EFFECTS OF VOLCANIC ASH ON THE BENTHIC ENVIRONMENT OF A MOUNTAIN STREAM, NORTHERN IDAHO

By S. A. Frenzel

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CONVERSION FACTORS

Concentrations of chemical constituents are given in mg/L (milligrams per liter), which is numerically equal to values expressed in parts per million. Specific conductance is expressed as µmho/cm (micromhos per centimeter at 25 degrees Celsius).

Multiply SI unit	By	To obtain inch-pound unit
	Length	
centimeter (cm)	0.3937	inch
millimeter (mm)	0.03937	inch
meter (m)	3.281	foot
kilometer (km)	0.6214	mile
	Area	
square meter (m^2)	10.76	square foot
square kilometer (km^2)	0.3861	square mile
	Volume	
square centimeter (cm^2)	0.155	square inch
cubic centimeter (cm^3)	0.06102	cubic inch
	Volume Per Unit Time	
cubic meter per second (m^3/s)	35.31	cubic foot per second
	Velocity	
centimeter per second (cm/s)	0.0328	foot per second
	Mass	
gram (g)	0.03527	ounce avoirdupois
metric ton	1.102	ton (short)

Temperature

Conversion of °C (degrees Celsius) to °F (degrees Fahrenheit) is based on the equation, °F=(1.8)(°C)+32. All water temperatures are reported to the nearest 0.5 degree.

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ABSTRACT

The May 18, 1980, eruption of Mount St. Helens deposited about 15 millimeters of volcanic ash on the Big Creek basin in northern Idaho. Much of the ash remained on hillsides a year after the eruption. Suspended-sediment concentrations in Big Creek were low, owing to lack of fine-grained material in the streambed. Physical and chemical analyses of water samples from Big Creek collected from December 1980 to December 1981 showed no anomalies attributable to ash. Qualitative collections showed benthic invertebrates to be abundant and diverse in Big Creek. Experiments conducted in a mountain stream unimpacted by ash revealed a small quantity of volcanic ash was not detrimental to invertebrate communities. Benthic invertebrates were most abundant on ash-covered artificial substrates, with detritovores dominating the communities on all substrates. Addition of volcanic ash to artificial substrate samplers may increase detritus-trapping efficiency and, consequently, may offer a more suitable microhabitat for benthic invertebrates.

INTRODUCTION

Mount St. Helens, in southwestern Washington, erupted explosively on May 18, 1980, depositing volcanic ash from Washington to western Montana. Total volume of material deposited downwind from the eruption was about 3.67×10^8 metric tons (Sarna-Wojcicki and others, 1980). Depths of uncompacted ash in the fallout area in northern Idaho were reported to be as much as 20 mm (Sarna-Wojcicki and others, 1980), although local U.S. Geological Survey personnel reported ash depths up to about 50 mm in the Plummer-St. Maries area. Variability of ash depths over short distances probably was the result of wind patterns and topography.

Purpose and Scope

The purpose of the study was to determine whether a thin layer of volcanic ash measurably affects aquatic environments. Study objectives were to: (1) Determine the amount of ash initially deposited in Big Creek basin and the amount remaining 1 year after the eruption, and (2) describe the impact of ash on water quality and benthic invertebrate communities.

Description of the Study Area

Big Creek near Calder, Idaho, was chosen as the study basin (fig. 1). A gaging station was built on Big Creek 5.5 km upstream of its confluence with the St. Joe River. At the gaging site, Big Creek is a fourth-order, southward-flowing stream. The basin above the gage is steep, undeveloped forest and scrubland and has a drainage area of about 105 km^2. The stream channel, at the study reach (altitude 725 m), is 12-15 m wide and has a moderate gradient and cobble substrate; riparian vegetation consists of deciduous brush and perennial grasses. A forest fire burned the basin in 1910 and salvage logging occurred until 1913; subsequent activity by man has been minimal.

Peak discharge for the 1980 water year in streams near Big Creek occurred at the end of April, and discharge was still relatively high on May 18 when volcanic ash fell on northern Idaho. Ash sank quickly in streams and accumulated in pools and slack water. Some ash was intercepted by vegetation. Minor amounts of ash may have reached the stream as wind and rain removed ash from the vegetation. Ash was airborne on windy days until autumn rains dampened and compacted the ash.

Gedney Creek near Selway Falls Guard Station (fig. 1) was unaffected by ash fallout and therefore was selected for conducting experiments on the effects of applied ash on benthic invertebrates. Gedney Creek is a fourth-order, southward-flowing tributary to the Selway River. The watershed is steep, heavily forested, undisturbed by man, and has a drainage area of 125 km^2. Channel gradient is steeper and substrate particle size larger than in Big Creek; elevation at the mouth is 512 m.

Previous and Related Work

A study of ash effects on Big Creek trout populations and their growth rates is being conducted by Idaho State University. Thurow (1976) studied trout populations in St. Joe River tributaries and included some results from

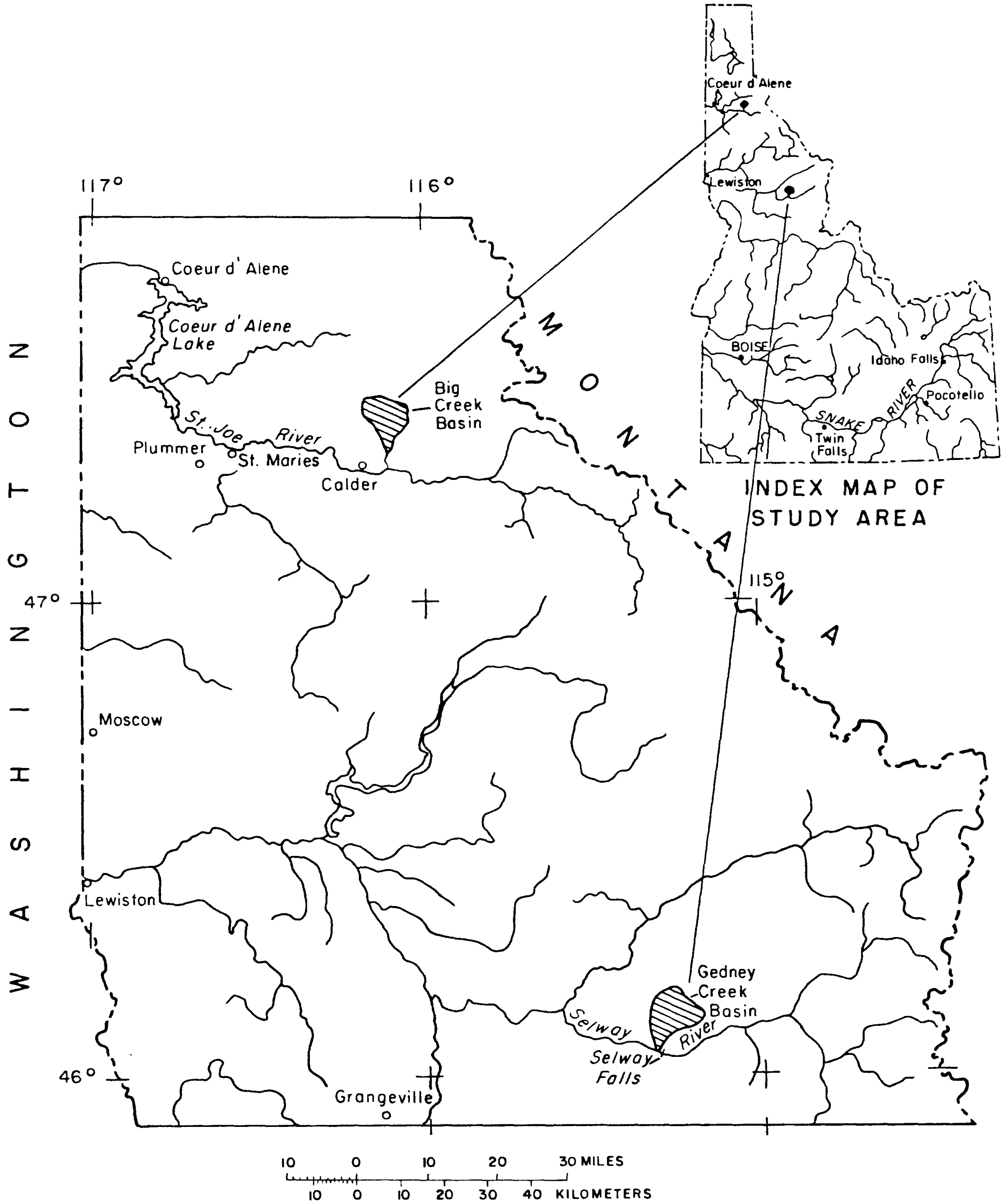

Figure I. -- Location of the study area.

Big Creek. Segerstrom (1950) studied erosion and transport of volcanic ash in the Parícutin area of Mexico. Several reports by Eicher and Rounsefell (1957), Kurenkov (1966), and Mathisen and Poe (1978) discuss effects of volcanic ash on sockeye salmon populations in lakes.

METHODS AND RESULTS OF SAMPLE COLLECTION AND ANALYSIS

Water samples for determination of nutrients, trace metals, and common ions were collected, preserved, and analyzed by methods described by Skougstad and others (1979). Suspended sediment was collected using equal-width increments and was analyzed according to methods described by Guy (1969). Bacteria samples were collected, incubated, and analyzed as described by Greeson and others (1977).

Volcanic Ash

Uncompacted ash depths in Big Creek basin were estimated to be 15 mm, from maps delineated by Sarna-Wojcicki and others (1980), M. M. Folsom and R. R. Quinn (Eastern Washington University, written commun., 1980), and from personal observations. Total weight of ash in the study area was estimated to be 473,000 metric tons, on the basis of 15 mm depth and 0.3 g/cm^3 bulk density.

During July and August 1981, 26 soil samples were collected throughout the basin and analyzed to estimate the amount of ash remaining in the basin. Sampling procedure was to (1) Dig a small pit in the soil to reveal the lower limit of ash deposition, (2) insert a metal plate below the ash and parallel to the land surface, (3) core down to the plate with a 5.1-cm-diameter steel soil sampler, and (4) place the sample in a plastic bag. Samples were later dried and sieved through a 0.090-mm screen to remove nonash particles. Material less than 0.090 mm was examined petrographically to determine percentage of volcanic ash.

On the basis of mean dry weight of ash in the samples, about 374,000 metric tons of volcanic ash remained in the study basin. However, one standard deviation from the sample mean is 148,000 metric tons. Due to potential errors in estimating ash deposition, it is not possible to determine exactly how much ash has been transported out of the basin.

Sediment

Dry, uncompacted ash was easily transported by winds and initially resisted wetting. Compacted ash exhibited high water-retention capacity and resistance to downslope movement. In sparsely vegetated areas, ash formed a thin, cementlike crust.

Volcanic ash may be carried through streams as bedload or suspended sediment. Sediment transport is a function of material availability and stream energy. Sediment particles in the size range of ash deposited in Idaho, generally less than 0.045 mm (Fruchter and others, 1980), normally would be carried in suspension. Maximum observed suspended-sediment concentration in Big Creek was 5 mg/L (table 1), which occurred during a falling stage at a discharge of 7.65 m^3/s. Concentrations were probably higher at the peak discharge of 127 m^3/s. Ash, whether moved as suspended load or bedload, probably is stored in bed material.

In a sample of Big Creek bed material collected in December 1980, sediment finer than 2 mm accounted for only 4 percent of the fraction finer than 128 mm (fig. 2). Volcanic ash comprised 29 percent of material finer than 0.063 mm. Optical particle-size analysis determined bed-material size distribution of particles larger than 128 mm; maximum size detected was 207 mm. Particles larger than 128 mm comprised a substantial fraction of the substrate. Suspended-sediment transport in Big Creek for discharges sampled was low, owing to a relative lack of fine-grained material available. Suspended-sediment transport during storm runoff would be higher. Although no bedload samples were collected, visual observations in clear water revealed no bedload movement, except for occasional, isolated stringers of sand movement.

At Gedney Creek, 10 percent of the bed material finer than 128 mm was finer than 2 mm. Maximum suspended-sediment concentration of 32 mg/L (table 1) was observed during a sharp rise in stage.

Water Chemistry

Ash from Mount St. Helens was reported to be high in barium, chloride, sulfur, zinc, vanadium, strontium, and zirconium (Fruchter and others, 1980). They also noted that ash samples obtained near Spokane, Wash., Pullman, Wash., and Missoula, Mont., were about 80 percent glass (SiO_2). Periodic analyses of water sampled from Big Creek between December 1980 and December 1981 indicated low concentrations of barium, chloride, sulfur (as sulfate), and zinc. Analyses for vanadium, strontium, and zirconium were not made.

Table 1.--Selected streamflow and water-quality data from Big Creek and Gedney Creek November 1980 to December 1981

[<, less than]

Streamflow and water-quality data	Big Creek			Gedney Creek		
	Mean	Maximum	Minimum	Mean	Maximum	Minimum
Discharge[1] (m^3/s)	3.04	127	0.396	4.22	37.7	0.760
Specific conductance[1] (μmho)	36	48	15	21	31	11
Water temperature[1] (°C)	6.5	20.0	0	8.0	22.0	0
pH[2]	7.3	7.6	7.0	7.2	7.3	6.9
Dissolved oxygen[2] (mg/L)	11.4	13.3	8.5	11.3	13.2	8.6
Alkalinity[2] (mg/L as calcium carbonate)	23	29	15	14	17	10
Suspended sediment[2] (mg/L)	2	5	1	5	32	1

[1]Continuous record

[2]Periodic samples; mean, maximum, and minimum of periodic samples are not necessarily mean, maximum, and minimum for the period.

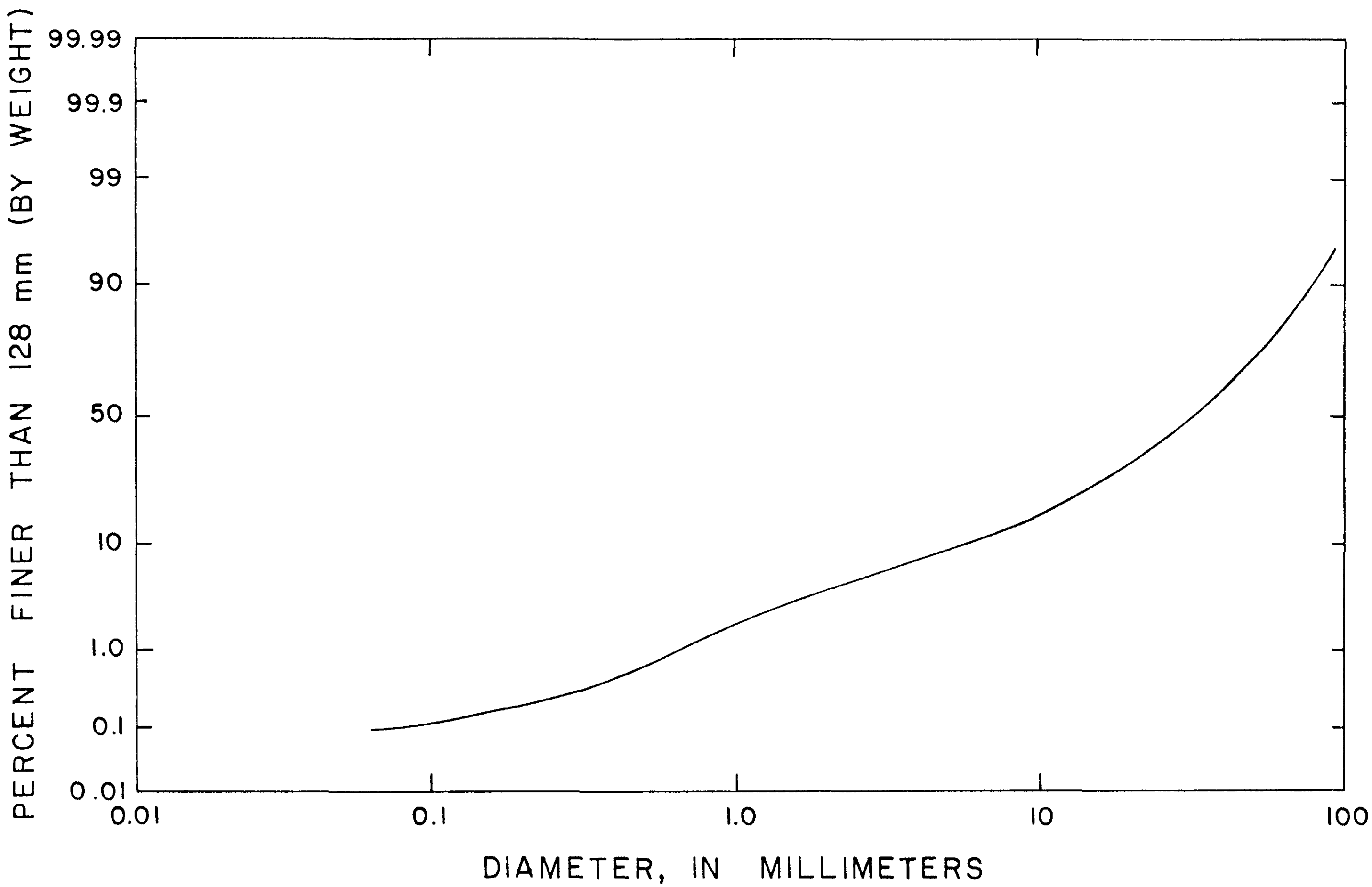

Figure 2.--Particle-size distribution of bed material finer than 128 mm in Big Creek.

Selected streamflow and water-quality data from Big and Gedney Creeks are shown in table 1. Water from both streams was low in dissolved constituents and was near neutral pH (range 6.9-7.6). Dissolved-oxygen concentrations were always at or near saturation. Concentrations of fecal coliform and fecal streptococci bacteria were generally low (less than 10 colonies per 100 milliliter), except during late summer and early autumn, when concentration of fecal streptococci increased. Overall water quality of both streams is good.

Continuous records of discharge, water temperature, specific conductance, and periodic chemical, physical, and biological analyses are published in the annual water-data report by the U.S. Geological Survey (1982).

Benthic Invertebrates

Benthic invertebrates were collected with a D-shaped dip net of 210 μm mesh as specified by Greeson and others (1977). Invertebrates were collected by agitating the streambed just upstream of the net and by turning over rocks to dislodge organisms, allowing the current to carry them into the net. This sampling method should be considered strictly qualitative, as no effort was made to quantify collections. Slack, Nauman, and Tilley (1976) observed for a qualitative faunal survey, the dip-net method gave maximum coverage of diverse habitats compared to drift nets and to scrubbing of 10 randomly selected rocks. Invertebrates were preserved with 70 percent ethyl alcohol and later identified to species where possible.

Descriptive Biological Statistics

Invertebrate collections were described by their community structure. Collections were thought to be representative of the community at the collection site, but extent of the community was not known (Slack, Nauman, and Tilley, 1979). Therefore, each collection was treated as an entity, not as a random sample from a larger population (Pielou, 1969). Community structure can be expressed as organisms present, their functional groups, diversity, and evenness. Classifications of functional groups are collectors-gatherers, collectors-filterers, shredders, scrapers, and predators; each group employs a slightly different mode of feeding or utilizes different food sources. Diversity is an expression of the number of taxa in a collection and their relative abundance. Diversity is high when there are many taxa and abundances are fairly even; diversity is low when taxa are few and abundances are uneven. Diversity of each collection was expressed as a diversity index calculated using the equation of Brillouin (1962):

$$H = \frac{1}{N} \log_2 \frac{N!}{N_1!\ N_2!\ldots N_s!}$$

where

H = diversity,
N = total number of individuals,
N_i (i = 1, 2, ..., s) = number of individuals in the ith species, and
s = number of species.

Unidentified Chironomidae were not included in diversity and evenness calculations. Evenness describes observed uniformity in distribution of individuals among taxa in a collection (K. V. Slack, U.S. Geological Survey, written commun., 1981).

Relative evenness was calculated using the equation of Zand (1976):

$$e = \frac{H - H_{min}}{H_{max} - H_{min}}$$

where

e = relative evenness,
H = diversity,
H_{max} = maximum diversity = $1/N \log_2 N!/(m+1)^r(m!)^s$, and
H_{min} = minimum diversity = $1/N \log_2 N!/[N-(s-1)]!$
(m and r are quotient and remainder, respectively, of N/s; that is, [$N=ms+r$ and $r<s$]).

Qualitative Biological Samples

Qualitative dip-net samples of benthic invertebrates were collected from May 1981 to December 1981 at Big Creek and from May 1981 to November 1981 at Gedney Creek. Six collections from Big Creek contained 80 invertebrate taxa (table 2). Number of taxa in a single collection ranged from 20 to 40. Only three taxa were present in every

Table 2.--Dip-net collections of benthic invertebrates; Big Creek, May 1981 to December 1981

[Functional groups: C-G, collectors-gatherers; C-F, collectors-filterers; S, scrapers; SH, shredders; P, predators]

Organism	Functional group	Collection date May 5	June 16	July 28	Aug. 27	Oct. 6	Dec. 1
Insecta							
Acari	P	--	2	2	--	--	
Coleoptera							
Heterlimnius corpulentis	C-G	--	--	1	--	--	--
Lara avara	SH	--	--	--	--	1	--
Narpus sp.	C-G	--	2	1	--	--	--
Optioservus sp.	S	1	5	4	4	10	6
Ordobrevia nubifera	C-G	--	--	6	--	--	--
Oreodytes congruus	P	--	--	7	--	--	--
Stenelmis sp.	C-G	--	--	--	--	1	--
Zaitzevia parvula	C-G	1	4	4	10	1	--
Collembola		--	1	--	--	--	--
Diptera							
Atherix sp.	P	2	1	--	11	28	14
Bezzia sp.	P	--	2	--	--	--	--
Ceratopogonidae	P	--	1	--	--	--	--
Chironomidae form 1	C-G	--	--	--	4	9	6
Chironomidae form 2	C-G	--	--	--	--	1	--
Chironomidae form 3	SH	--	--	--	--	2	--
Chironomidae form 5	P	--	--	--	--	--	1
Chironomidae form 7	C-G	--	--	--	2	2	--
Chironomidae (unidentified)[1]		--	39	10	--	1	--
Chrsyops sp.	C-G	--	--	1	--	--	--
Dicranota sp.	P	--	1	--	--	--	--
Dixa sp.	C-G	--	--	--	4	--	--
Hesperoconopa sp.	C-G	--	--	--	2	1	1
Hexatoma sp.	P	--	--	1	--	1	2
Palpomyia sp.	P	--	--	1	1	--	--
Simulium sp.	C-F	6	10	--	3	3	--
Tabanus sp.	P	--	--	--	1	1	--

Table 2.--Dip-net collections of benthic invertebrates; Big Creek, May 1981 to December 1981--Continued

Organism	Functional group	Collection date May 5	June 16	July 28	Aug. 27	Oct. 6	Dec. 1
Insecta--Continued							
Ephemeroptera							
Ameletus connectus	C-G	--	--	3	--	--	--
Ameletus cooki	C-G	--	--	1	1	--	--
Ameletus oregonensis	C-G	--	--	--	--	--	3
Ameletus sparsatus	C-G	--	21	--	--	--	--
Baetis bicaudatus	C-G	2	1	--	4	10	198
Baetis hageni	S	--	3	1	--	--	--
Baetus tricaudatus	C-G	12	29	2	6	5	--
Cinygmula sp.	S	7	1	--	3	23	112
Drunella flavilinea	C-G	1	5	3	--	--	--
Drunella grandis	C-G	--	1	--	--	1	1
Epeorus albertae	S	--	2	2	--	--	--
Epeorus deceptivus	S	--	--	--	--	--	8
Epeorus longimanus	S	2	3	2	1	2	--
Ephemerella infrequens	C-G	1	8	--	--	4	26
Paraleptophlebia debilis	C-G	--	3	--	--	--	--
Paraleptophlebia heteronea	C-G	--	2	--	--	10	13
Paraleptophlebia sp.	C-G	--	--	1	--	--	--
Rhithrogena hageni	S	--	--	--	--	--	6
Rhithrogena robusta	S	1	--	--	--	6	2
Serratella tibialis	C-G	--	10	13	2	--	--
Hemiptera							
Gerris sp.	P	1	--	--	2	1	--
Plecoptera							
Alloperla sp.	P	1	--	6	--	--	--
Calineuria californica	P	1	2	--	--	2	--
Chloroperlidae	P	--	4	--	1	8	13
Claassenai sabulosa	P	--	--	1	--	--	2
Cultus sp.	P	--	--	2	--	--	--
Doroneuria theodora	P	--	--	--	--	3	--
Hesperoperla pacifica	P	--	1	--	--	3	--
Isoperla fulva	P	--	--	--	--	--	5
Paraleuctra sp.	SH	--	--	--	--	--	13
Pteronarcella badia	SH	--	--	--	--	--	1
Pteronarcys californica	SH	--	4	1	1	--	--
Skwala sp.	P	--	--	--	1	2	2
Taenionema sp.	SH	--	--	--	--	--	2
Zapada sp.	SH	--	--	--	--	6	16

Table 2.--Dip-net collections of benthic invertebrates; Big Creek, May 1981 to December 1981--Continued

Organism	Functional group	May 5	June 16	Collection date July 28	Aug. 27	Oct. 6	Dec. 1
Insecta--Continued							
Trichoptera							
Agapetus sp.	S	--	--	1	--	--	--
Apatania sp.	S	--	--	--	--	2	--
Arctopsyche grandis	C-F	--	--	--	--	9	7
Brachycentrus americanus	C-F	1	5	1	10	30	5
Dolophilodes sp.	C-F	--	--	5	6	5	--
Ecclisiomyia sp.	C-G	--	1	--	--	--	--
Hydropsyche sp.	C-F	--	3	1	2	50	46
Hydroptila sp.	SH	--	3	--	1	1	1
Lepidostoma sp.	SH	12	50	26	5	5	16
Limniphilidae	SH	--	--	--	--	2	--
Micrasema bactro	SH	2	4	1	--	--	2
Neophylax sp.	S	--	16	12	8	--	--
Neothremma alicia	S	--	--	--	--	1	--
Onocosmoecus sp.	SH	1	3	--	--	--	--
Psychoglypha sp.	C-G	1	--	16	6	--	1
Rhyacophila angelita	P	--	1	3	--	--	--
Hirudinea	P	--	3	--	--	--	--
Oligochaeta	C-G	1	17	1	--	4	
Turbellaria	P	--	--	4	--	1	
Number of individuals		57	274	147	102	258	542
Number of taxa		20	39	35	27	40	33
Diversity index		3.00	3.92	3.80	3.82	3.96	3.16
Evenness		0.672	0.728	0.740	0.901	0.785	0.594

[1]Not included in diversity and evenness calculations.

sample: two caddisflies, Brachycentrus americanus and Lepidostoma sp., and a riffle beetle, Optioservus sp. Twenty-seven taxa were collected on only one sampling date. Diversity ranged from 3.00 on May 5 to 3.96 on October 6. Evenness was lowest (0.594) on December 1 and highest (0.901) on August 27. The final collection, December 1, 1981, contained large numbers of two mayflies, Baetis bicaudatus and Cinygmula sp., which slightly reduced diversity and evenness.

Invertebrates were collected from Gedney Creek on eight occasions. Five collections corresponded with dates of artificial substrate placement or retrieval. A total of 68 taxa was collected, ranging from 24 to 33 in any one collection (table 3). Three taxa were present in all samples; a mayfly, Baetis tricaudatus; a caddisfly, Hydropsyche sp.; and as in Big Creek, the riffle beetle, Optioservus sp. Twenty-four taxa were collected only once during the eight sampling dates. Diversity was lowest (3.23) on October 7 and highest (3.84) on August 26. Evenness ranged from 0.669 on October 7 to 0.904 on July 16.

Cummins (1975) categorized streams as headwaters (orders 1-3), medium-sized rivers (orders 4-6), or large rivers (orders 7-12). He noted headwaters are characteristically dependent upon terrestrial contributions of organic matter with little photosynthetic production in the streams. In such waters, collector and shredder benthic invertebrates are the dominant macroconsumers. As stream order increases (orders 4-6), terrestrial inputs decrease and instream photosynthetic production increases. These changes result in a shift of the benthic community composition to decreased shredder abundance and increased scraper abundance. Both study streams are fourth order but contain communities somewhat more typical of Cummins' headwater streams (fig. 3).

BIOLOGICAL EXPERIMENTS

Experimental Procedures

Two experiments were conducted in Gedney Creek: the first was to determine effects of ash on substrate colonization; the second was to determine effects of ash on existing invertebrate communities.

Artificial substrate samplers are advantageous in that they offer a uniform surface for colonization; consequently, results are comparable (Hellawell, 1978). Open-topped wire (6-mm mesh) baskets, 25x25x10 cm deep, filled

Table 3.--Dip-net collections of benthic invertebrates; Gedney Creek, May 1981 to November 1981

[Functional groups: C-G, collectors-gatherers; C-F, collectors-filterers; S, scrapers; SH, shredders; P, predators]

Organism	Functional group	Collection date May 7	June 17	July 16	July 29	Aug. 26	Sep. 13	Oct. 7	Nov. 4
Insecta									
Acari	P	--	--	3	--	--	--	--	--
Coleoptera									
Lara avara	SH	--	--	--	1	--	--	--	--
Narpus concolor	C-G	--	--	4	--	--	--	--	--
Optioservus sp.	S	11	1	10	19	17	26	27	33
Ordobrevia nubifera	C-G	--	1	--	2	--	--	--	--
Stenelmis sp.	C-G	--	--	--	--	--	2	--	--
Zaitzevia parvula	C-G	4	1	4	12	--	9	5	4
Diptera									
Antocha sp.	C-G	--	--	3	21	1	--	1	4
Atherix sp.	P	1	--	5	15	8	9	12	7
Chironomidae form 1	C-G	--	--	--	--	7	4	2	2
Chironomidae form 2	C-G	--	--	--	--	6	--	--	--
Chironomidae form 3	SH	--	--	--	--	3	1	--	--
Chironomidae form 4	C-G	--	--	--	--	1	--	--	--
Chironomidae form 5	P	--	--	--	--	1	--	--	--
Chironomidae form 7	C-G	--	--	--	--	1	--	--	--
Chironomidae (unidentified)[1]		12	3	39	31	--	--	--	--
Dicranota sp.	P	--	--	--	--	--	--	1	4
Hexatoma sp.	P	--	--	--	1	1	1	1	2
Palpomyia sp.	P	--	--	--	1	2	3	1	1
Simulium sp.	C-F	4	8	11	19	2	4	--	--
Ephemeroptera									
Ameletus cooki	C-G	--	1	--	--	--	--	--	--
Baetis bicaudatus	C-G	--	3	2	--	20	21	3	39
Baetis hageni	S	--	--	1	1	--	--	--	--
Baetis tricaudatus	C-G	47	13	17	21	9	13	14	7
Caudatella edmundsi	C-G	3	1	--	--	--	--	--	--
Caudatella heterocaudata	C-G	3	1	5	--	--	--	--	--

Table 3.--Dip-net collections of benthic invertebrates; Gedney Creek, May 1981 to November 1981--Continued

Organism	Functional group	Collection date May 7	June 17	July 16	July 29	Aug. 26	Sep. 13	Oct. 7	Nov. 4
Insecta--Continued									
Ephemeroptera--Continued									
Cinygmula sp.	S	--	2	--	--	--	--	--	9
Drunella coloradensis	C-G	--	1	--	--	--	--	--	--
Drunella flavilinea	C-G	38	3	13	4	--	--	--	--
Drunella grandis	C-G	3	--	--	--	1	--	--	--
Epeorus albertae	S	--	5	3	2	--	--	--	--
Epeorus grandis	S	1	--	--	1	--	--	--	--
Epeorus longimanus	S	4	5	10	3	--	--	--	2
Ephemerella infrequens	C-G	30	8	--	--	1	--	2	36
Heptagenia solitaria	S	--	--	--	1	--	--	--	--
Paraleptophlebia heteronea	C-G	--	--	--	--	--	--	--	1
Rhithrogena robusta	S	5	--	--	--	3	4	4	4
Serratella tibialis	C-G	--	6	7	6	7	--	1	--
Hemiptera									
Gerris sp.	P	--	6	--	--	--	1	--	--
Plecoptera									
Alloperla sp.	P	--	--	2	4	--	--	--	--
Calineuria californica	P	2	1	--	--	--	1	2	6
Chloroperlidae	P	--	1	--	--	4	11	13	34
Doroneuria theodora	P	--	--	--	--	--	--	5	--
Hesperoperla pacifica	P	1	--	2	3	2	1	6	5
Isoperla sp.	P	--	--	--	--	3	3	3	4
Megarcys sp.	P	--	--	--	--	--	--	1	--
Paraleuctra sp.	SH	--	--	--	--	2	--	--	--
Perlinodes sp.	P	--	--	--	--	1	--	--	--
Pteronarcella badia	SH	--	--	--	--	--	--	--	3
Pteronarcys californica	SH	2	1	2	2	--	2	6	2
Pteronarcys princeps	SH	--	--	--	--	5	--	--	--
Skwala sp.	P	--	--	--	--	--	--	--	2
Zapada sp.	SH	--	--	--	--	--	1	--	6

Table 3.--Dip-net collections of benthic invertebrates; Gedney Creek, May 1981 to November 1981--Continued

Organism	Functional group	Collection date May 7	June 17	July 16	July 29	Aug. 26	Sep. 13	Oct. 7	Nov. 4
Insecta--Continued									
Trichoptera									
Agapetus sp.	S	--	--	--	1	--	--	--	--
Amiocentrus aspilus	C-G	1	--	--	--	--	--	--	--
Arctopsyche grandis	C-F	5	--	--	9	6	20	7	6
Brachycentrus americanus	C-F	--	--	1	2	2	9	5	1
Brachycentrus occidentalis	C-F	3	--	--	--	--	--	--	--
Dolophilodes sp.	C-F	--	--	5	11	9	12	10	8
Glossosoma sp.	S	3	--	--	--	--	1	--	--
Hydropsyche sp.	C-F	15	2	1	10	13	56	77	94
Hydroptila sp.	SH	--	--	1	--	--	--	--	2
Lepidostoma sp.	SH	17	2	--	--	--	4	1	21
Micrasema bactro	SH	--	2	2	--	--	--	--	1
Parapsyche sp.	C-F	--	--	--	1	--	--	--	--
Rhyacophila angelita	P	--	1	1	--	--	--	--	1
Rhyacophila coloradensis	P	--	--	2	1	--	2	1	1
Crustacea									
Decopoda									
Pacifastacus leniusculus	C-G	--	--	--	--	--	--	1	--
Oligochaeta	C-G	--	1	4	2	2	--	--	1
Number of individuals		217	80	160	210	140	221	212	353
Number of taxa		24	26	27	30	29	26	27	33
Diversity index		3.28	3.52	3.78	3.78	3.84	3.51	3.23	3.58
Evenness		0.731	0.757	0.904	0.776	0.845	0.793	0.669	0.721

[1]Not included in diversity and evenness calculations.

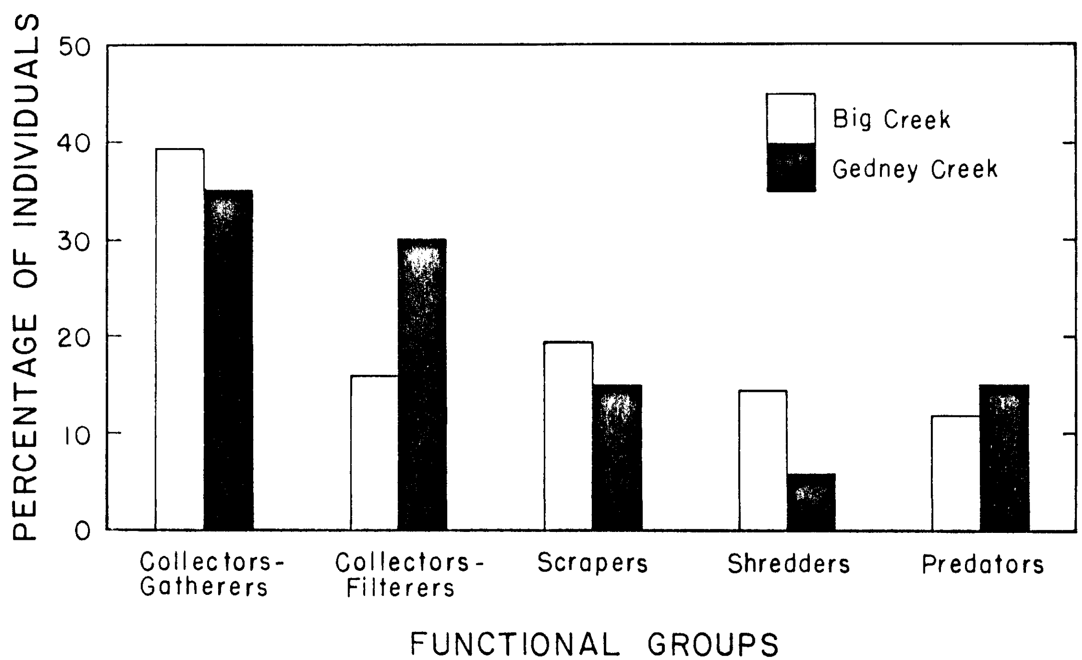

Figure 3.-- Relative abundances of functional groups for benthic invertebrates collected with dip nets, May 1981 to December 1981.

with ceramic (porcelain) balls were used as artificial substrates. Ceramic balls were used instead of gravel because the uniform size and shape minimizes physical habitat variability among baskets. Mean surface area of ceramic balls per basket in each experimental series was 0.60 m^2. Pegboards perforated with 6-mm holes on 25.4-mm centers were attached to upstream and downstream sides of all baskets to reduce flushing of ash. Volcanic ash used in experiments was collected in northern Idaho, oven dried at 110°C, and sieved through a 0.063-mm sieve.

Baskets were placed on the streambed in three rows with controls placed upstream of ash-covered substrates. At the beginning of each experiment, water depth and velocity were measured at each basket location. Artificial substrates were removed from the stream in an upstream direction using nylon mesh (210-µm) bags to avoid loss of invertebrates; however, fine-grained sediment and detritus were able to wash out. Ceramic balls were cleaned and mesh bags were rinsed with a solution of 70 percent ethyl alcohol to remove organisms.

Effects of Ash on Substrate Colonization

For the first experiment, from July 16 to August 26, 1981, 18 wire baskets were used: 9 containing 400 2.5-cm diameter balls each and 9 containing 50 5.1-cm diameter balls each. Three baskets of each ball size were covered with a layer of ash equivalent to 0.5-cm unconsolidated ash; three each were covered with 2.0-cm ash; and three each were untreated (controls). In an effort to decrease ash loss during substrate emplacement, ash was mixed with water to form a paste, which was applied between layers of ceramic balls. Baskets were placed in 210- µm mesh nylon bags and lowered into the stream. The bags were then tucked beneath the baskets to be used for substrate retrieval. Volcanic ash flushed out of the baskets for several minutes after placement. As a result of vandalism, only 12 substrates (4 in each ash-treatment series) were retrieved from Gedney Creek.

Water depths, velocities, and weights of accumulated materials for each experimental series are shown in table 4. A total of 61 taxa, ranging from 49 to 54 in a series, were collected on artificial substrates. Invertebrate density was similar on substrates initially covered with 0.5-cm ash (1,759/m^2) and controls (2,026/m^2) but was more than twice as great (4,186/m^2) on substrates initially covered with 2.0-cm ash (table 5). Diversity and evenness of collections

Table 4.--Characteristics of artificial substrate experiments, Gedney Creek

Retrieval date	Treatment	Mean depth (m)	Mean velocity (cm/s)	Duration of exposure (days) Total	Duration of exposure (days) With ash
August 26	Control	[1]0.38	[1]26.8	41	0
---Do.---	Ash, 0.5-cm	[1].40	[1]36.3	41	41
---Do.---	Ash, 2.0-cm	[1].35	[1]29.3	41	41
October 8	Control	[2].20	[2]37.8	25	0
---Do.---	Ash	[2].29	[2]29.3	25	1
October 21	Control	[2].27	[2]33.5	38	0
---Do.---	Ash	[2].24	[2]27.4	38	14
November 4	Control	[2].29	[2]30.5	52	0
---Do.---	Ash	[2].27	[2]20.1	52	28

[1]Measured on July 16, 1981
[2]Measured on September 17, 1981

Table 5.--Mean density (numbers per square meter) of benthic invertebrates colonizing artificial substrates retrieved from Gedney Creek, August 26, 1981

[Functional groups: C-G, collectors-gatherers; C-F, collectors-filterers; S, scrapers; SH, shredders; P, predators]

Taxa	Functional group	Control	0.5-cm ash	2.0-cm ash
Insecta				
Coleoptera				
Lara avara	SH	2	2	2
Optioservus sp.	S	100	115	120
Oreodytes sp.	P	7	3	--
Zaitzevia parvula	C-G	24	28	14
Diptera				
Antocha sp.	C-G	10	11	30
Atherix sp.	P	5	15	8
Chelifera sp.	P	--	2	12
Chironomidae form 1	C-G	752	663	1,446
Chironomidae form 2	C-G	17	13	22
Chironomidae form 3	SH	74	82	328
Chironomidae form 4	C-G	21	38	122
Chironomidae form 5	P	72	66	58
Chironomidae form 7	C-G	258	243	478
Chironomidae form 10	C-G	22	20	21
Chironomidae form 13	C-G	28	48	40
Chironomidae pupa[1]		63	44	84
Dicranota sp.	P	2	2	2
Hemerodromia sp.	P	13	10	--
Hexatoma sp.	P	1	2	1
Palpomyia sp.	P	6	5	2
Simulium sp.	C-F	1	--	4
Tipulidae pupa		2	2	14
Ephemeroptera				
Ameletus cooki	C-G	9	7	24
Attenella margarita	C-G	2	3	--
Baetis bicaudatus	C-G	43	38	122
Baetis tricaudatus	C-G	89	13	146
Cinygmula sp.	S	--	2	20
Drunella grandis	C-G	--	2	--
Drunella spinifera	C-G	--	1	--
Epeorus sp.	S	1	--	--
Ephemerella sp.	C-G	7	11	36
Paraleptophlebia bicornuta	C-G	--	--	4
Paraleptophlebia heteronea	C-G	8	3	8
Rhithrogena hageni	S	--	13	28
Rhithrogena robusta	S	16	--	--
Serratella tibialis	C-G	25	23	38

Table 5.--Mean density (numbers per square meter) of benthic invertebrates colonizing artificial substrates retrieved from Gedney Creek, August 26, 1981--(Continued)

Taxa	Functional group	Control	0.5-cm ash	2.0-cm ash
Insecta--Continued				
Plecoptera				
Calineuria californica	P	1	5	6
Chloroperlidae	P	63	25	121
Claasenia sabulosa	P	7	8	4
Hesperoperla pacifica	P	9	4	6
Isoperla sp.	P	2	7	--
Paraleuctra sp.	SH	--	2	--
Pteronarcella badia	SH	6	--	--
Pteronarcys californica	SH	1	2	2
Pteronarcys princeps	SH	--	9	13
Skwala sp.	P	6	--	12
Zapada cinctipes	SH	2	3	2
Zapada columbiana	SH	13	5	18
Trichoptera				
Arctopsyche grandis	C-F	29	21	86
Brachycentrus americanus	C-F	8	13	20
Clostoeca sp.	SH	2	2	1
Dolophilodes sp.	C-F	--	--	4
Glossosoma sp.	S	5	2	4
Hydropsyche sp.	C-F	123	62	438
Hydroptila sp.	SH	6	13	36
Lepidostoma sp.	SH	32	21	96
Leucotrichia sp.	SH	--	2	--
Micrasema sp.	SH	9	5	22
Psychoglypha sp.	S	1	4	1
Rhyacophila coloradensis	P	2	2	2
Crustacea				
Decapoda				
Pacifastacus leniusculus	C-G	--	1	--
Oligochaeta				
Limnodrilus sp.	C-G	19	11	58
Mean total density (numbers per square meter)		2,026	1,759	4,186
Number of taxa		50	54	49
Mean diversity index		3.56	3.57	3.58
Mean evenness		0.618	0.614	0.638

[1]Not included in diversity and evenness calculations.

were nearly constant. Mean diversity ranged from 3.56 to 3.58 and evenness from 0.614 to 0.638. The dip-net sample collected August 26, 1981, had a diversity of 3.84 and an evenness of 0.845 (table 3). Taxa collected on artificial substrates, their abundances, and diversities are listed in table 5.

Volcanic ash was probably not retained on experimental substrate series long enough to affect the outcome of this experiment. Sediment and detritus deposition in the baskets was probably a function of discharge (fig. 4), which decreased steadily, and the manner in which artificial substrates were arranged on the streambed. Total material accumulated was much less in 2.0-cm ash-covered substrates than controls or 0.5-cm ash-covered substrates. Slack, Tilley, and Hahn (1982) found invertebrate catch may decrease at high detritus loads; a similar phenomenon may have influenced invertebrate densities in this experiment.

Peckarsky and Dodson (1980) and Stauffer and others (1976) noted predators colonizing artificial substrates may strongly influence species structure and may retard colonization by other species. Predators comprised 10 percent of the community colonizing control substrates, 9 percent on 0.5-cm ash-covered substrates, and 6 percent on 2.0-cm ash-covered substrates (fig. 5). Reduced predator percentage on 2.0-cm ash-covered substrates may partially explain greater total invertebrate density on these substrates compared with controls and 0.5-cm ash-covered substrates.

Collectors-gatherers dominated communities in all three substrate series (fig. 5). Total detritovores (collectors and shredders) accounted for 83-90 percent of the collections, compared with 71 percent detritovores in a lumped (8 sampling dates) qualitative collection from Gedney Creek and 70 percent for the August 26 dip-net sample. Slack, Tilley, and Hahn (1982) noted similar abundances of detritovores on artificial substrates (multiple plates, 89 percent; rock-filled perforated plastic bags, 85 percent) and in dip-net (73 percent) collections from the East Fork Salmon River, Idaho, drainage. Scrapers exhibited a negative relation with addition of volcanic ash to artificial substrate samplers. Scrapers may be more abundant on untreated substrates, because clean ceramic balls offer a more stable surface for periphyton attachment.

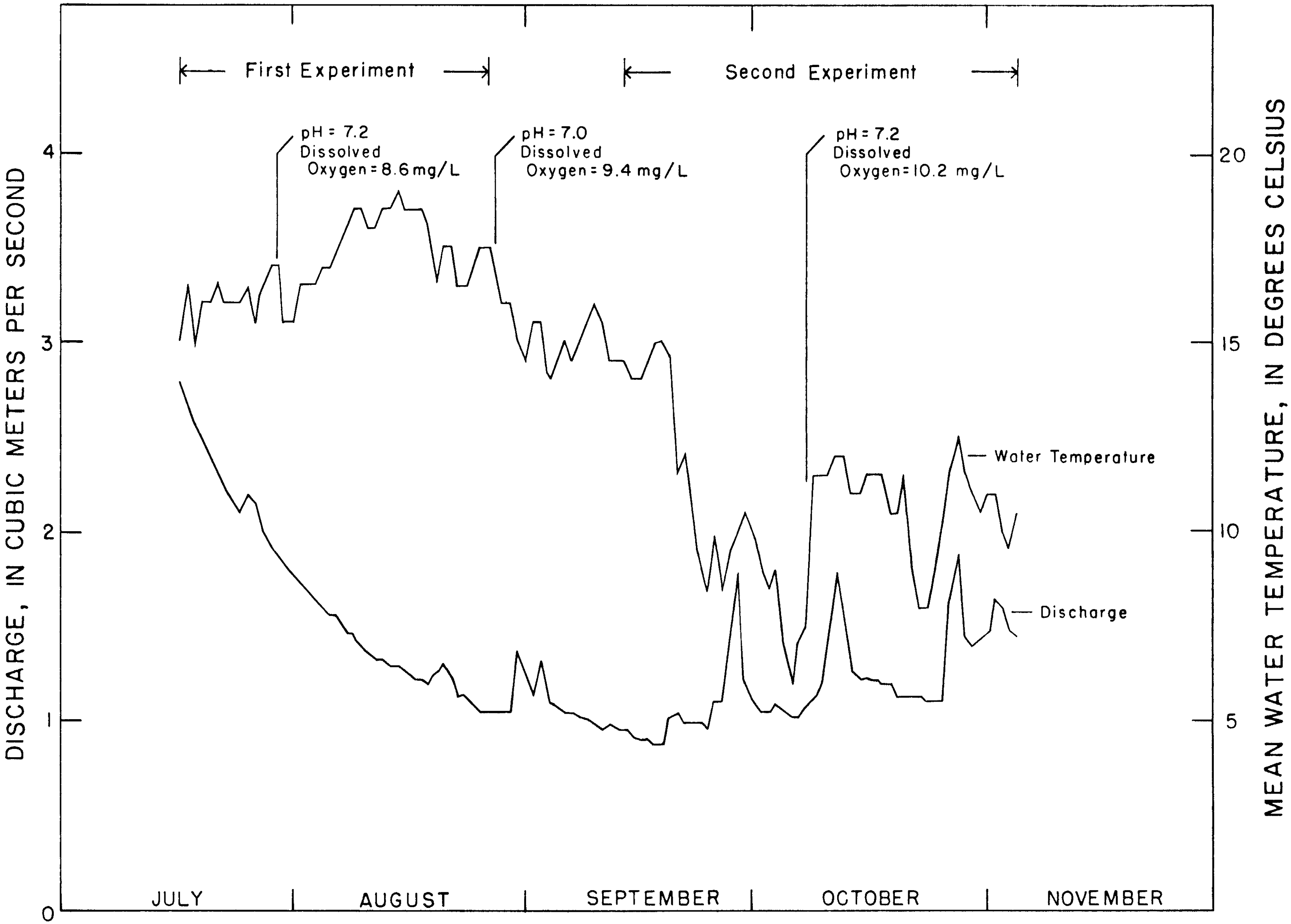

Figure 4.-- Discharge and water temperature of Gedney Creek, July 16 to November 4, 1981.

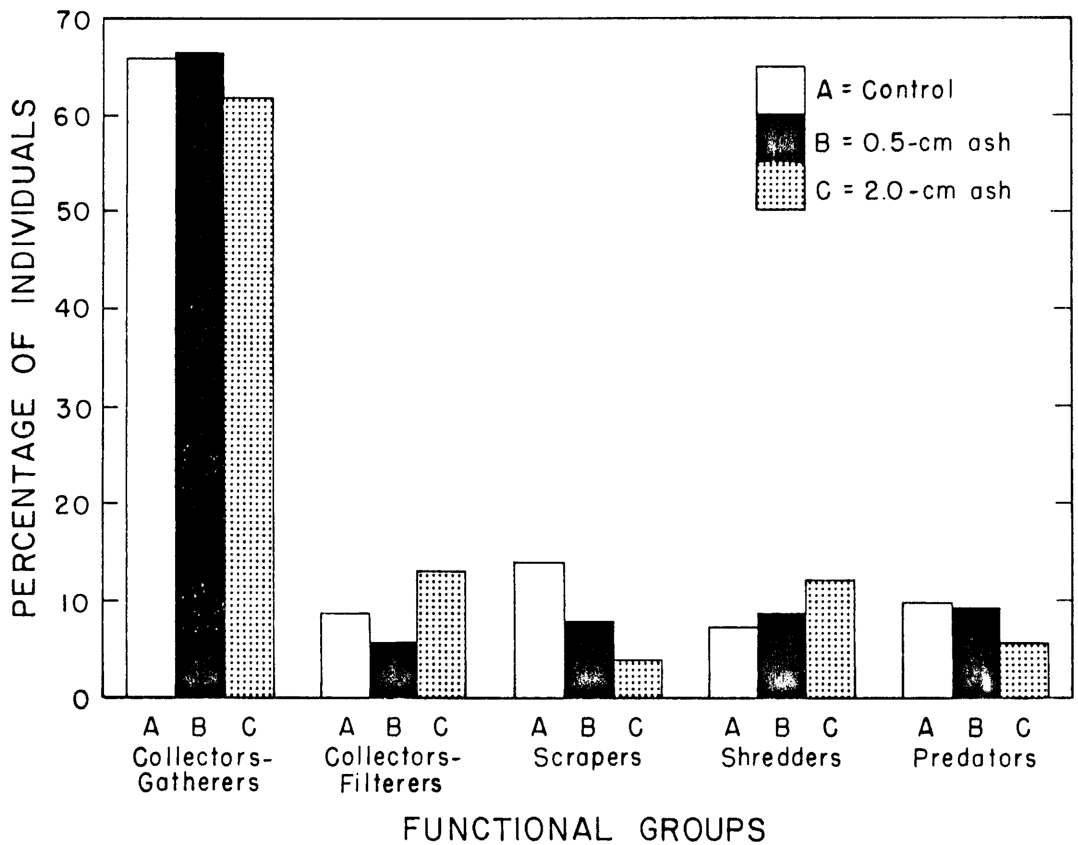

Figure 5.-- Relative abundances of functional groups for benthic invertebrates colonizing artificial substrates, Gedney Creek, August 1981.

Effects of Ash on Existing Invertebrate Communities

For the second experiment, wire baskets were filled with 200 2.5-cm balls covered by 25 5.1-cm balls. Twelve baskets were placed in Gedney Creek on September 13, 1981, and left for 24 days, at which time half were treated with ash. Seven hundred fifty grams of ash was applied as a paste to the surface of the baskets instream, but much of it was immediately washed away. One-third of the substrates, two treated and two controls, were removed on days 25, 38, and 52. Thirty-three taxa, ranging from 20 to 24 in a series, were collected on artificial substrates (table 6). Mean diversity values for these collections ranged from 2.57 to 2.88; mean evenness was between 0.548 and 0.597. Diversity was slightly greater on controls versus treated substrates on the first two retrievals and was about equal on November 4. As in the previous experiment, collectors-gatherers dominated colonizing communities (fig. 6); detritovores comprised 74-89 percent of the individuals. Detritovores made up a greater percentage of communities on treated substrates than on controls, although on November 4, percentages were nearly equal (83 versus 85 percent).

Ash-covered substrates were more effective than controls in retaining fine-grained sediment and detritus, and invertebrates were more numerous on ash-covered substrates than on controls. One day following the addition of ash, invertebrate density on controls was 53 percent of the density on ash-covered substrates. Two weeks following the addition of ash, controls showed a relative density increase to 63 percent of ash-covered substrates. Invertebrate density on controls had nearly equaled (94 percent) that of ash-covered substrates by November 4. Most of the changes in density can be explained by fluctuations in numbers of three collector taxa, *Baetis bicaudatus*, *Ephemerella infrequens*, and *Hydropsyche* sp. Rabeni and Minshall (1977) observed benthic organisms responded to detritus particle size and abundance. Addition of volcanic ash to artificial substrate samplers may increase detritus-trapping efficiency and, consequently, may offer a more suitable microhabitat for benthic invertebrates.

Excessive amounts of fine-grained sediments in streambeds are detrimental to aquatic biota (Cordone and Kelly, 1961; and Hynes, 1970). The detrimental effect principally focused upon is reduced spawning success of salmonids. However, Bjornn and others (1977) noted a slight to moderate layer of sediment (1.58-25.4 mm) around stream-bottom cobbles represents a more natural and often more favorable

Table 6.--Mean density (numbers per square meter) of benthic invertebrates colonizing artificial substrates retrieved from Gedney Creek, October 8, 21; November 4, 1981

[Functional groups: C-G, collectors-gatherers; C-F, collectors-filterers; S, scrapers; SH, shredders; P, predators]

		Retrieval date					
		Oct. 8		Oct. 21		Nov. 4	
Taxa	Functional group	Control	Ash	Control	Ash	Control	Ash
Insecta							
Coleoptera							
Lara avara	SH	2	--	--	--	--	--
Optioservus sp.	S	1	1	--	--	--	--
Diptera							
Antocha sp.	C-G	3	1	--	1	1	5
Chironomidae form 1	C-G	3	6	1	3	--	1
Chironomidae form 2	C-G	--	--	--	--	2	--
Chironomidae form 3	SH	--	--	1	1	1	--
Chironomidae form 7	C-G	1	2	1	1	--	1
Chironomidae pupa[1]		1	--	1	1	--	--
Simulium sp.	C-F	1	--	1	--	1	1
Ephemeroptera							
Ameletus sp.	C-G	--	--	--	--	--	1
Baetis bicaudatus	C-G	45	85	27	27	83	79
Baetis tricaudatus	C-G	2	1	1	--	3	--
Cinygmula sp.	S	3	17	10	9	12	11
Drunella grandis	C-G	--	--	--	--	1	--
Epeorus sp.	S	1	2	--	1	9	8
Ephemerella infrequens	C-G	23	64	31	65	50	61
Rhithrogena hageni	S	6	3	8	1	5	2
Rhithrogena robusta	S	16	8	14	8	9	7
Serratella tibialis	C-G	--	--	--	--	--	1
Plecoptera							
Calineuria californica	P	2	--	1	--	--	1
Chloroperlidae	P	--	1	1	2	--	1
Claassenia sabulosa	P	--	--	1	--	1	--
Hesperoperla pacifica	P	1	1	--	1	--	1
Pteronarcella badia	SH	--	--	1	--	--	--
Pteronarcys californica	SH	2	2	1	1	1	4
Skwala sp.	P	--	--	--	--	--	1
Taenionema sp.	SH	--	--	1	--	1	--
Zapada sp.	SH	1	2	1	3	--	--

Table 6.--Mean density (numbers per square meter) of benthic invertebrates colonizing artificial substrates retrieved from Gedney Creek, October 8, 21; November 4, 1981--Continued

Taxa	Functional group	Retrieval date Oct. 8 Control	Oct. 8 Ash	Oct. 21 Control	Oct. 21 Ash	Nov. 4 Control	Nov. 4 Ash
Insecta--Continued							
Tricoptera							
Arctopsyche grandis	C-F	2	1	1	3	1	--
Brachycentrus americanus	C-F	--	5	1	5	4	3
Glossosoma sp.	S	--	2	1	2	2	4
Hydropsyche sp.	C-F	30	68	32	62	24	30
Hydroptila sp.	SH	--	--	1	--	--	--
Lepidostoma sp.	SH	1	2	2	26	10	12
Micrasema sp.	SH	--	1	--	2	--	--
Mean number of individuals		147	275	141	225	221	235
Number of taxa		21	21	24	21	20	21
Mean diversity index		2.80	2.57	2.88	2.73	2.70	2.73
Mean evenness		0.592	0.548	0.581	0.597	0.595	0.584

[1]Not included in diversity and evenness calculations.

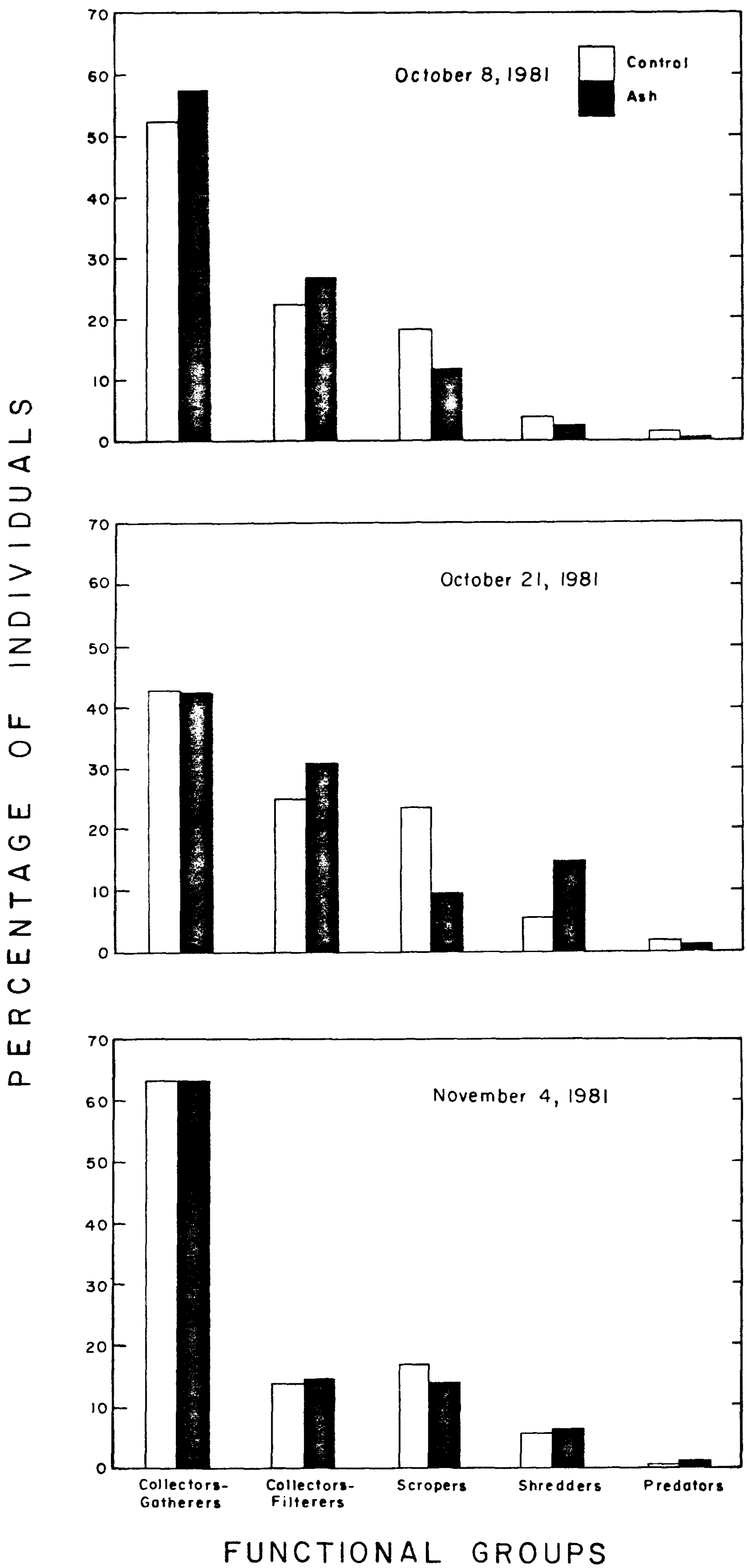

Figure 6.-- Relative abundances of functional groups for benthic invertebrates colonizing artificial substrates, Gedney Creek.

benthic insect habitat than unnaturally clean cobbles. Tyler and Gibbons (1973) compared a logged stream to an unlogged stream and discovered aquatic insects were more abundant in the logged stream, which had 5.5 percent higher concentration of sediment finer than 3.33 mm. Bjornn and others (1977) manually cleaned a plot in a heavily sedimented riffle and noticed the number of species and individuals of insects initially decreased, then increased as fine-grained material began to accumulate. In streams not stressed by high concentrations of fine-grained sediments, such as Big Creek and Gedney Creek, addition of small amounts of fine-grained sediment (such as volcanic ash) does not appear to be detrimental, and in fact may be beneficial, to benthic invertebrates.

SUMMARY

Volcanic ash deposited in northern Idaho by the May 18, 1980, eruption of Mount St. Helens did not have a significant impact on water quality or aquatic biota of Big Creek near Calder, Idaho. Chemical and physical analyses showed water quality is good and no measurable effect of volcanic ash was detected. About 80 percent of the 473,000 metric tons of ash initially deposited on the study basin remained after 1 year. Due to potential errors in estimating ash deposition, it is not possible to determine exactly how much ash has been transported out of the basin. Fine-grained sediments, including volcanic ash, comprised a very small percentage of the bed material in Big Creek, and suspended-sediment concentrations were low.

Benthic invertebrates were abundant and diverse in Big Creek; a total of 80 taxa was collected between May 1981 and December 1981. Invertebrate community structure was typical of forested headwater streams receiving terrestrial input of organic material. Experiments using artificial substrate samplers in a stream unaffected by ash-fall showed moderate amounts of volcanic ash were not detrimental to invertebrate communities. Volcanic ash probably enhanced the detritus-trapping ability of the substrates and thus provided a more favorable habitat than unnaturally clean substrates.

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