THE EFFECT OF SCOURING FLOODS ON THE BENTHOS OF BIG BUFFALO CREEK, MISSOURI

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ABSTRACT

The effects of scouring floods on the diversity and density of the riffle benthic macroinvertebrate community of Big Buffalo Creek, an unpolluted Missouri Ozark stream, were evaluated from December, 1968 through December, 1969. A modified Hess sampler was used to collect the invertebrate samples. Flash floods that scoured stream substrates had little effect on water quality assessments, although they did cause the temporary dislocation and dispersal of riffle benthic macroinvertebrates. The density and structure of this community were essentially identical to pre-flood conditions 1 month after floods. Diversity index values for samples collected 8 days after a flood were near normal. Apparently, riffle invertebrates were not dispersed over great distances and were therefore able to rapidly repopulate scoured areas. At the end of the study, after seven severe floods, the density, diversity, and species composition of the macroinvertebrate fauna were nearly identical to values observed at the start of the study.

INTRODUCTION

Many authors have noticed that stream scouring during flash floods has pronounced effects on the biological community. No constituent part of the stream biota is unaffected by floods. Rapid increases in water volume and velocity may scour aquatic vegetation from the stream bed, or wash accumulated deposits of silt and organic material downstream. Floods may also drastically affect the structure and composition of fish communities by destroying eggs, young-of-the-year fish, or by altering habitat location and structure (Hoopes, 1975; Elwood and Waters, 1969; Seegrist and Gard, 1972).

Benthic macroinvertebrate communities have also been observed to be severely affected by floods. Needham (1927) found that floods washed almost every type of benthic organism into the water column, and that many were injured by the grinding action of the scour. Moffett (1936) observed almost complete destruction of benthos in a mountain stream, and Tarzwell (1937) remarked that severe floods were the major factor limiting benthos and, therefore, fish production in southwestern streams. Stehr and Branson (1938), Sprules (1947), Logan (1963), McLay (1968), Denham (1938), Lehmkuhl and Anderson (1972), and Pearson and Franklin (1968) also observed reductions in benthos populations following floods.

Benthic macroinvertebrates and the diversity of their community are widely used as indicators of stream water quality. Changes which occur in this community as a result of floods could conceivably affect the accuracy of such water quality assessments. The objective of this study was to determine the quantitative effects of scouring floods on benthic macroinvertebrate density and diversity in Big Buffalo Creek, an unpolluted Ozark stream and thereby evaluate the effects of flash floods on water quality measurements. Samples which were analyzed in this study were collected from December 1968 through December 1969 by Mr. Walter L. Redmon. Ms. Linden Trial identified the invertebrates.

MATERIAL AND METHODS

Big Buffalo Creek, in Benton and Morgan counties, was selected as the study stream (Figure 1). It is located in the Osage-Gasconade Hills subdivision of the Ozarks, an area characterized by steep sided hills, chert covered ridges with an oak hickory climax forest, and numerous springs, sinks, and caves (Sauer, 1920).

The creek originates about 840 feet above mean sea level, and flows for 10 miles through southeastern Benton County to Lake of the Ozarks. Stream gradient is about 20 feet per mile. Fajen (1959) reported that permanent flow existed only in the lower 6 miles of Big Buffalo Creek. During dry weather, most of this flow originates from Boyler's Mill Spring, just upstream from the study area.

Physically and chemically Big Buffalo Creek is a typical Ozark stream. It is alkaline, has pH values between 7.5 and 8.5, and temperatures ranging from 27° C in July to 1° C in January and February. The water is clear except during periods of peak runoff. The low flow in the sampling area was 2.8 cfs, and the maximum flow was 9,150 cfs (U.S.G.S., 1969). The relationship between gage height and stream discharge is shown in Figure 2. Floods which raise the water level at least 3 feet above base flow cause considerable downstream transportation of materials in the creek bed. This downstream

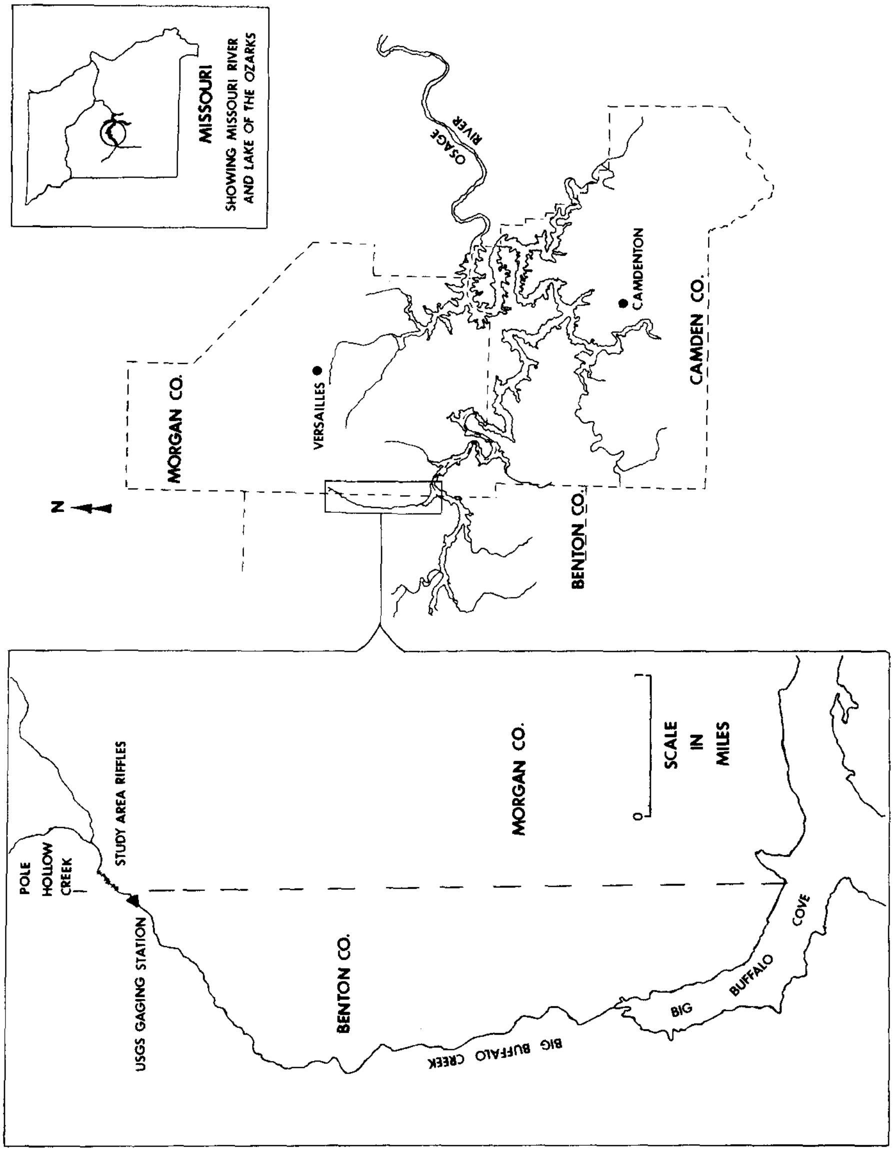

Figure 1. Big Buffalo Creek study area, Benton and Morgan counties, Missouri.

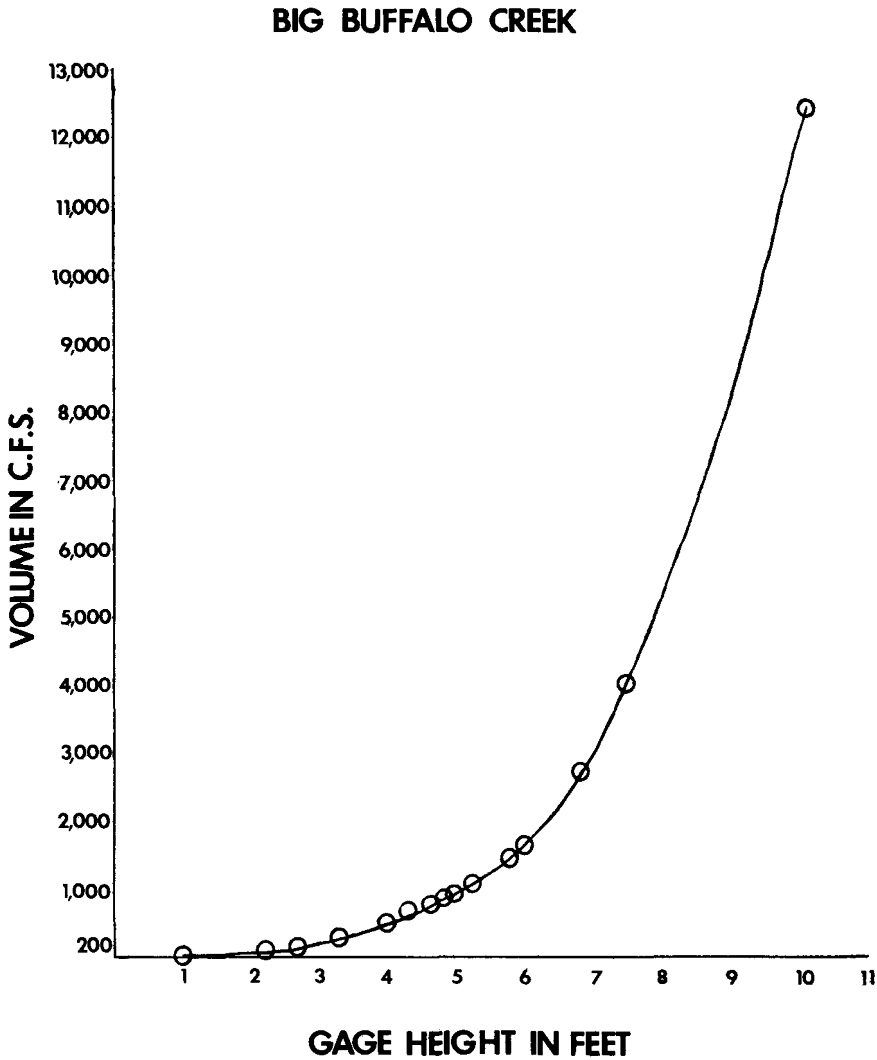

Figure 2. The relationship between gage height and volume of flow of Big Buffalo Creek, Benton and Morgan counties, Missouri.

movement of the substrate resulting from the increased volume and velocity of stream flow is termed a "scour" because it removes diatom and algal growths from rock surfaces by abrasion, and dislodges benthic organisms from their normal niches.

Diatoms are the dominant type of aquatic vegetation. Smallmouth bass, green sunfish, creek chubs, hornyhead chubs, stonerollers, and bleeding shiners are common in the stream (Pflieger, 1971).

The Missouri Department of Conservation purchased part of the Big Buffalo Creek drainage in 1963 which included 1.3 miles of stream that had been straightened and channelized in 1943. In 1966, the Department re-routed the creek in an attempt to revitalize the aquatic environment by creating greater channel diversity and stability (Fajen, 1973). Because of the channel alterations, the stream substrate is an unstable mixture of chert and dolomitic limestone fragments that range from gravel to boulder size. The effects of scouring on the benthos of Big Buffalo Creek, are, therefore, probably more pronounced than in more stable, undisturbed, Ozark streams.

The sample riffles were located downstream from the relocated channel and within 100 yards of the gaging station. Floods frequently changed the number and nature of riffles in the sampling area. Either three or four riffles were present on any sampling date.

Benthos samples were collected monthly from December, 1968 to December, 1969, except for August and September, with a sampler that operated on principals described by Hess (1941) and Waters and Knapp (1961). The sampler was a 10 gallon milk can with both bottom and neck removed. "Windows" were cut-out on opposite sides of the cylinder. The front or upstream "window" was covered with 1/16-inch wire screen and 1/4-inch hardware cloth and fastened with steel strapping and bolts. The back or downstream "window" was a 30 mesh per inch Surber net bag. The sampler had handles welded to the top which facilitated "turning" it into the substrate with downward pressure.

Once the sampler was in place in a riffle, the substrate within the cylinder was stirred vigorously to a depth of 3 to 4 inches with a 3-pronged garden digger. The organisms in the sample area were carried into the net by the current which entered the upstream, screened, "window" and flowed through the Surber net. Larger rocks in the sample area were examined, and clinging organisms removed before the sampler was moved. The inside diameter of the sampler was 12.5 inches, and, therefore, an area of 0.85 ft^2 was sampled at each placement. Three placements were sampled in each riffle that was present in the study area. Since either three or four riffles were present, this gave total sample areas of 7.65 ft^2 or 10.2 ft^2. Kuester (1964) found that 5 ft^2 samples from streams like Big Buffalo Creek, which were less than 25 ft wide, resulted in the collection of a high percentage of the species actually present.

Samples were washed and separated in the field with 1/2-inch mesh hardware cloth and 1/40-inch mesh brass strainer cloth. Material on the coarse screen was examined, organisms found retained, and debris discarded. Organisms from the coarse screen and all material from the fine screen were preserved in 10% formalin. In the laboratory, invertebrates were separated from debris by sugar flotation and handpicking (Anderson, 1959). Using standard references, identification of organisms was as follows:

(1) Flatworms *(Platyhelminthes)*, annelids *(Annelida)*, and round worms *(Nematoda)* were identified to class.
(2) Flies *(Diptera)* were identified to family or genus.
(3) Stoneflies *(Plecoptera)*, mayflies *(Ephemeroptera)*, caddisflies *(Trichoptera)*, mussels *(Pelecypoda)*, snails *(Gastropoda)*, crustaceans, and insect groups other than those named were identified to genus or species.

Diversity index values were calculated by the equation:

$$d = \frac{s-1}{\log_e N}$$

where s is the total number of types or taxa of organisms, and N is the total number of organisms in the sample (Wilhm, 1967).

RESULTS

The benthic macroinvertebrate fauna of Big Buffalo Creek was similar to that found in other unpolluted Ozark streams. Seventy-eight taxa were collected from the four riffles that were routinely sampled, including 30 taxa of mayfly and stonefly larvae, which was in close agreement to the mean of 28 for other unpolluted Ozark streams (Ryck, 1973). There were seven scouring floods during the study.

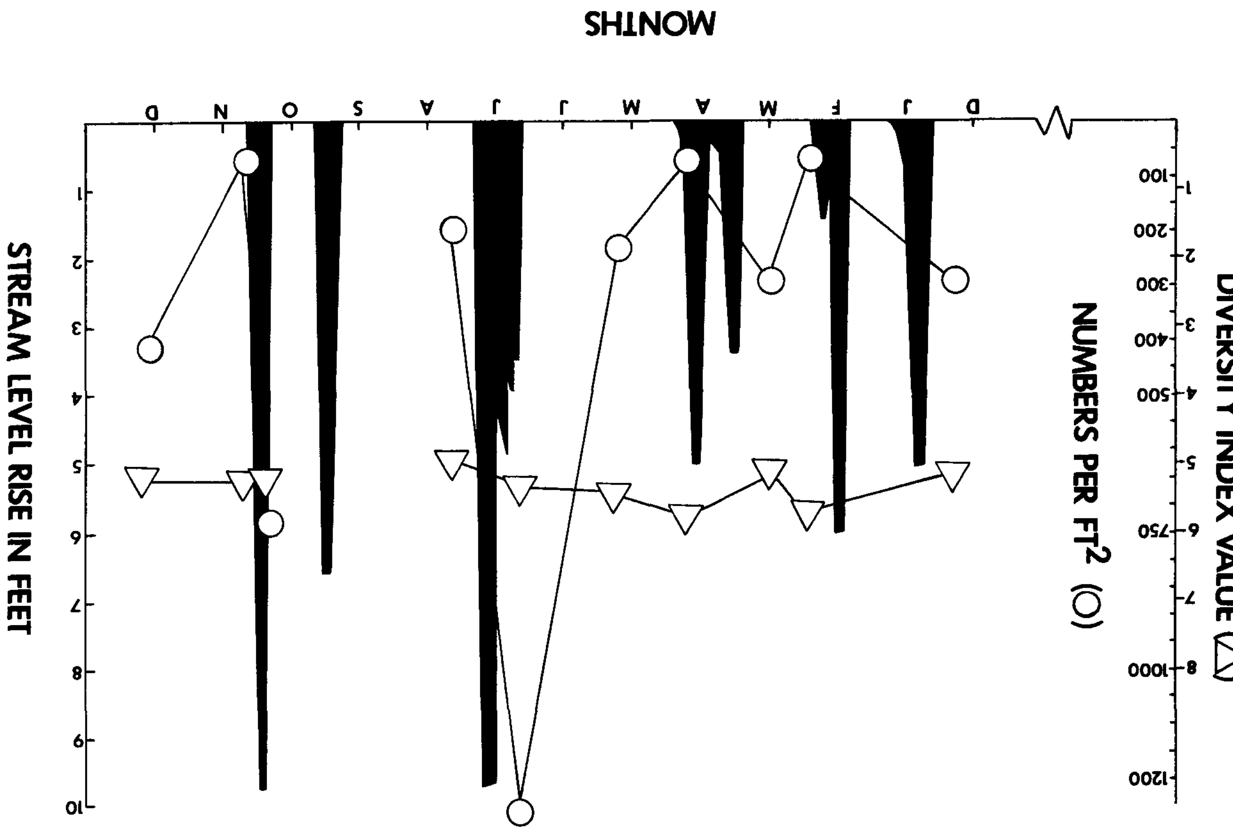

Figure 3. The effects of scouring floods on density and diversity index values of benthic macroinvertebrate samples from Big Buffalo Creek, Benton and Morgan counties, Missouri, December 1968 through December 1969.

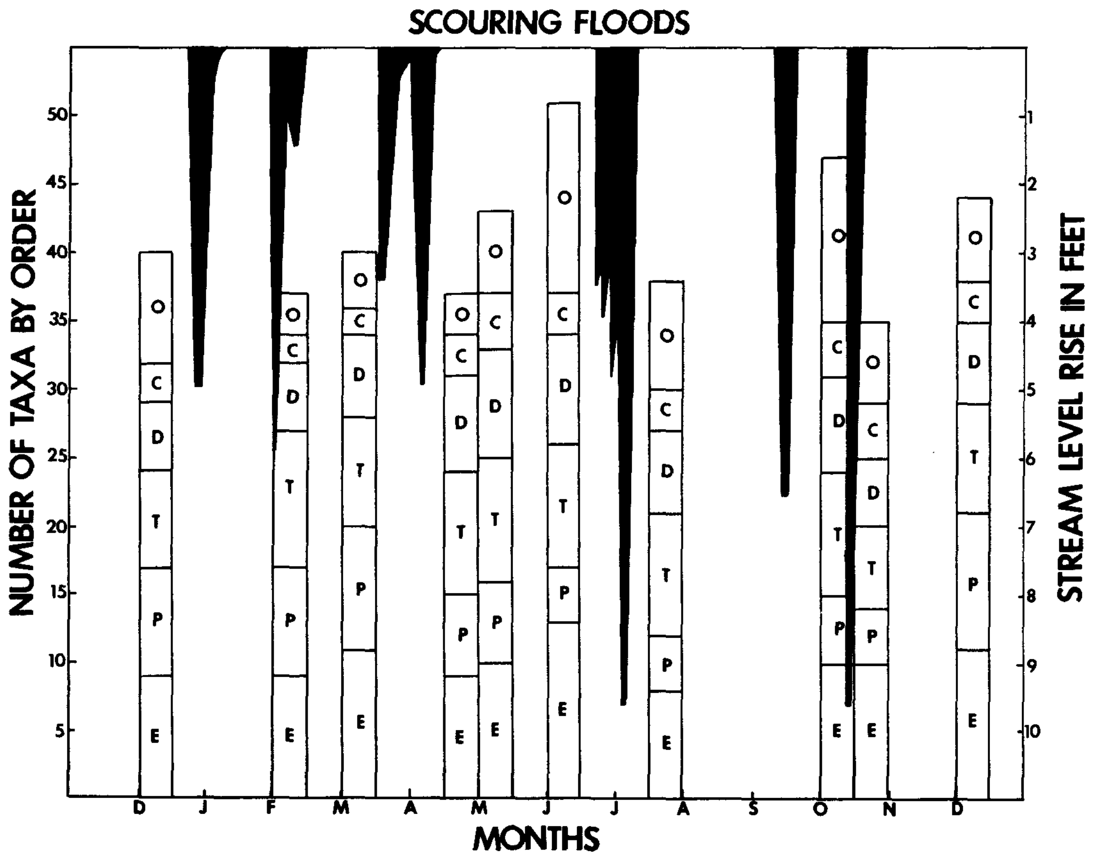

Figure 4. The number of taxa, by Order, of benthic macroinvertebrates collected from Big Buffalo Creek in 1968-1969. E = Ephemeroptera, P = Plecoptera, T = Trichoptera, C = Coleoptera, D = Diptera, O = Other.

Effects on invertebrate density

Scouring floods in Big Buffalo Creek caused reductions in invetebrate density. The magnitude of the reductions was dependent on both the time of the year and the severity of flooding. The winter and spring floods were of similar magnitude, and had very similar effects on the numbers of organisms in the collections. During both these seasons, invertebrate densities were reduced from about 290 organisms per ft^2 to 72 organisms per ft^2 (Figure 3); a reduction in density of 75%. However, 1 month after the winter floods the density of the invertebrate community was essentially identical to the pre-flood values, and only slightly different 1 month after the spring floods.

Summer and autumn floods in 1969 were greater in magnitude than those in winter and spring. Since pre-flood invertebrate densities appeared to be greater, the effects of the floods on density were proportionately more pronounced. In June, the pre-flood density was 1,249 organisms per ft^2. In July, after several severe floods, the density was reduced to 197 organisms per ft^2; a reduction of 84%. Since no samples were collected in August or early September it was not possible to follow the recovery of the invertebrate density. The October flood reduced invertebrate density by 90%, from 722 organisms per ft^2 to 69 organisms per ft^2. Approximately 2 months later, the invertebrate density was 57% of the October density, but it was substantially higher than the density recorded at the start of the study in December, 1968.

Winter floods resulted in numerical losses of 56% for Ephemeroptera (mayflies), 52% for Coleoptera (beetles), and 99% for Diptera (flies) from the study riffles. Numerically, most of the loss was attributable to the reduction in midge larvae (Chironomidae). Other invertebrates that were sensitive to scouring floods were the mayflies *Paraleptophlebia* sp., *Baetis* ssp., *Heptagenia* sp., *Stenonema tripunctatum/femoratum*, and S. *pulchellum*; the stoneflies *Brachyptera* sp., *Paracapnia* sp., *Isoperla marlynia*, and *I. bilineata/richardsoni*; the caddisfly *Helicopsyche* sp., and the beetles *Psephenus* sp., and *Optioservus* sp.

Following spring floods, there was a numerical loss of 29% of all Ephemeroptera, a 34% increase in Plecoptera, a 55% reduction in Trichoptera, a 66% reduction in Coleoptera, and a 99% reduction in Diptera. Again, most of the total loss was due to reduction in the number of Chironomidae. Other populations that were greatly reduced during this period were the mayflies *Pseudocloeon* sp., and *Baetis* spp.; the stoneflies *Paracapnia* sp., and *Isoperla bilineata/richardsoni;* the caddisflies *Cheumatopsyche* sp., *Hydropsyche* (bifida gp.), and *Helicopsyche* sp.; the beetles *Psephenus* sp., and *Optioservus* sp.; and the fly *Atherix* sp.

Summer floods reduced Ephermeroptera by 87%, Plecoptera by 85%, Trichoptera by 57%, Coleoptera by 81%, and Diptera by 95%. Organisms most sensitive to scouring floods during the summer were the mayflies *Tricorythodes* sp., *Paraleptophlebia* sp., *Isonychia* sp., *Pseudocloeon* sp., *Baetis* spp., *Heptagenia* sp.; the stoneflies *Leuctra* sp., *Neoperla* sp., and *Perlesta* sp.; the caddisflies *Rhyacophila* sp., *Chimarra aterrima, Cheumatopsyche* sp., *Hydropsyche* (bifida gp.), and *Helicopsyche* sp.; the beetles *Psephenus* sp., and *Optioservus* sp.; and the flies *Hexatoma/Eriocera,* Chironomidae, Simuliidae, *Chrysops/Tabanus,* and *Empididae*.

Autumn floods reduced the numbers of Ephemeroptera by 93%, Plecoptera by 77%, Trichoptera by 86%, and Diptera by 97%. Organisms most susceptible to scouring floods during the autumn were the mayflies *Ephemerella* (bicolor gp.), *Leptopheliba* sp., *Isonychia* sp., *Pseudocloeon* sp., *Baetis* spp., and *Stenonema pulchellum;* the stonefly *Neoperla* sp.; the caddisflies *Chimarra aterrima, Polycentropus* sp., *Cheumatopsyche* sp., *Hydropsyche* (bifida gp.), and *Helicopsyche* sp.; the beetles *Psephenus* sp., and *Optioservus* sp.; and the flies *Hexatoma/Eriocera, Chironomidae,* Simuliidae, *Atherix* sp., and Empididae. *Baetis* spp, *Cheumatopsyche* sp., and *Chironomidae* showed the greatest numerical losses after the autumn flood.

Effects on invertebrate diversity

The total number of invertebrate taxa that were collected decreased after each scouring flood. There were seasonal differences in the magnitude of the observed reductions, but generally the changes were small. For example, winter and spring floods typically resulted in reductions in the number of taxa collected of about 6% (Figure 4). Organisms other than mayflies, stoneflies, caddisflies, beetles, and true flies were responsible for much of this loss. The summer and autumn floods were of greater magnitude than those earlier in the year and they resulted in reduction of about 30% in the number of collectable taxa. Most of the summer reduction was due to reductions in Ephemeroptera (mayfly) taxa and organisms in the "other" category. Autumn floods seriously affected the number of Trichoptera (caddisflies) and "other" organisms.

Diversity index values were generally unaffected by the scouring floods (Figure 3). The slight increase in diversity index values observed for samples collected following winter and spring floods resulted from the relatively small decrease (6%) in total taxa collected and the large decrease (75%) in the number of organisms.

DISCUSSION

Streams with unstable substrates, like Big Buffalo Creek, scour readily. In such streams, many benthic macroinvertebrates are forcibly removed from their niches by the increased current and the grinding, downstream movement of the substrate during floods. Other organisms may actively enter the water column. Both groups of organisms make up the "catastrophic drift" of the stream (Waters, 1965). Streams with relatively stable substrates have a proportionately higher fraction of volunteer organisms in the "catastrophic drift" than do streams with unstable substrates (Anderson and Lehmkuhl, 1968.)

When an organism enters the "catastrophic drift" of a stream its fate is largely determined by factors such as gradient, water velocity and volume of flow. Sprules (1947) found that many organisms in the drift of high gradient streams were damaged. Other organisms are doubtless displaced considerable distances downstream to areas where they may be stranded by receding water levels (Pearson and Franklin, 1968; Kroger, 1973; Denham, 1938), deposited in areas where they may die for lack of suitable habitat, or be eaten by predators (Pate, 1932). Most of the "catastrophic drift", however, is probably not displaced downstream for any significant distance, but rather, is deposited in pools and eddies where currents are slower. Lehmkuhl and Anderson (1972) found that winter floods resulted in the redistribution of benthos from the larger substrate of riffles to glides and backwaters that had smaller substrate particle sizes.

The repopulation of riffles scoured by flash floods may occur as a result of downstream drift from upstream unaffected headwaters, tributaries, and spring branches (Waters, 1964; Moffett, 1936; Stehr and Branson, 1938; Radford and Hartland-Rowe, 1971; and many others). It may also result from the upstream movement of larva (Stehr and Branson, 1938; Neave, 1930; Elliott, 1971; Bishop and Hynes, 1969), or from upstream ovaposition flights of adult insects (Muller, 1954; Pearson and Kramer, 1972; Stehr and Branson, 1938; Larimore et al., 1959; Roos, 1957). In almost every instance, the mechanism responsible for the recovery of riffle benthic macroinvertebrate populations is probably a combination of downstream drift and upstream movement of larva, and upstream ovaposition flights of adults.

The riffle benthic macroinvertebrate community of Big Buffalo Creek recovered quite rapidly from the effects of each scouring flood. The numbers of invertebrates collected per ft^2 and the number of taxa collected were equal to pre-flood values within 1 month of any flood. Since the riffles sampled were near the upper limit of permanent flow in the creek, the observed rapid recovery supports the view that invertebrates in the "catastrophic drift" are not displaced great distances during floods.

Benthic macroinvertebrate samples from unpolluted Ozark streams usually have diversity index values greater than 4.0 and eight or more total taxa of mayflies and stoneflies (Ryck, 1974). Samples collected in Big Buffalo Creek from 8 days to 1 month after scouring floods all had diversity index values above 4.0, all values were fairly constant, and no sample contained fewer than eight total taxa of mayfly and stonefly larva. Chutter (1972) cautioned that, where the riffle community of benthic macroinvertebrates is temporarily depleted by scouring floods, pollution determinations based on the density and diversity of this community must be made with considerable care. This warning is especially apt where samples are collected from areas polluted by organic wastes which may have had associated sludge deposits or heavy growths of filamentous algae or sewage fungus. Scouring floods remove these growths and deposits from the stream bed. Organisms such as midge larva and oligochaetes that are intimately associated with the deposits are readily scoured, and may take considerable time to build their numbers back to pre-flood levels. Longer periods of time are therefore required before accurate water quality assessments can be made in areas seriously polluted by organic wastes.

SUMMARY

There were seven flash floods on Big Buffalo Creek in 1969 that caused substantial scouring of the stream substrate which resulted in the temporary dislocation of benthic macroinvertebrates. Recovery of this community was rapid, and essentially complete 1 month after floods. Since the invertebrate community structure and density after seven scouring floods were similar to those present at the start of the year, one can assume that large numbers of organisms were not destroyed. Scouring floods in Big Buffalo Creek probably disperse most invertebrates only short distances downstream to

quieter, less turbulent water in pools and backwaters. After the waters receded, they were able to quickly repopulate nearby riffles. Diversity index values and the total number of mayfly and stonefly taxa in macroinvertebrate samples gave accurate assessments of community diversity 8 days after floods.

LITERATURE CITED

Anderson, N. H., and D. M. Lehmkuhl. 1968. Catastrophic drift of insects in a woodland stream. Ecology, 49(2):198-206.

Anderson, R. O. 1959. A modified flotation technique of sorting bottom fauna samples. Limnol. Oceanog., 4(2):223-225.

Bishop, J. E., and H. B. N. Hynes. 1969. Upstream movements of the benthic invertebrates in the Speed River, Ontario. J. Fish. Res. Bd. Canada, 26(2):279-298.

Chutter, F. M. 1972. An empirical biotic index of the quality of water in South African streams and rivers. Water Res., 6:19-30.

Denham, S. C. 1938. A limnological investigation of the west fork and common branch of White River. Invest. Indiana Lakes and Streams, No. 5:17-71.

Elliott, J. M. 1971. Upstream movements of benthic inveterbrates in a lake district stream. J. Anim. Ecol., 40(1):235-252.

Elwood, J. W., and T. F. Waters. 1969. Effects of floods on food consumption and production rates in a stream brook trout population. Trans. Amer. Fish. Soc., 98(2):253-262.

Fajen, O. F. 1959. Movement and growth of smallmouth bass in small Ozark streams. Unpublished M. A. Thesis, Univ. of Mo., 96pp.

Fajen, O. F. 1973. Stabilization and improvement at Big Buffalo Creek. Mo. Dept. Conserv., unpublished D-J Progress Report, F-1-R-22, Study S-13, Job No. 1, 8pp.

Hess, A. D. 1941. New limnological sampling equipment. Limnol. Soc. Amer. Spec. Publ. No. 6, 5pp.

Hoopes, R. 1975. Flooding as a result of Hurricane Agnes, and its effect on a native brook trout population in an infertile headwater stream in central Pennsylvania. Trans. Amer. Fish. Soc., 104(1):96-99.

Kuester, D. 1964. The benthos of the streams in the Meramec River basin as related to water quality. pp. 24-40. *In:* Missouri Water Pollution Board. Water quality of the Big, Bourbeuse, and Meramec river basins. 65pp.

Kroger, R. L. 1973. Biological effects of fluctuating water levels in the Snake River, Grand Teton National Park, Wyoming. Amer. Midl. Nat., 89(2):478-481.

Larimore, R. W., W. F. Childers, and C. Heckrotte. 1959. Destruction and reestablishment of stream fish and invertebrates affected by drought. Trans. Amer. Fish. Soc., 88(4):261-285.

Lehmkuhl, D. M., and N. H. Anderson. 1972. Microdistribution and density as factors affecting the downstream drift of mayflies. Ecology, 53(4):661-667.

Logan, S. M. 1963. Winter observations on bottom organisms and trout in Bridger Creek, Montana. Trans. Amer. Fish. Soc., 92(2):140-145.

McLay, C. L. 1968. A study of drift in the Kakanui River, New Zealand. Austr. J. Mar. Freshwater Res., 19(2):139-149.

Moffett, J. W. 1936. A quantative study of the bottom fauna in some Utah streams variously affected by erosion. Bull. Univ. Utah, 26(9):1-32.

Muller, K. 1954. Investigations on the organic drift in north Swedish streams. Rept. Inst. Freshwater Res., Drottningholm., 35:133-148.

Neave, F. 1930. Migratory habits of the mayfly, *Blasturus cupidus* Say. Ecology, 11(3):568-576.

Needham, P. R. 1927. A quantitative study of the fish food supply in selected areas. A biological survey of the Oswego River system. N. Y. State Conser. Dept., Suppl. to 17th Ann. Rept., 229-232.

Pate, V. S. L. 1932. Studies on the fish food supply in selected areas. A biological survey of the Oswegatchie and Black river systems. Suppl. to 21st Ann. Rept. N. Y. State Conser. Dept., 133-149.

Pearson, W. D., and D. R. Franklin. 1968. Some factors affecting drift rates of *Baetis and* Simulidae in a large river. Ecology, 49(1):75-81.

Pearson, W. D., and R. H. Kramer. 1972. Drift and production of two aquatic insects in a mountain stream. Ecol. Monogr., 42(3):365-385.

Pflieger, W. L. 1971. A distributional study of Missouri fishes. Univ. Kans. Mus. Nat. Hist. Surv. Bull., 23(1):316pp.
Radford, D. S., and R. Harland-Rowe. 1971. A preliminary investigation of bottom fauna and invertebrate drift in an unregulated and a regulated stream in Alberta. J. Appl. Ecol., 8:883-903.
Roos, T. 1957. Studies on upstream migration in adult stream-dwelling insects. Rept. Inst. Freshwater Res., Drottningholm., 38:167-193.
Ryck, F. M., Jr. 1973. The mayfly and stonefly fauna of Missouri Ozark streams. Trans. Mo. Acad. Sci. 7-8:3-21.
Ryck, F. M., Jr. 1974. Water quality survey of the southeast Ozark mining area, 1965-1971. Mo. Dept. Conserv. Aquatic Series, No. 10, 28pp.
Sauer, C. O. 1920. The geography of the Ozark highland of Missouri. Geographic Soc. Chicago Bull., No. 7, 245pp.
Seegrist, D. W., and R. Gard. 1972. Effects of floods on trout in Sagehen Creek, California. Trans. Amer. Fish. Soc., 101(3):478-482.
Sprules, W. M. 1947. An ecological investigation of stream insects in Algonquin Park, Ontario. Univ. Toronto Studies, Biol. Ser., No. 56, 81pp.
Stehr, W. C., and J. W. Branson. 1938. An ecological study of on intermittent stream. Ecology, 19(2):294-310.
Tarzwell, C. M. 1937. Factors influencing fish food and fish production in southwestern streams. Trans. Amer. Fish. Soc., 67:246-255.
U. S. Geological Survey. 1969. *Surface water records of Missouri.* Published annually and available on request from U.S.G.S., Rolla, Mo.
Waters, T. F. 1964. Recolonization of denuded stream bottom areas by drift. Trans. Amer. Fish. Soc., 93(3):311-315.
Waters, T. F. 1965. Interpretation of invertebrate drift in streams. Ecology, 46(3):327-334.
Waters, T. F., and R. J. Knapp. 1961. An improved stream bottom fauna sampler. Trans. Amer. Fish. Soc., 90(2):225-226.
Wilhm, J. L. 1967. Comparison of some diversity indices applied to populations of benthic macroinvertebrates in a stream receiving organic wastes. Jour. Water Poll. Contr. Fed., 39(10):1,673-1,683.