invertebrates. Additional studies are needed to document natural changes in functional group composition of stream invertebrate communities with seasons.

Future studies need to address such factors as; seasonal differences in quantity and quality of stream allocthonous and autocthonous food resources, geographic as well as seasonal variation in species feeding behavior (functional group), and the effects of logging on stream invertebrate functional group composition.

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PERSONAL COMMUNICATION

Lauck, D. R. Biology Professor, Humboldt State University, Arcata,
CA. 95521.

Appendix A. Abundance of Benthic Invertebrates from Lost Man Creek, March 1986-March 1987. Sample Dates Represent Total Invertebrates from 15 Individual Collections. (* = adjusted winter values for three sample date comparisons).

TAXA	Lost Man Creek										
	Spring			Summer			Autumn			Winter	
	Mar 16/87	Mar 26/86	Apr 28/86	Jun 4/86	Jul 7/86	Aug 13/86	Sep 11/86	Oct 21/86	Nov 24/86	Dec 30/86	Feb 4/87
Phylum Arthropoda											
Subphylum Mandibulata											
Class Insecta											
Order Ephemeroptera											
Family Baetidae											
<u>Baetis</u> spp.	637	332	1264	1390	6377	5487	2654	1590	669	874	654
Family Ephemerellidae											
<u>Attenella</u> <u>margarita</u>					20	5					
<u>Caudatella</u> <u>heterocaudata</u>	1	1			1	2	4	10	9	5	18
<u>Ephemerella</u> <u>infrequens</u>		4									
<u>Ephemerella</u> <u>mollitia</u>	78	4	2		181	1826	513	1329	908	759	78
<u>Drunella</u> <u>coloradensis</u>	47	59	76	21	5			1	87	240	392
<u>Drunella</u> <u>doddsi</u>	2		15	33	17	19	16	4	3		4
<u>Serratella</u> <u>levis</u>					3						
<u>Serratella</u> <u>teresa</u>	17	20	110	97	22	11	2				
<u>Serratella</u> <u>tibialis</u>	5	23	129	302	99	54	8			1	
<u>Timpanoga</u> <u>hecuba</u>			9	24	10	3					
Family Heptageniidae											
<u>Cinygmula</u> sp.	1049	347	295	67	165	453	70	524	712	1738	681
<u>Epeorus</u> <u>albertae</u>	536	236	345	150		23	533	640	1303	1077	304
<u>Epeorus</u> <u>longimanus</u>	245	48	200	391	117	16	2	32	40	288	458
<u>Heptagenia</u> sp.		2	2	38	245	49	51	1			2
<u>Ironodes</u> sp.	39	13	14	23	39	60	103	233	186	176	72
<u>Rhithrogena</u> sp.	54	42	14	5	777	2752	2400	1210	728	328	89
Family Leptophlebiidae											
<u>Paraleptophlebia</u> <u>bicornuta</u>							61				
<u>Paraleptophlebia</u> sp.	388	177	234	222	140	235	555	288	252	314	105
Family Siphonuridae											
<u>Ameletus</u> sp.	181	27	106	195	71	38	63	59	63	88	38
Family Tricorythidae											
<u>Tricorythodes</u> sp.						2					

Appendix A. Abundance of Benthic Invertebrates from Lost Man Creek, March 1986-March 1987. Sample Dates Represent Total Invertebrates from 15 Individual Collections. (* = adjusted winter values for three sample date comparisons). (continued)

TAXA	Lost Man Creek									
	Spring			Summer			Autumn			Winter
	Mar 16/87	Mar 26/86	Apr 28/86	Jun 4/86	Jul 7/86	Aug 13/86	Sep 11/86	Oct 21/86	Nov 24/86	Dec 30/86 Feb 4/87
Order Odonata										
Family Gomphidae										
<u>Gomphus sp.</u>	8	1	3	2	2		3	19	29	6 5
Order Plecoptera										
Family Capniidae										
<u>Capnia sp.</u>	61	12	32	42	50	29	52	1221	230	869 45
<u>Paracapnia angulata</u>	14	2			1	2		10	3	8 6
Family Chloroperlidae										
<u>Paraperla frontalis</u>	1	8	18	10	15	5	8	29	5	4 6
<u>Suwalia sp.</u>	72	53	93	93	46	42	106	87	53	53 58
Family Nemouridae										
<u>Zapada cinctipes</u>	177	101	102	658	753	963	385	550	282	628 132
<u>Zapada oregonensis</u>	1	1	8		29	65	15	20	14	26 4
Family Peltoperlidae										
<u>Yoroperla brevis</u>	1	1	1	1	5	3		1		1 3
Family Perlidae										
<u>Calineuria californica</u>	158	219	757	590	350	399	306	165	222	149 102
<u>Hesperoperla pacifica</u>	30	7	7	28	13	12	7	10	11	30 32
Family Perlodidae										
<u>Cultus sp.</u>		21	19							
<u>Isoperla sp.</u>					1	32	114	70	76	51
<u>Kogotus nonus</u>	40	2	12	9	2					1 51
Family Pteronarcyidae										
<u>Pteronarcys californica</u>			1	1	1		1	1	2	4 2
Order Hemiptera										
Family Gerridae										
<u>Gerris sp.</u>								1		

Appendix A. Abundance of Benthic Invertebrates from Lost Man Creek, March 1986-March 1987. Sample Dates Represent Total Invertebrates from 15 Individual Collections. (* = adjusted winter values for three sample date comparisons). (continued)

TAXA	Lost Man Creek									
	Spring			Summer			Autumn			Winter
	Mar 16/87	Mar 26/86	Apr 28/86	Jun 4/86	Jul 7/86	Aug 13/86	Sep 11/86	Oct 21/86	Nov 24/86	Dec 30/86 Feb 4/87
Order Megaloptera										
Family Corydalidae										
<u>Orohermes crepusculus</u>	1	1		4			5		1	
Family Sialidae										
<u>Sialis sp.</u>	2						18		2	
Order Trichoptera										
Family Brachycentridae										
<u>Micrasema onisca</u>			2	6	2	8	1	2	7	9 11
Family Calamoceratidae										
<u>Heteroplectron californicum</u>				1		2	7	1	2	1 1
Family Glossosomatidae										
<u>Agapetus taho</u>					24	22	11	1		1
<u>Glossosoma sp.</u>	14	9	28	27	57	266	43	18	59	121 38
Family Hydropsychidae					6	10	2	5	2	1
<u>Arctopsyche grandis</u>										
<u>Hydropsyche sp.</u>	34	93	162	75	30	908	604	468	188	202 131
Family Hydroptilidae										
<u>Hydroptila sp.</u>						12	10	2	2	1
<u>Ochrotrichia sp.</u>			3	124	308	6	1		2	
<u>Palaeagapetus nearcticus</u>			2							4
Family Lepidostomatidae										
<u>Lepidostoma sp.</u>	43	5	7	7	120	29	124	31	41	29 3
Family Limnephilidae										
<u>Apatania sorex</u>	46		14	136	133	34	127	6	10	
<u>Dicosmoecus gilvipes</u>	74	9	9	13	4			2	54	3 12
<u>Ecclisomyia conspersa</u>						5	12	21	22	1
<u>Hydatophylax hesperus</u>						30	93	7	4	6
<u>Neophylax rickeri</u>	350	43	31	6	8	16	6			2 159
<u>Onocosmoecus sp.</u>									1	
Family Philopotamidae										
<u>Wormaldia sp.</u>			1	8	45	3		1		

Appendix A. Abundance of Benthic Invertebrates from Lost Man Creek, March 1986-March 1987. Sample Dates Represent Total Invertebrates from 15 Individual Collections. (* = adjusted winter values for three sample date comparisons). (continued)

TAXA	Lost Man Creek										
	Spring			Summer			Autumn			Winter	
	Mar 16/87	Mar 26/86	Apr 28/86	Jun 4/86	Jul 7/86	Aug 13/86	Sep 11/86	Oct 21/86	Nov 24/86	Dec 30/86	Feb 4/87
Family Polycentropodidae											
<u>Polycentropus sp.</u>							1				
Family Rhyacophilidae											
<u>Rhyacophila spp.</u>	141	157	181	198	127	177	104	143	148	248	125
Family Sericostomatidae											
<u>Gumaga griseola</u>	48	8	20	15	18	29	150	112	29	35	7
Family Uenoidae											
<u>Farula sp.</u>	1	6	1	4	3	5	1			3	
Order Coleoptera (larvae)										3	
Family Anthicidae (adult)			1								
Family Dytiscidae											
<u>Oreodytes sp.</u> (adult)			1	1		15	2	11			
<u>Oreodytes sp.</u> (larvae)				6	15	14	2			1	
Family Elmidae											
<u>Ampunixis dispar</u> (adult)						1					
<u>Ampunixis dispar</u> (larvae)	2	14		14	47	36	41	33	6	4	1
<u>Heterlimnius koebeleii</u> (adult)			3	2	12	4	15				
<u>Heterlimnius koebeleii</u> (larvae)			5								
<u>Lara sp.</u> (larvae)	2	4	4	2			2	4	4	1	1
<u>Narpus concolor</u> (adult)				4	26	1	1	2			
<u>Narpus concolor</u> (larvae)	48	42	14	35	26	28	168	60	18	6	9
<u>Optioservus sp.</u> (adult)	23	42	128	264	132	312	583	86	29	4	20
<u>Optioservus sp.</u> (larvae)	58	182	823	1384	713	1440	3478	2930	357	45	48
<u>Ordobrevia nubifera</u> (adult)		1	1	6	6	4	14	4			
<u>Ordobrevia nubifera</u> (larvae)		27	74	266	70	84	386	32		2	
<u>Zaitzevia parvula</u> (adult)	1	12	184	207	98	90	107	8	12	1	
<u>Zaitzevia parvula</u> (larvae)	20	237	335	492	720	292	651	344	127	15	14
Family Haliplidae											
<u>Brychius sp.</u> (larvae)					3	5	4	1			
<u>Haliplus sp.</u> (larvae)					30				1		

Appendix A. Abundance of Benthic Invertebrates from Lost Man Creek, March 1986-March 1987. Sample Dates Represent Total Invertebrates from 15 Individual Collections. (* = adjusted winter values for three sample date comparisons). (continued)

TAXA	Lost Man Creek									
	Spring			Summer			Autumn			Winter
	Mar 16/87	Mar 26/86	Apr 28/86	Jun 4/86	Jul 7/86	Aug 13/86	Sep 11/86	Oct 21/86	Nov 24/86	Dec 30/86 Feb 4/87
Family Hydrophilidae										
<u>Tropisternus</u> sp. (larvae)			1							
Family Psephenidae										
<u>Eubrianax edwardsi</u> (larvae)		1		3	2	3	2	1		1
Family Ptilodactylidae										
<u>Anchytarsus</u> sp. (larvae)	1									1
Family Salpingidae (larvae)	1									
Order Diptera										
Family Blephariceridae										
<u>Philorus californicus</u>								1		
Family Ceratopogonidae										
<u>Bezzia</u> sp.	8	11	16	158	48	97	87	73	27	39 12
<u>Atrichopogon</u> sp.		1					1			
Family Chironomidae										
Subfamily Chironominae										
Tribe Chironomini	1					3	7			
<u>Polypedilum</u> sp.	32	33	68	62	271	391	486	1168	726	601 17
Tribe Tanytarsini	114	36	160	422	702	2068	3743	2343	2126	710 58
<u>Rheotanytarsus</u> sp.	3				7	8	7	2	8	10 2
<u>Stempellina</u> sp.	21	46	1		9	150	69	312	150	25 15
<u>Stempellinella</u> sp.	488	170	69	37	115	51	62	11	166	224 72
Subfamily Orthocladiinae	256	157	2051	870	2299	2717	338	836	822	909 142
<u>Heterotanytarsus</u> sp.	2						4	1	1	
<u>Krenosmittia</u> sp.	3	2	5	6	2	15	6	2	3	13 4
<u>Lopescladius</u> sp.					1		2	1		
Subfamily Podonominae										
Tribe Boreochlini										
<u>Boreochlus</u> sp.					2					
Subfamily Tanypodinae	17	17	35	113	168	127	192	72	15	21 10

Appendix A. Abundance of Benthic Invertebrates from Lost Man Creek, March 1986-March 1987. Sample Dates Represent Total Invertebrates from 15 Individual Collections. (* = adjusted winter values for three sample date comparisons). (continued)

TAXA	Lost Man Creek										
	Spring			Summer			Autumn			Winter	
	Mar 16/87	Mar 26/86	Apr 28/86	Jun 4/86	Jul 7/86	Aug 13/86	Sep 11/86	Oct 21/86	Nov 24/86	Dec 30/86	Feb 4/87
Family Dixidae											
<u>Dixa sp.</u>					7	2	26	5			1
Family Dolichopodidae	2			3	2	1	1	2		1	
Family Empididae											
<u>Chelifera sp.</u>	33	36	24	33	10	4	12	18	6	15	16
Family Muscidae						5					
Family Pelecorhynchidae											
<u>Glutops sp.</u>	2	1	6	17	4	25	24	5	4	4	
Family Psychodidae											
<u>Maruina lanceolata</u>			2		1			1			
<u>Pericoma sp.</u>	1				15	38	23	30	24	5	3
Family Ptychopteridae											
<u>Ptychoptera sp.</u>	8										1
Family Sarcophagidae											2
Family Simuliidae											
<u>Prosimulium sp.</u>			7							1	1
<u>Simulium sp.</u>	12	5	436	42	3771	2055	1222	1178	2851	389	102
Family Stratiomyidae											
<u>Myxosargus sp.</u>	1						1				
Family Tabanidae											
<u>Tabanus sp.</u>	1						4		1		
Family Tipulidae											
<u>Antocha monticola</u>	8	6	21	18	83	445	14	86		40	35
<u>Dicranota sp.</u>						18	7	5	1		4
<u>Hexatoma sp.</u>	4	23	60	88	16	120	46	148	31	9	4
Insect totals	5769	3200	8844	9571	19875	24818	21193	18739	13958	11480	4428
Class Crustacea											
Order Amphipoda											
Family Gammaridae											
<u>Anisogammarus conferviculus</u>	24	6	9	8	38	8	18	29	11	31	33

Appendix A. Abundance of Benthic Invertebrates from Lost Man Creek, March 1986-March 1987. Sample Dates Represent Total Invertebrates from 15 Individual Collections. (* = adjusted winter values for three sample date comparisons). (continued)

TAXA	Lost Man Creek										
	Spring			Summer			Autumn			Winter	
	Mar 16/87	Mar 26/86	Apr 28/86	Jun 4/86	Jul 7/86	Aug 13/86	Sep 11/86	Oct 21/86	Nov 24/86	Dec 30/86	Feb 4/87
Subphylum Chelicerata											
Class Arachnida											
Order Acari											
Suborder Hydracarina	50	16	498	1255	904	1058	1037	171	71	11	17
Phylum Mollusca											
Class Gastropoda											
Order Basommatophora											
Family Physidae											
Physa sp.						1					
Family Planorbidae											
Gyraulus sp.	3	1	1		1	2		3	2	2	
Order Mesogastropoda											
Family Pleuroceridae											
Juga sp.	1	7	10	69	28	120	205	34	51	23	5
Class Pelecypoda											
Order Heterodonta											
Family Sphaeriidae											
Sphaerium corneum	4	5		3	3	1	12	4	7		
Phylum Annelida											
Class Oligochaeta	434	40	35	175	398	1489	395	1910	933	3929	603
Noninsect totals	516	75	553	1510	1372	2679	1667	2151	1075	3996	658
Collection Totals	6285	3275	9397	11081	21247	27497	22860	20890	15033	15476	*10281
SEASONAL TOTALS	18957			59825			58783			20562	*39490

Appendix B. Abundance of Benthic Invertebrates from Prairie Creek, March 1986-March 1987. Sample Dates Represent Total Invertebrates from 15 Individual Collections. (* = adjusted winter values for three sample date comparisons).

Prairie Creek											
Taxa	Spring			Summer			Autumn			Winter	
	Mar 13/87	Mar 24/86	Apr 30/86	Jun 2/86	Jul 8/86	Aug 12/86	Sep 12/86	Oct 23/86	Nov 25/86	Dec 29/86	Feb 3/87
Phylum Arthropoda											
Subphylum Mandibulata											
Class Insecta											
Order Ephemeroptera											
Family Baetidae											
<u>Baetis</u> spp.	406	229	712	635	1476	2093	1148	670	446	638	632
Family Ephemerellidae											
<u>Ephemerella inermis</u>		10	1				1				
<u>Ephemerella infrequens</u>			1								
<u>Ephemerella mollitia</u>	24	1		1	1	68	347	320	313	150	71
<u>Drunella coloradensis</u>	44	80	31	14	2	1		1	14	710	69
<u>Drunella doddsi</u>	5	15	128	168	105	45	121	47	21	37	9
<u>Drunella grandis</u>									1		
<u>Drunella spinifera</u>								2		1	
<u>Serratella teresa</u>			38	25	23						
<u>Serratella tibialis</u>	24	57	314	151	27	9					1
<u>Timpanoga hecuba</u>			3	10							
Family Heptageniidae											
<u>Cinygmula</u> sp.	496	200	129	81	181	33	27	298	456	768	661
<u>Epeorus albertae</u>	601	432	751	404	130	69	94	753	270	952	877
<u>Epeorus longimanus</u>	134	24	173	252	23	12	5	1	40	284	246
<u>Heptagenia</u> sp.	11	1	30	27	113	18	28	18	5	16	11
<u>Ironodes</u> sp.	81	41	86	68	28	93	113	185	179	156	208
<u>Rhithrogena</u> sp.	48	42	6	14	492	488	1115	602	143	156	124
Family Leptophlebiidae											
<u>Paraleptophlebia</u> sp.	155	96	233	88	69	112	243	599	172	286	210
Family Siphonuridae											
<u>Ameletus</u> sp.	55	93	98	295	88	37	47	49	95	194	39
Order Odonata											
Family Gomphidae											
<u>Gomphus</u> sp.	16	15	14	6	12	11	10	30	8	13	62

Appendix B. Abundance of Benthic Invertebrates from Prairie Creek, March 1986-March 1987. Sample Dates Represent Total Invertebrates from 15 Individual Collections. (* = adjusted winter values for three sample date comparisons). (continued)

Taxa	Prairie Creek										
	Spring			Summer			Autumn			Winter	
	Mar 13/87	Mar 24/86	Apr 30/86	Jun 2/86	Jul 8/86	Aug 12/86	Sep 12/86	Oct 23/86	Nov 25/86	Dec 29/86	Feb 3/87
Order Plecoptera											
Family Capniidae											
<u>Capnia sp.</u>	30	30	75	68	37	36	182	176	145	118	95
<u>Paracapnia angulata</u>	6	5	6		3	2	3	17	13	21	25
Family Chloroperlidae											
<u>Paraperla frontalis</u>	1	27	22	27	10	11	19	5	5	7	9
<u>Suwalia sp.</u>	79	65	100	130	94	79	194	150	64	79	111
Family Nemouridae											
<u>Zapada cinctipes</u>	230	77	115	550	768	382	822	88	177	246	269
<u>Zapada oregonensis</u>				16	32	11	16	5	6	1	1
Family Peltoperlidae											
<u>Yoroperla brevis</u>	15	6	23	18	17	71	8	42	70	18	11
Family Perlidae											
<u>Calineuria californica</u>	130	260	373	507	514	253	321	205	100	168	195
<u>Hesperoperla pacifica</u>	20	6	13	7	7	16	7	6	17	17	21
Family Perlodidae											
<u>Cultus sp.</u>	2	12		3					1		
<u>Isoperla sp.</u>							3	2	16	10	
<u>Kogotus nonus</u>						1					
Family Pteronarcyidae											
<u>Pteronarcys californica</u>	4	1	5	1	8	6		7	12	5	11
Order Hemiptera											
Family Corixidae											
<u>Sigara vandekeyi</u>									3		
Order Megaloptera											
Family Corydalidae											
<u>Orohermes crepusculus</u>			6	1	5	2	1	22	2		8
Family Sialidae											
<u>Sialis sp.</u>	1		1		4	1	8	6	2	11	

Appendix B. Abundance of Benthic Invertebrates from Prairie Creek, March 1986-March 1987. Sample Dates Represent Total Invertebrates from 15 Individual Collections. (* = adjusted winter values for three sample date comparisons). (continued)

Taxa	Prairie Creek									
	Spring			Summer			Autumn			Winter
	Mar 13/87	Mar 24/86	Apr 30/86	Jun 2/86	Jul 8/86	Aug 12/86	Sep 12/86	Oct 23/86	Nov 25/86	Dec 29/86 Feb 3/87
Order Trichoptera										
Family Brachycentridae										
<u>Micrasema onisca</u>	7	1	3	10	5	142	25	54	27	30 8
Family Calamoceratidae										
<u>Heteroplectron californicum</u>	5	6	3	2	1	1	12	10	2	
Family Glossosomatidae										
<u>Agapetus taho</u>			6	13	211	26	1			
<u>Glossosoma sp.</u>	276	118	74	118	389	1031	1907	1307	295	541 451
Family Hydropsychidae										
<u>Hydropsyche sp.</u>	86	125	146	53	134	1047	469	587	231	149 309
<u>Parapsyche sp.</u>			1							
Family Hydroptilidae										
<u>Ochrotrichia sp.</u>	1									
<u>Palaeagapetus nearcticus</u>	11			1	1	1		1	1	4
Family Lepidostomatidae										
<u>Lepidostoma sp.</u>	11	19	12	257	129	38	267	63	32	172 13
Family Limnephilidae										
<u>Apatania sorex</u>		20	7	75	125	5	17	18		8
<u>Dicosmoecus gilvipes</u>	4	2			1	3				
<u>Ecclisomyia conspersa</u>	2							2	5	
<u>Hydatophylax hesperus</u>	1									5
<u>Neophylax rickerti</u>	241	3	6		12	4	1		2	311 279
Family Philopotamidae										
<u>Wormaldia sp.</u>	78	12	15	12	6	39	44	29	55	134 79
Family Polycentropodidae										
<u>Polycentropus sp.</u>		2	1	4	2		22	6		6
Family Psychomyiidae										
<u>Psychomyia lumina</u>								1		
Family Rhyacophilidae										
<u>Rhyacophila spp.</u>	80	142	221	137	124	84	188	160	98	105 152

Appendix B. Abundance of Benthic Invertebrates from Prairie Creek, March 1986-March 1987. Sample Dates Represent Total Invertebrates from 15 Individual Collections. (* = adjusted winter values for three sample date comparisons). (continued)

Taxa	Prairie Creek										
	Spring			Summer			Autumn			Winter	
	Mar 13/87	Mar 24/86	Apr 30/86	Jun 2/86	Jul 8/86	Aug 12/86	Sep 12/86	Oct 23/86	Nov 25/86	Dec 29/86	Feb 3/87
Family Sericostomatidae											
<i>Gumaga griseola</i>	112	120	65	58	125	63	232	294	153	76	232
Family Uenoidae											
<i>Farula</i> sp.	226	1575	636	401	1272	629	588	908	866	179	367
Order Coleoptera											
Family Anthicidae (adult)	1			2	4	2					1
Family Dytiscidae											
<i>Oreodytes</i> sp. (adult)	2		7	3		5	17			2	
<i>Oreodytes</i> sp. (larvae)			3	8	15	10	9	1			
Family Elmidae											
<i>Ampumixis dispar</i> (larvae)		6		1			3	6	6		
<i>Heterlimnius koebelei</i> (adult)				2	7		1				
<i>Heterlimnius koebelei</i> (larvae)				2		4					
<i>Lara</i> sp. (larvae)	7	1	4	2		5	3	2	9	1	5
<i>Narpus concolor</i> (adult)				2	7						
<i>Narpus concolor</i> (larvae)	15	31	12	19	24	18	25	10	8	5	28
<i>Optioservus</i> sp. (adult)	67	115	98	187	164	92	611	455	29	12	22
<i>Optioservus</i> sp. (larvae)	129	329	546	1415	538	273	2536	1189	308	203	145
<i>Ordobrevia nubifera</i> (larvae)			1	1							
<i>Zaitzevia parvula</i> (adult)		1	5	15	10	14	7	1	1		2
<i>Zaitzevia parvula</i> (larvae)	29	36	28	25	42	25	32	15	6	4	7
Family Hydraenidae											
<i>Ochthebius</i> sp. (adult)						1					
Family Psephenidae											
<i>Eubrianax edwardsi</i> (larvae)	1										
Family Ptilidae (adult)						2					

Appendix B. Abundance of Benthic Invertebrates from Prairie Creek, March 1986-March 1987. Sample Dates Represent Total Invertebrates from 15 Individual Collections. (* = adjusted winter values for three sample date comparisons). (continued)

Taxa	Prairie Creek										
	Spring			Summer			Autumn			Winter	
	Mar 13/87	Mar 24/86	Apr 30/86	Jun 2/86	Jul 8/86	Aug 12/86	Sep 12/86	Oct 23/86	Nov 25/86	Dec 29/86	Feb 3/87
Order Diptera											
Family Ceratopogonidae											
<u>Bezzia sp.</u>	8	13	38	36	45	18	58	43	20	15	20
<u>Atrichopogon sp.</u>					1		5				
Family Chironomidae											
Subfamily Chironominae											
Tribe Chironomini	15	3	2		5	2	1				
<u>Polypedilum sp.</u>	15	36	91	27	17	13	140	261	123	192	186
Tribe Tanytarsini	592	270	661	378	715	198	1284	728	257	383	525
<u>Rheotanytarsus sp.</u>	5		22		56	36	21	24	17	4	16
<u>Stempellina sp.</u>	94	72	8	1	11	14	156	433	430	76	278
<u>Stempellinella sp.</u>	475	484	165	25	66	7	74	80	37	67	951
Subfamily Orthocladinae	311	363	583	387	462	225	718	364	345	356	272
<u>Heterotanytarsus sp.</u>	7						394	22	5	33	2
<u>Krenosmittia sp.</u>	14	33	14	2	5				1	4	22
Subfamily Tanypodinae	24	28	121	83	107	12	24	20	19	47	23
Family Culicidae											
<u>Anopheles sp.</u>								1			
Family Dixidae											
<u>Dixa sp.</u>				2	3	42	23	4			1
Family Dolichopodidae	1							1			
Family Empididae											
<u>Chelifera sp.</u>	30	85	110	43	17	8	18	8	25	18	35
Family Pelecophryidae											
<u>Glutops sp.</u>	8	12	27	26	42	15	52	35	8	8	22
Family Psychodidae											
<u>Maruina lanceolata</u>	9	1	5	14	1			1	1	4	18
<u>Pericoma sp.</u>					2	1	2	2			1
Family Ptychopteridae											
<u>Ptychoptera sp.</u>	2				5	4	17	1	1	13	3
Family Simuliidae											
<u>Simulium sp.</u>	30	6	29	47	121	337	49	102	117	36	94

Appendix B. Abundance of Benthic Invertebrates from Prairie Creek, March 1986-March 1987. Sample Dates Represent Total Invertebrates from 15 Individual Collections. (* = adjusted winter values for three sample date comparisons). (continued)

Taxa	Prairie Creek										
	Spring			Summer			Autumn			Winter	
	Mar 13/86	Mar 24/86	Apr 30/86	Jun 2/86	Jul 8/86	Aug 12/86	Sep 12/86	Oct 23/86	Nov 25/86	Dec 29/86	Feb 3/87
Family Stratiomyidae											
<u>Allognosta</u> sp.	1										
Family Tipulidae											
<u>Antocha</u> <u>monticola</u>	2	1	2	9	6	9	23	13	8	12	3
<u>Oicranota</u> sp.	1		3				1				
<u>Hexatoma</u> sp.	1	5	3	8	3	1	6	5	8	5	3
Insect totals	5655	5901	7271	7480	9307	8466	14966	11573	6352	8278	8555
Class Crustacea											
Order Amphipoda											
Family Gammaridae											
<u>Anisogammarus</u> <u>confervicolus</u>	108	84	81	470	38	33	758	30	36	137	44
Order Isopoda											
Family Asellidae											
<u>Asellus</u> sp.		1									
Subphylum Chelicerata											
Class Arachnida											
Order Acari											
Suborder Hydracarina	61	16	490	510	458	320	593	230	51	25	50
Phylum Mollusca											
Class Gastropoda											
Order Basommatophora											
Family Physidae											
<u>Physa</u> sp.	3	2		2	6				2	4	3
Family Planorbidae											
<u>Gyraulus</u> sp.			2	2	1			1	1	1	3

Appendix B. Abundance of Benthic Invertebrates from Prairie Creek, March 1986-March 1987. Sample Dates Represent Total Invertebrates from 15 Individual Collections. (* = adjusted winter values for three sample date comparisons). (continued)

Taxa	Prairie Creek									
	Spring			Summer			Autumn			Winter
	Mar 13/87	Mar 24/86	Apr 30/86	Jun 2/86	Jul 8/86	Aug 12/86	Sep 12/86	Oct 23/86	Nov 25/86	Dec 29/86 Feb 3/87
Order Mesogastropoda										
Family Hydrobiidae										
<u>Amnicola sp.</u>							6			
Family Pleuroceridae										
<u>Juga sp.</u>	75	64	93	220	94	95	664	568	30	97 86
Class Pelecypoda										
Order Heterodonta										
Family Sphaeriidae										
<u>Sphaerium corneum</u>	13		8	8	16	8	4	7	21	20 40
Phylum Annelida										
Class Oligochaeta	457	196	289	459	536	477	914	802	1410	1002 583
Class Adenophorea										
Order Rhabditida		3						1	1	
Noninsect totals	717	366	963	1671	1149	933	2939	1639	1552	1286 809
Collection Totals	6372	6267	8234	9151	10456	9399	17905	13212	7904	9564 9364 *9464
Seasonal Totals	20873			29006			39021			18928 *28392

Appendix C. Functional Group Composition from Lost Man Creek Benthic Invertebrate Collections, March 1986-March 1987. 77

Lost Man Creek

Predator Collector Scraper Shredder

Spring

March 26/86

60	139	53	14
41	132	48	10
38	31	32	0
78	202	138	9
29	57	30	5
59	108	41	13
1	44	7	3
26	147	83	14
38	143	52	7
22	34	17	0
30	20	25	5
57	215	70	12
98	349	164	38
31	63	22	6
22	16	2	1

March 16/87

60	123	120	5
22	108	54	13
28	265	141	31
61	560	188	74
131	768	219	85
61	154	211	9
12	74	72	18
29	45	42	3
20	101	6	42
24	50	21	8
43	179	226	4
45	107	338	16
2	441	6	3
88	379	278	60
53	70	86	9

April 28/86

92	572	56	2
24	217	24	2
62	227	47	7
68	533	58	2
58	200	64	7
82	368	35	2
61	292	52	1
166	364	270	34
318	472	317	28
93	533	30	3
88	336	49	7
167	653	135	8
140	636	33	54

Appendix C. Functional Group Composition from Lost Man Creek Benthic Invertebrate Collections, March 1986-March 1987. (continued) 73

Lost Man Creek

Predator Collector Scraper Shredder

April 28/86	95	385	130	21
	91	239	96	9
season				
totals	2914	11151	4188	704
				18957

Summer

June 4/86	414	1030	167	34
	48	264	74	15
	350	727	147	292
	125	262	219	19
	163	474	124	43
	28	262	70	23
	253	496	567	68
	484	471	228	67
	134	300	106	29
	70	114	22	23
	169	522	69	56
	61	159	47	11
	75	164	59	18
	194	192	106	17
	94	179	69	23

July 7/86	51	2012	52	122
	21	2915	46	25
	212	1673	118	70
	126	1614	151	131
	174	962	330	108
	395	1339	227	90
	108	2068	75	113
	62	651	105	49
	56	333	145	12
	45	217	69	25
	212	430	87	102
	54	192	103	38
	28	190	57	25
	30	613	41	34
	198	1393	285	83

Aug 13/86	236	1308	241	102
	240	988	299	44
	47	547	234	19
	332	1243	290	31
	88	3021	127	165
	105	1073	325	99

Appendix C. Functional Group Composition from Lost Man Creek Benthic Invertebrate Collections, March 1986-March 1987. (continued) 79

Lost Man Creek

Predator Collector Scraper Shredder

Aug 13/86	59	1592	120	35	
	283	1339	455	54	
	325	1223	490	150	
	233	2276	296	155	
	42	572	100	32	
	107	1078	258	57	
	111	790	93	67	
	189	1094	537	23	
	213	1418	237	136	
season					
totals	7044	41780	8067	2934	59825

Autumn

Sept 11/86	156	1741	258	10
	182	768	249	4
	77	221	115	22
	94	1159	173	127
	143	720	218	51
	62	532	89	43
	132	647	133	105
	52	1372	116	8
	159	793	294	32
	143	1289	616	107
	209	1235	505	33
	180	1282	483	12
	152	1071	1178	43
	256	737	1104	134
	143	531	182	125

Oct 21/86	35	818	256	171
	81	686	516	439
	148	534	634	477
	166	625	557	99
	65	539	202	43
	60	398	158	14
	23	295	53	18
	37	570	157	41
	144	2838	455	530
	43	763	175	29
	48	627	141	14
	84	1933	663	120
	58	860	258	23
	35	298	98	11
	101	1287	281	62

Appendix C. Functional Group Composition from Lost Man Creek Benthic Invertebrate Collections, March 1986-March 1987. (continued) 80

Lost Man Creek

Predator Collector Scraper Shredder

Nov 24/86	10	443	107	18	
	38	604	121	18	
	59	1161	190	50	
	48	975	155	66	
	48	524	177	29	
	76	495	200	36	
	42	463	104	5	
	84	285	151	9	
	69	378	181	43	
	73	1817	292	110	
	40	746	119	73	
	30	782	36	19	
	122	1033	303	57	
	91	1049	205	43	
	33	371	142	34	
season					
totals	4131	38295	12800	3557	58783

Winter

Dec 30/86	29	1866	55	87
	82	1672	408	219
	85	560	375	150
	57	286	190	49
	241	1927	339	366
	47	291	191	35
	16	225	98	21
	89	638	297	65
	40	230	115	26
	56	583	174	155
	32	146	94	36
	64	342	87	16
	32	125	86	22
	82	598	129	269
	74	568	200	114

Feb 4/87	35	130	62	10
	58	212	88	47
	48	106	72	5
	4	26	18	0
	67	234	84	13
	62	179	101	13
	5	99	8	2
	37	174	119	5
	108	493	178	75

Appendix C. Functional Group Composition from Lost Man 31
 Creek Benthic Invertebrate Collections,
 March 1986-March 1987. (continued)

<u>Lost Man Creek</u>					
	Predator Collector Scraper Shredder				
Feb 4/87	64	230	116	30	
	60	207	166	8	
	40	135	75	10	
	26	35	125	3	
	91	127	187	9	
	80	138	70	2	
season totals	1811	12582	4307	1862	20562
Grand Totals	15900	103808	29362	9057	158127

Appendix D. Functional Group Composition from Prairie
Creek Benthic Invertebrate Collections,
March 1986-March 1987.

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Prairie Creek

Predator Collector Scraper Shredder

Spring

March 24/86

42	78	87	11
28	85	73	13
31	62	21	1
52	55	56	6
24	76	229	3
42	156	263	23
69	151	267	12
72	247	298	18
49	403	85	80
50	156	421	5
34	81	113	16
77	142	178	8
61	239	193	19
105	501	246	70
46	113	65	18

March 13/87

42	237	184	49
43	276	176	96
52	356	200	47
62	158	199	12
10	207	48	14
14	90	71	9
80	466	366	136
62	333	390	29
39	286	177	29
28	103	47	14
10	224	1	3
28	564	5	29
23	55	33	6
7	38	33	6
10	24	34	3

April 30/86

171	218	236	25
90	172	115	7
69	266	132	24
91	211	67	33
97	245	162	19
83	499	114	44
107	337	8	15
116	419	10	12
135	316	99	50
162	345	221	11
142	314	347	37
109	235	361	18
90	246	110	29

Appendix D. Functional Group Composition from Prairie Creek Benthic Invertebrate Collections, March 1986-March 1987. (continued) 83

Prairie Creek

Predator Collector Scraper Shredder

April 30/86	153	241	191	42	
	9	18	14	16	
season					
totals	2916	10044	6746	1167	20873

Summer

June 2/86	89	217	249	143
	136	339	390	283
	78	274	40	101
	74	152	127	83
	155	314	326	203
	109	259	200	53
	116	268	173	35
	75	131	181	19
	103	270	174	25
	47	133	87	10
	100	208	121	35
	142	228	212	33
	183	384	444	138
	56	190	114	37
	102	176	96	35

July 8/86	52	132	56	33
	65	230	56	48
	156	320	195	211
	50	180	84	54
	79	569	69	54
	82	202	144	55
	70	508	120	54
	64	323	137	21
	121	373	297	191
	69	190	126	74
	180	424	339	60
	134	389	353	40
	119	176	660	87
	112	204	644	95
	140	235	109	69

Aug 12/86	29	116	165	48
	75	181	302	51
	25	121	190	11
	118	233	380	68
	50	356	261	38
	77	690	227	29

Appendix D. Functional Group Composition from Prairie Creek Benthic Invertebrate Collections, March 1986-March 1987. (continued) 84

<u>Prairie Creek</u>					
	Predator Collector Scraper Shredder				
Aug 12/86	12	139	55	3	
	17	133	28	5	
	27	186	83	23	
	72	757	352	49	
	132	860	138	244	
	79	338	11	50	
	112	341	214	109	
	56	293	85	26	
	26	288	42	22	
season totals	3965	13030	8856	3155	29006
Autumn					
Sept 12/86	63	325	95	190	
	103	676	240	267	
	50	1146	798	359	
	159	488	444	119	
	144	572	998	49	
	124	533	497	44	
	102	649	292	37	
	119	459	170	261	
	64	289	211	14	
	113	553	663	22	
	76	332	166	42	
	53	511	103	171	
	43	206	66	14	
	212	265	1062	210	
	166	699	774	167	
Oct 23/86	124	393	700	43	
	66	310	413	30	
	86	347	204	117	
	17	284	19	4	
	31	391	252	48	
	44	371	33	66	
	104	740	782	251	
	131	645	470	59	
	118	642	789	151	
	36	342	246	17	
	36	232	262	9	
	32	287	163	19	
	164	633	260	47	
	71	486	308	25	
	29	274	149	10	

Appendix D. Functional Group Composition from Prairie
Creek Benthic Invertebrate Collections,
March 1986-March 1987. (continued)

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Prairie Creek

Predator Collector Scraper Shredder

Nov 25/86	20	183	100	57	
	59	541	232	62	
	22	165	13	14	
	25	204	9	29	
	31	383	304	23	
	21	224	28	19	
	18	237	84	64	
	48	277	377	44	
	67	506	482	210	
	45	174	344	38	
	24	533	86	30	
	16	310	20	5	
	9	121	33	5	
	38	284	122	31	
	28	187	92	13	
season					
totals	3151	18409	13955	3506	39021

Winter

Dec 29/86	155	472	163	114
	128	244	177	23
	106	211	241	55
	84	397	370	59
	223	458	295	54
	19	250	46	39
	130	602	504	137
	65	241	197	19
	34	251	234	47
	51	284	158	50
	78	134	122	43
	22	95	81	21
	18	116	80	32
	32	241	154	45
	124	438	134	38

Feb 3/87	29	170	49	27
	21	195	49	31
	15	278	7	86
	46	204	214	18
	55	206	169	25
	61	253	189	76
	56	450	231	83
	96	226	161	49
	59	332	265	49

Appendix D. Functional Group Composition from Prairie Creek Benthic Invertebrate Collections, March 1986-March 1987. (continued) 86

<u>Prairie Creek</u>					
	Predator Collector Scraper Shredder				
Feb 3/87	37	290	162	56	
	68	799	419	25	
	68	587	380	24	
	60	248	164	54	
	76	499	253	91	
	70	317	180	36	
season totals	2086	9488	5848	1506	18928
Grand Totals	12118	50971	35405	9334	107828