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Bottom Fauna in Some Utah Streams
Variously Affected by Erosion

BY

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A Quantitative Study of the Bottom Fauna in Some Utah Streams Variouslly Affected by Erosion*

BY JAMES W. MOFFETT

INTRODUCTION

Floods and cloudbursts in the Intermountain region of western United States cause considerable damage to watersheds and streams. Because of steep gradients these torrential waters remove vast quantities of debris, stones, gravel and soil from the stream beds. It follows that, with the removal of materials from a stream bottom, the flora and fauna would also be affected. To determine the effects of flood conditions upon bottom fauna and the subsequent reestablishment of these forms is the purpose of this study.

Floods definitely reduce the productivity of streams by their scouring action upon the bottom and by the turbidity of their torrential waters. By using drift nets in streams under flood conditions in central New York, Paul R. Needham (1928) found that myriads of aquatic nymphs, washed away from the bottom, were ground to bits by the scouring action of the materials carried in flood waters. He states that floods cause untold damage to bottom fauna in this manner.

To the author's knowledge, no previous studies of this particular nature have been undertaken. Just when a stream can be expected to reach a normal productive stage after a flood has caused doubt and no little speculation. Because of the limited scope of this study generalizations cannot be made concerning recovery in all streams. It is believed, however, that the streams studied are typical of many streams in the Great Basin. Rate of recovery will vary in different waters since few streams present identical physical, chemical, and biological characteristics which have direct effect upon the cycle of their aquatic life. Severity of disturbance would also determine the rate of recovery. The time of year in which floods occur may vary the recovery rate since the reproductive cycle of the stream bottom fauna is to a certain extent seasonal.

Sincere thanks are extended to Dr. Albert S. Hazzard, under whose guidance this study was made, to many friends who aided the work greatly and to the United States Bureau of Fisheries for the use of equipment necessary in the work.

*A thesis presented to the Faculty of the University of Utah in partial fulfillment of requirements for the degree of Master of Arts.

METHODS

SELECTION OF STREAM SECTIONS

The sections of the various streams were selected for study because of their similarities in gradient, size and volume fluctuation. The entire length of one (South Willow Creek) was studied in comparison with portions of the others.

Stations two hundred yards apart were selected in the various sections chosen. Distances were determined by the use of a one hundred foot tape. Stations were placed at 100 yard intervals for the first survey of South Willow Creek in order to determine more definitely the condition of the stream at the beginning of the study.

PHYSICAL DATA

At each station the width and average depth were recorded. In order to determine the average depth the several measurements taken at intervals across the stream bed were added and divided by a number greater by one than the number of measurements. This method corrects for the zero depth at a point where the water and banks meet.

Both air and water temperatures were taken. The air temperatures were secured by holding the thermometer at fore-arms length away from the body, at the level of the waist, while standing in the middle of the stream with the back to the sun. Water temperatures were taken by completely immersing the thermometer.

Type of bottom for each station was recorded and based upon the observer's ability to designate types as recommended by Hazzard (1934A).

Rate of flow and the amount of water in cubic feet per second were measured according to the field method used by the United States Bureau of Fisheries in its biological surveys of streams. Average widths and depths of the stream were measured in several places within a length of 50 feet. Floats of uniform size were then timed over the 50 foot stretch. At least three tests were made and the average determined. The figures thus obtained were set up in the following formula.

$$\frac{\text{Ave. Width} \times \text{Ave. Depth} \times 0.8 \times \text{Length of Stretch}}{\text{Ave. Time}} = \text{c. f. s.}$$

The factor 0.8 is a constant designated for streams with bowl shaped bottom covered with gravel.

CHEMICAL DATA

Chemical analysis of the waters in each stream under consideration were made for comparison and possible correlation with the existing fauna and flora. The method used was adopted from "The Standard Method of Water Analysis" (1933).

BIOLOGICAL DATA

Square foot samples were obtained by the use of a specially built net designed by the United States Bureau of Fisheries (Fig. 1). This net consists of a bag (A) made from coarse mesh bolting silk mounted upon a vertical brass frame (B). Attached to this is a horizontal frame (C), enclosing an area of one square foot. Samples were taken by placing the net on the stream bottom with horizontal frame pointing upstream. In this position the net was distended by the current and all organisms dislodged from the square foot area enclosed in the horizontal frame were washed into the net. The organisms as

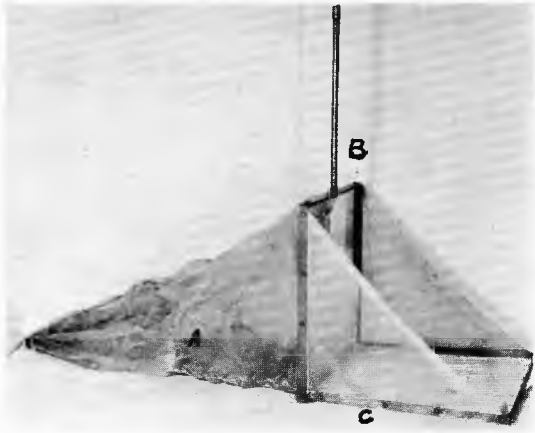


FIG. 1

Square Foot Stream Bottom Sampler.

well as certain debris were then concentrated in the cone of the net by vigorous swishing. The accumulated organisms and debris were preserved in four percent formalin and taken to the laboratory for study. Each sample was emptied into a white enamel pan and the organisms counted and identified as they were removed. In order to feel sufficiently sure that all were removed from the debris, a second check was made.

After the organisms were separated into their respective groups the excess water was removed by placing them on blotting paper. Measurements were made as soon as the organisms were sufficiently dry to fall from the blotting paper when held in a vertical position. This procedure required about two minutes.

The samples were then weighed on a balance sensitive to 0.01 gram. Because the percentage of error would be quite large, it was not thought advisable to weigh each group separately. Dry weights were not made

because they are neither comparable to the weights under natural conditions nor to the results of other investigators.

Organisms were classified to the order in the case of mayflies (Ephemera), stoneflies (Plecoptera), caddisflies (Trichoptera), and beetles (Coleoptera). In the order Diptera classification was carried to families for the midges (Chironomidae), black flies (Simuliidae) and crane flies (Tipulidae) while the remainder, such as Tabanidae, were included under the caption, "Other Diptera". The following groups were classified to phylum or class depending on their relative abundance: Turbellaria, Nematoda, Mollusca and Oligochaeta.

Discussion of Streams Studied

SOUTH WILLOW CREEK

South Willow Creek is a small stream draining to the northeast from the Stansbury range of mountains located south of Great Salt Lake in Tooele County, Utah. It lies within the Grantsville division of the Wasatch National Forest and drains an area of approximately 20 square miles. The flow of South Willow Creek is practically constant since it is fed almost entirely by springs throughout the year, except at periods of spring run-off and very infrequent floods. The stream has its source in a spring at the mouth of Mill Fork. It flows approximately 50 yards before it reaches the main channel of the canyon. It then courses northeast with an estimated gradient of 200 feet per mile, passing over quartzites and limestones of Paleozoic age. One mile below the source of the main creek another spring enters. Numerous small seepages along the banks enlarge the stream over its length of two miles at which point South Willow Creek is diverted into a power conduit and conducted to the mouth of the canyon three miles below.

On August 7, 1934, a cloud-burst took place in the head of South Willow Creek giving rise to the first flood which had swept the canyon in fifty years. This flood reached a height of six feet and carried large quantities of debris and gravel down the canyon. The onslaught gouged the bottom of the stream in places to a depth of fifteen feet. (Fig. 2). Silt was removed from the gravel and all pools were obliterated. The cover and shade were torn out and piled high against obstructions farther down stream. The flood left the canyon practical-



FIG. 2
Showing Condition of South Willow Creek
Following the Flood.

TABLE I.

NUMBERS OF ORGANISMS PER SQUARE FOOT IN SAMPLES TAKEN FROM SOUTH WILLOW CREEK,
SEPTEMBER 22-23, 1934

Sample No.	Chironomidae	Simuliidae	Ephemeroidea	Trichoptera	Other Diptera	Turbellaria	Coleoptera	Oligochaeta	Nematoda	Tipulidae	Plecoptera	Total Number
1	5	....	20	3	1	44	19	4	....	1	....	97
2	133	....	20	1	6	3	....	....	....	....	1	164
3	142	....	....	3	5	1	....	....	....	....	....	151
4	199	....	....	....	5	....	....	1	....	....	....	205
5	247	....	....	1	....	....	....	....	....	....	....	248
6	395	4	....	....	....	....	....	....	....	....	....	399
7	65	....	40	18	5	....	....	....	1	....	....	129
8	9	....	3	....	2	....	....	....	....	....	....	14
9	79	....	11	14	11	....	....	1	....	....	....	116
10	31	1	3	....	2	....	....	....	....	....	....	40
11	26	....	5	2	....	....	....	....	....	....	....	33
12	63	1	2	1	1	....	....	....	....	....	....	68
13	98	10	23	....	1	....	....	....	....	....	....	132
14	23	1	....	....	1	....	....	....	....	....	....	25
15	165	91	8	2	1	....	....	....	....	1	....	268
16	176	2	....	....	....	....	....	....	....	....	....	178
17	218	2	1	....	....	....	....	....	....	....	....	221
18	237	4	9	3	....	....	....	....	1	....	....	254
19	387	27	7	2	....	....	....	....	....	....	....	423
20	283	13	8	....	....	....	....	....	....	....	....	304
21	125	38	20	3	7	....	....	....	....	....	....	193
22	115	153	15	....	2	....	1	....	1	....	....	287
23	84	90	17	....	1	....	....	....	....	....	....	200
24	6	2	....	....	....	....	....	....	....	....	....	8
25	19	6	5	....	....	....	....	....	....	....	1	31
26	14	7	8	....	....	....	....	....	....	....	....	29
27	14	12	3	....	....	....	....	....	....	....	....	29
28	5	....	....	....	....	....	....	1	....	....	....	6
Totals	3366	472	228	53	51	48	20	7	3	2	2	4252
Ave.	120	17	8	2	2	2	1	....	....	....	....	152
% of Total	79.16	11.10	5.36	1.24	1.19	1.12	0.47	0.16	0.07	0.04	0.04	....

TABLE II.

VOLUMES OF ORGANISMS PER SQUARE FOOT IN SAMPLES TAKEN FROM SOUTH WILLOW CREEK,
SEPTEMBER 22-23, 1934

Sample No.	Chironomidae	Simuliidae	Tipulidae	Ephem-erida	Trichop-tera	Other Diptera	Turbel-laria	Oligo-chaeta	Coleop-tera	Nema-toda	Pleco-p-tera	Total Volume	Total Weight
1	neg.	---	0.50	0.10	0.08	neg.	0.18	neg.	0.03	---	---	0.89	0.98
2	0.20	---	---	0.03	neg.	0.08	0.01	---	---	---	neg.	0.32	0.35
3	0.12	---	---	---	0.02	0.06	neg.	---	---	---	---	0.20	0.23
4	0.10	---	---	---	---	0.06	---	neg.	---	---	---	0.16	0.19
5	0.20	---	---	---	0.15	---	---	---	---	---	---	0.35	0.41
6	0.15	neg.	---	---	---	---	---	---	---	---	---	0.15	0.19
7	0.05	---	---	0.20	0.02	0.03	---	---	---	neg.	---	0.30	0.38
8	neg.	---	---	0.02	---	0.03	---	---	---	---	---	0.05	0.05
9	0.08	---	---	0.05	0.02	0.03	---	neg.	---	---	---	0.18	0.19
10	0.04	neg.	---	0.01	---	neg.	---	---	---	---	---	0.05	0.06
11	0.01	---	---	0.02	0.01	---	---	---	---	---	---	0.04	0.05
12	0.05	neg.	---	0.01	neg.	0.01	---	---	---	---	---	0.07	0.10
13	0.04	0.02	---	0.06	---	0.02	---	---	---	---	---	0.14	0.20
14	0.01	neg.	---	---	---	0.01	---	---	---	---	---	0.02	0.05
15	0.18	0.20	0.40	0.03	0.20	0.01	---	---	---	---	---	1.02	1.14
16	0.40	neg.	---	---	---	---	---	---	---	---	---	0.40	0.47
17	0.50	neg.	---	neg.	---	---	---	---	---	---	---	0.50	0.55
18	0.70	neg.	---	0.04	neg.	---	---	---	---	neg.	---	0.74	0.85
19	0.80	0.08	---	0.02	neg.	---	---	---	---	---	---	0.90	0.99
20	0.60	0.08	---	0.02	---	---	---	---	---	---	---	0.70	0.80
21	0.08	0.12	---	0.12	neg.	0.03	---	---	---	---	---	0.35	0.49
22	0.10	0.30	---	0.06	---	neg.	---	---	neg.	neg.	---	0.46	0.55
23	0.09	0.21	---	0.04	---	neg.	---	---	---	---	---	0.34	0.44
24	neg.	neg.	---	---	---	---	---	---	---	---	---	neg.	0.02
25	0.02	0.01	---	0.01	---	---	---	---	---	---	neg.	0.04	0.07
26	0.01	0.01	---	0.02	---	---	---	---	---	---	---	0.04	0.06
27	0.01	0.02	---	neg.	---	---	---	---	---	---	---	0.03	0.05
28	neg.	---	---	---	---	---	---	0.06	---	---	---	0.06	0.07
Totals	4.54	1.05	0.90	0.86	0.50	0.37	0.19	0.06	0.03	neg.	neg.	8.50	9.98
Ave.	0.16	0.04	0.03	0.03	0.02	0.01	0.007	0.002	---	---	---	0.30	0.36
% of Total	53.41	12.35	10.57	10.12	5.88	4.35	2.23	0.70	0.35	---	---	---	---

ly impassable and filled the stream bed with very loose gravel and rubble. The water was spread out to such an extent that it was visible only at a few points along the stream.

On August 20th., the stream was visited by a survey party of the United States Bureau of Fisheries. This party, of which the author was a member, had planned to make a limnological study of the creek relative to fish management. However, due to the existing conditions, only a hurried survey was made of the damage. Observations revealed no aquatic insect life present in the stream. Algae of several varieties were rapidly spreading down stream from both of the above mentioned springs. The stream was beginning to silt-in a definite channel and was continuous in its flow.

Survey of September 22, 1934.

The first survey was made on the above date. Stations were established on South Willow Creek as described under "Methods". Twenty-eight square foot samples were taken. It was noted, during the sampling, that the restoration of algae was virtually complete. All the stones were covered with algae. The diatoms and slime algae were confined to the small stones in the swifter areas while the filamentous forms were hanging to the ragged edges of boulders near the banks. The algae deposition had materially aided the stream in channelization by sealing the bottom area.

PHYSICAL DATA

The physical data covering the first survey of South Willow Creek, made September 22-23, 1934, showed an air temperature range from 9.5 to 17.7°C. Water temperature ranged from 7.5 to 9.2°C. for all stations. All temperature readings were made between two and five o'clock p. m. The average width of the stream section studied was 4.87 feet and the average depth was 0.15 feet. The stream's flow was approximately 3.0 cubic feet per second. The stream bottom is predominately gravel but other types are present which vary from clay to rubble. Gravel and rubble are the most productive types of stream bottom according to Needham and Pate (1932) as stated in their four-year summary of quantitative food studies on New York streams. It can readily be seen that the type of bottom is very important in the consideration of stream fauna, since it predetermines the kinds and numbers of organisms present.

TABLE III.

NUMBERS OF ORGANISMS PER SQUARE FOOT IN SAMPLES TAKEN FROM SOUTH WILLOW CREEK,
NOVEMBER 11, 1934

Sample No.	Simuliidae	Chironomidae	Plecoptera	Ephem-erida	Trichop-tera	Other Diptera	Oligo-chaeta	Turbel-laria	Coleop-tera	Tipul-idae	Nema-toda	Total Number
1 .....	....	5	82	50	8	5	63	50	40	6	—	309
2	14	385	12	81	26	24	1	9	6	....	3	561
3	37	548	7	11	10	13	4	1	....	....	3	634
4	128	465	....	....	9	6	2	....	....	....	....	610
5	2	133	62	14	....	3	....	....	....	....	....	230
6	678	143	3	9	3	1	....	1	....	....	....	838
7	175	171	1	3	10	....	....	....	....	....	1	371
8	530	67	6	14	7	....	....	....	....	3	....	627
9	845	595	62	6	....	....	....	....	....	....	....	1508
10	700	272	1	9	2	2	....	1	....	....	....	986
11	245	169	12	17	1	....	1	3	....	....	....	448
12	4028	370	4	3	32	6	....	....	....	....	2	4445
13	570	261	2	6	4	11	....	....	....	3	....	857
14	1708	364	39	20	7	1	....	....	....	1	....	2140
Totals	9660	3948	293	253	135	72	71	64	46	13	9	14564
Ave.	690	282	21	18	10	5	5	4	3	1	1	1040
% of Total.....	66.33	27.11	2.01	1.74	0.92	0.49	0.48	0.44	0.32	0.09	0.06	....

TABLE IV.

VOLUMES OF ORGANISMS PER SQUARE FOOT IN SAMPLES TAKEN FROM SOUTH WILLOW CREEK,
NOVEMBER 11, 1934

Sample No.	Stmul- tidae	Chiro- nomidae	Trichop- tera	Tipul- idae	Ephem- erida	Other Diptera	Trichop- tera	Oligo- chaeta	Turbel- laria	Coleop- tera	Nema- toda	Total Volume	Total Weight
1 .....	....	neg.	0.10	0.70	0.03	neg.	0.20	0.12	0.13	0.05	....	1.33	1.75
2	0.02	0.70	0.25	....	0.20	0.35	0.01	neg.	0.05	0.01	neg.	1.59	1.69
2	0.05	0.73	0.11	....	0.05	0.10	neg.	0.20	neg.	....	neg.	1.24	1.69
4	0.24	0.40	0.50	....	....	0.12	....	neg.	....	....	....	1.06	1.43
5	0.01	0.13	0.30	....	0.02	neg.	0.03	....	....	....	....	0.49	0.53
6	1.00	0.11	0.07	....	0.05	neg.	neg.	....	neg.	....	....	1.23	1.40
7	0.14	0.04	0.30	....	0.17	....	neg.	....	....	....	neg.	0.65	0.76
8	0.60	0.03	0.15	0.50	0.60	....	0.01	....	....	....	....	1.45	1.54
9	0.81	0.24	....	....	0.02	....	0.04	....	....	....	....	1.11	1.26
10	1.00	0.08	0.03	....	0.03	0.02	neg.	....	....	....	....	1.16	1.31
11	0.20	0.03	0.05	....	0.20	....	0.02	0.06	0.01	....	....	0.57	0.61
12	4.70	0.12	0.80	....	0.01	0.01	0.01	....	....	....	neg.	5.65	5.75
13	9.70	0.12	0.05	0.90	0.02	0.10	0.01	....	....	....	....	1.90	1.97
14	1.80	0.12	0.30	0.06	0.19	0.03	0.05	....	....	....	....	2.55	2.71
Totals	11.27	2.85	2.81	2.16	1.15	0.73	0.38	0.38	0.19	0.06	neg.	21.98	24.40
Ave	0.81	0.20	0.20	0.16	0.08	0.05	0.05	0.03	0.01	0.004	neg.	1.57	1.74
% of Total....	51.27	12.97	12.78	9.83	5.23	3.32	1.73	1.73	0.86	0.03	....	....	....

BIOLOGICAL DATA

Samples taken on the first survey of South Willow Creek are presented in Tables I and II. The total number of organisms collected during this survey was 4252 with an average of 152. Of this total number Chironomidae constituted 79.16%, Simuliidae 11.10%, Ephemerida 5.30%, Trichoptera 1.24%, Other Diptera 1.19%, Turbellaria 1.12%, Oligochaeta 0.16%, Nematoda 0.07%, Plecoptera and Tipulidae 0.4% each.

The total volume of these organisms was 8.5 cc., averaging 0.30 cc. per square foot. Of the total, Chironomidae constituted 53.41%, Simuliidae 12.35%, Tipulidae 10.57%, Ephemerida 10.12%, Trichoptera 5.88%, Other Diptera 4.35%, Turbellaria 2.23%, Oligochaeta 0.70%, Coleoptera 0.35%. Plecoptera and Nematoda had volumes too small to measure.

The total weight of the organisms taken was 9.98 grams. This figure gives an average of 0.356 grams per square foot. Using this average to represent a square foot, a total of 15,517.36 grams were present on each acre of area. This figure converted to pounds per acre equals 34.21.

Survey of November 11, 1934.

The stream bed was filling with leaves at the time of the second survey. It was remarkable to observe the efficiency with which the leaves sealed the very loose bottom gravels. The current forced them into the crevices of the recently formed channel and caused them to adhere to the rocks to such an extent that they effectively confined the water to a narrow course.

PHYSICAL DATA

The physical data taken on the second survey of South Willow Creek are quite comparable to those of the first. Due to unsettled weather, the air temperature varied from 7.2 to 12.2°C. with an average of 8.3°C. Water temperatures ranged from 3.9 to 6.1°C., averaging about 5.0°C. The bottom composition was practically the same as that of the first survey except for the padding of leaves. Only one set of width and depth measurements were taken because of the small fluctuation in the volume of water.

CHEMICAL DATA

The chemical characteristics of the water on November 11, 1934 at 2:00 p. m., with air temperature at 17.2°C. and water temperature at

TABLE V.

NUMBERS OF ORGANISMS PER SQUARE FOOT IN SAMPLE TAKEN FROM SOUTH WILLOW CREEK,
MARCH 2, 1935

Sample No.	Simul- lidae	Ephem- erida	Chiro- nomidae	Plecop- tera	Oligio- chaeta	Trichop- tera	Other Diptera	Coleop- tera	Turbel- laria	Nema- toda	Tipul- idae	Total Number
1 .....	....	127	22	62	74	7	6	51	15	....	2	366
2	498	219	205	7	....	9	2	....	5	....	....	945
3	228	80	133	16	4	14	6	....	2	....	....	483
4	660	51	264	3	2	3	3	....	....	....	....	986
5	98	457	122	23	....	8	2	....	....	....	....	710
6	1186	200	163	8	2	6	5	....	....	8	....	1578
7	126	41	55	1	....	2	....	....	....	....	....	225
8	27	59	31	1	....	1	2	....	....	....	....	121
9	669	68	67	22	....	2	3	....	....	....	....	831
10	769	391	168	56	....	4	6	....	....	....	....	1394
11	897	360	253	77	....	4	3	1	3	....	....	1598
12	89	21	135	20	....	1	....	....	....	....	....	266
13	263	100	274	22	8	8	7	....	....	....	....	682
14	548	154	324	13	2	3	10	....	....	....	1	1055
Totals	6058	2328	2216	331	92	72	55	52	25	8	3	11240
Ave.	433	166	158	24	7	5	4	4	2	....	....	803
% of Total.....	53.89	20.71	19.71	2.92	0.82	0.64	0.50	0.47	0.22	0.07	0.02	....

TABLE VI.

VOLUMES OF ORGANISMS PER SQUARE FOOT IN SAMPLES TAKEN FROM SOUTH WILLOW CREEK
MARCH 2, 1935

Sample No.	Simuliidae	Ephemeroidea	Trichoptera	Tipulidae	Oligochaeta	Chironomidae	Plecoptera	Other Diptera	Turbellaria	Coleoptera	Nematoda	Total Volume	Total Weight
1 .....	....	0.22	0.14	1.40	0.20	0.01	0.25	0.02	0.06	0.07	....	2.37	2.50
2	1.05	0.55	0.30	....	....	0.15	0.02	0.02	0.01	....	....	2.10	2.25
3	0.30	0.20	0.55	....	0.30	0.03	0.02	0.06	0.01	....	....	1.47	1.62
4	1.10	0.08	0.05	....	0.02	0.09	neg.	0.01	....	....	....	1.35	1.53
5	0.10	1.15	0.25	....	....	0.15	0.07	neg.	....	....	....	1.72	1.85
6	2.15	0.40	0.40	....	neg.	0.06	0.02	0.01	....	....	neg.	3.04	3.21
7	0.22	0.16	0.01	....	....	0.01	neg.	....	....	....	....	0.40	0.42
8	0.04	0.14	0.13	....	....	0.01	neg.	neg.	....	....	....	0.32	0.40
9	1.20	0.27	0.02	....	....	0.05	0.03	0.01	....	....	....	1.58	1.70
10	1.15	0.90	0.20	....	....	0.08	0.10	0.02	....	....	....	2.45	2.84
11	1.60	0.50	0.30	....	....	0.12	0.25	0.01	0.02	neg.	....	2.80	3.15
12	0.19	0.26	0.10	....	....	0.09	0.04	....	....	....	....	0.68	0.75
13	0.50	0.20	0.50	....	1.00	0.10	0.10	0.01	....	....	....	2.40	2.92
14	0.90	0.50	0.15	0.75	neg.	0.07	0.03	0.03	....	....	....	2.43	2.46
Totals	10.50	5.53	3.10	2.15	1.52	1.02	0.93	0.20	0.10	0.07	neg.	25.12	27.60
Ave.	0.75	0.40	0.22	0.15	0.11	0.07	0.07	0.01	0.007	0.005	....	1.79	1.97
% of Total.....	41.80	22.01	12.34	8.56	6.05	4.06	3.70	0.79	0.40	0.27	....	....	....

6.1°C., were as follows: Dissolved oxygen 9.8 parts per million; Free carbon-dioxide 2.5 parts per million; Phenolphthalein alkalinity 0.0 parts per million; Methyl orange alkalinity 133.0 parts per million. The pH as determined colorimetrically was 7.6.

BIOLOGICAL DATA

The total number of organisms found in the fourteen samples taken on the second survey of South Willow Creek was 14,564 or an average of 1040 for each of the fourteen samples (See Table III). Of this total Simuliidae constituted 66.33%, Chironomidae 27.11%, Plecoptera 2.01%, Ephemera 1.7%, Trichoptera 0.92%, Other Diptera 0.49%, Oligochaeta 0.48%, Turbellaria 0.44%, Coleoptera 0.32%, Tipulidae 0.09% and Nematoda 0.06%.

The total volume of the fourteen samples was 21.98 cc., an average of 1.57 cc. per sample. Of this total Simuliidae constituted 51.27%, Chironomidae 12.97%, Trichoptera 12.78%, Tipulidae 9.83%, Ephemera 5.23%, Other Diptera 3.32%, Plecoptera and Oligochaeta 1.73% each and Nematoda a volume too small to measure. (See Table IV).

The total weight of the fourteen samples was 24.40 grams. The average derived from this total was 1.742 grams per square foot sample. This would amount to 75,881.52 grams or 167.32 pounds per acre. These weights are 60,364.16 grams or 133.11 pounds above those of the first survey.

Survey of March 2, 1935

At the time of this survey the watershed was covered with a heavy blanket of snow ranging from 6 to 36 inches in depth. However, the stream was entirely free from ice and snow. Numerous adult midges were observed on the snow and also several small adult stoneflies were taken as they rested just after emergence.

PHYSICAL DATA

Snow and general storm were encountered during this survey. Air temperatures ranged from 1.7 to 3.9°C. Water temperatures ranged from 3.9 to 5.5°C. which are similar to those of the second survey. The bottom types were likewise similar to those of previous observations described above.

BIOLOGICAL DATA

A total of 11,240 organisms was found in the fourteen samples taken with an average of 803. Of this total Simuliidae constituted 53.89%, Ephemera 20.71%, Chironomidae 19.71%, Plecoptera 2.94%,

Oligochaeta 0.82%, Trichoptera 0.64%, Other Diptera 0.50%, Coleoptera 0.46%, Turbellaria 0.22%, Nematoda 0.07% and Tipulidae 0.02%. (Table V).

The total volume of these samples was 25.12 cc. with an average of 1.79 cc. Of this total Simuliidae made up 41.80%, Ephemera 22.01%, Trichoptera 12.34%, Tipulidae 8.56%, Oligochaeta 6.05%, Chironomidae 4.06%, Plecoptera 3.70%, Other Diptera 0.79%, Turbellaria 0.40%, Coleoptera 0.27% and Nematoda a volume too small to measure. (Table VI).

The total weight of these was 27.6 grams with an average of 1.97 grams per square foot. Using this average the total number of grams per acre was 85,813.2 or 189.22 pounds. The pounds per acre of the third survey showed an increase of 155.01 over the first. The weight per acre of the third survey was 21.90 pounds over that of the second.

GENERAL DISCUSSION

Two focal points influenced the distribution of organisms in the restocking of South Willow Creek. Station 1 on the first survey was located in a stretch of stream unaffected by the flood. In this area the original bottom fauna was unmolested and consequently served as a source from which repopulation of the lower waters might take place. The tendency for organisms or their eggs to drift down stream before their final attachment is illustrated by the increase in numbers from station 1 to station 6 during the first survey and with some irregularity in the subsequent surveys (Tables I-VI). One mile below the above mentioned focus is another spring which reaches the main stream through a channel approximately fifty yards long. This channel was unmolested by the flood and showed a rich content of bottom forms. This is the second focal point of distribution from which restocking in the lower end of the stream took place. Repopulation from this point occurred both up and down stream but was more effective in the downstream direction.

Throughout the study of this stream those forms having the shortest life cycles were predominant. They were not only more numerous per unit area but exhibited a greater volume because of their numerical advantage. (Fig. 3). Chironomidae and Simuliidae constituted this group, the former dominating the first survey and the latter the second and third. In the third survey Ephemera supplanted Chironomidae as the second largest group. (Tables V and VI). All other groups increased in numbers during the study but a characteristic decline between the second and third surveys is evident. (Fig. 3). Winter conditions probably caused this since they are so adverse to insect emergence and ovi-

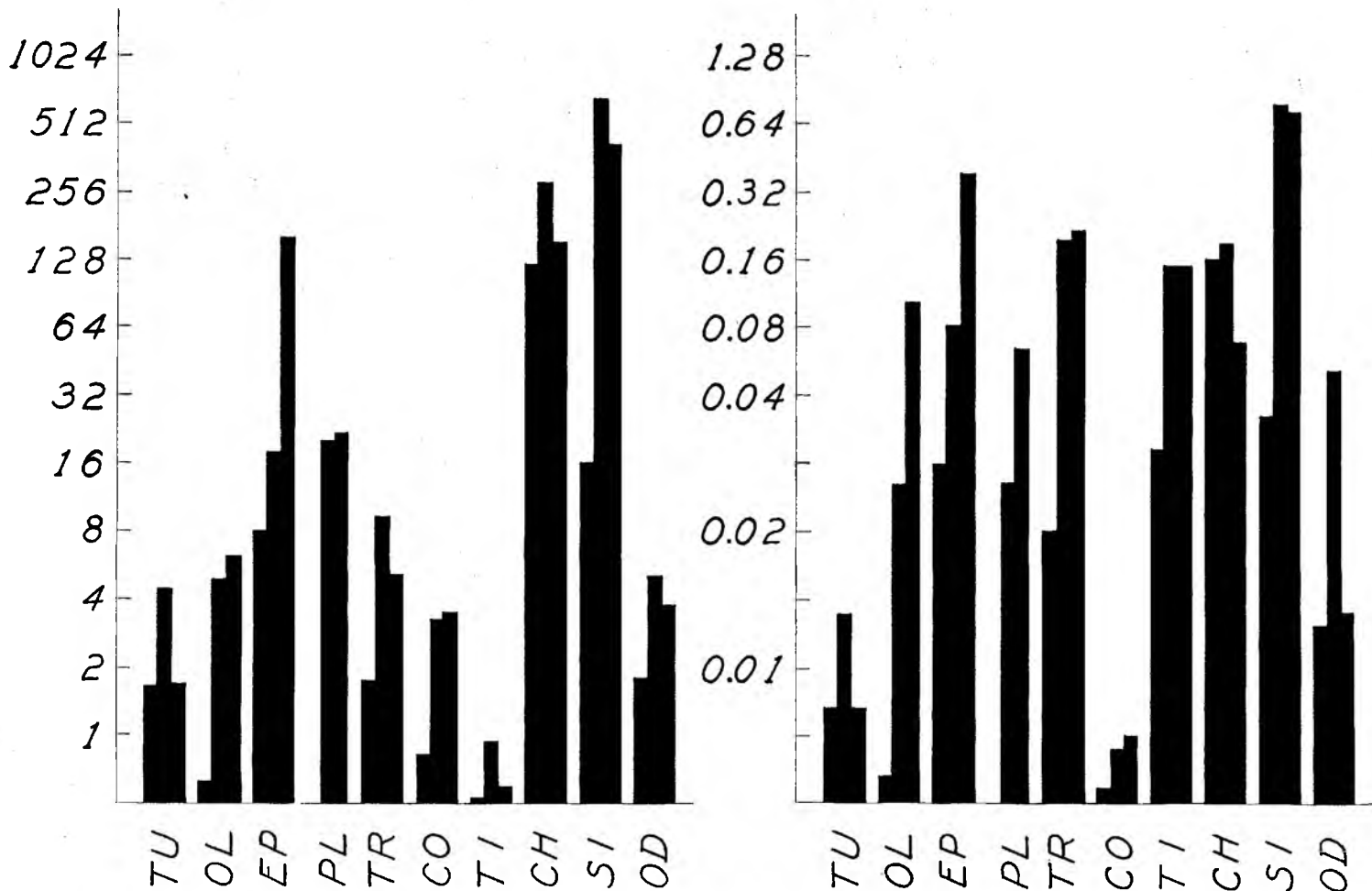


FIG. 3.—Illustrating the Average Numbers and Volumes per Square Foot, of the Several Groups of Organisms Present and their Fluctuation During the Study of South Willow Creek.

EXPLANATIONS: The three surveys are given in order for each group. Volumes are expressed in cubic centimeters.
 CO Coleoptera EP—Ephemera TI Tipulidae TU Turbellaria CH Stimuliidae

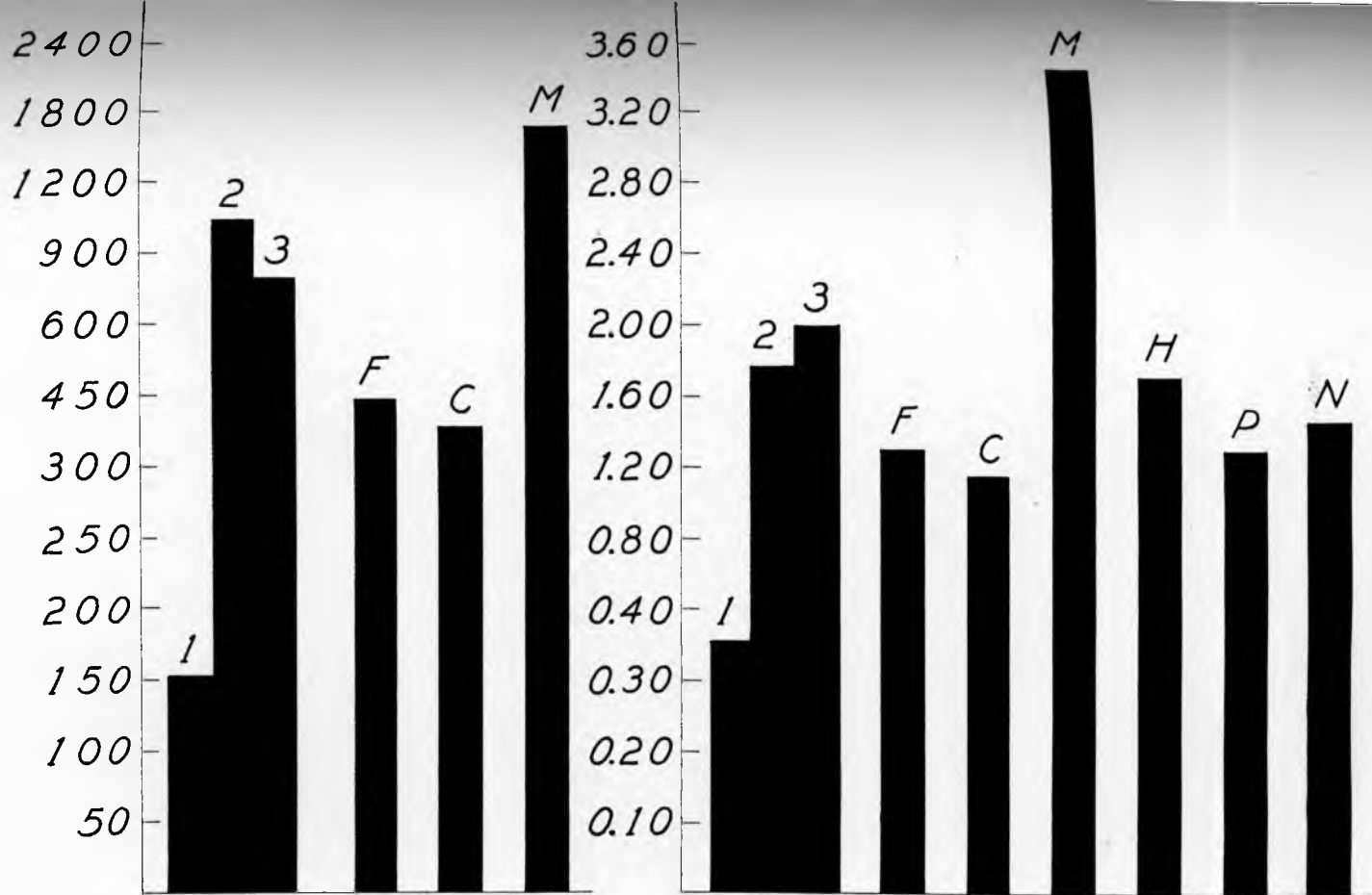


FIG. 5.—The Average Numbers and Weights of Organisms per Square Foot as Found in South Willow Creek (Surveys 1, 2, 3); Farmington Creek, (F); City Creek, (C); Mill Creek, (M); Hazzard's Studies, (H); Pate's Studies, (P); and Needham's Studies, (N). Weights are Expressed in Grams.

position. Average volumes continued to increase in most groups despite their numerical decreases between the second and third surveys, indicating that larger individual size made up for the decrease. The significance of volume in relation to numbers of individuals in aquatic economics cannot be neglected. Comparison of the numbers and volumes of Tipulidae or Trichoptera will suffice to illustrate the importance of the above statement. (Fig. 3).

Fish were not present in the above stream during the study. They were removed completely by the flood. Restocking of the stream must be artificial since it runs directly toward Great Salt Lake through which it is impossible for fish of any kind to migrate. The possible effects of a fish population upon the quantitative supply of bottom fauna was thus removed.

FARMINGTON CREEK

Farmington Creek is located in Davis County, Utah and drains westward from the Wasatch mountains. It has a watershed of approximately fourteen square miles. It is steep and rugged, offering a gradient sufficient to transform heavy rainfall into flood proportions. The watershed has been heavily over-grazed and at present is subject to severe erosion. Farmington Creek is spring fed although one tributary heads in a small lake. It fluctuates with the snow level and often reaches a very low state during drouth years as was the case in 1934. The stream is about seven miles long and descends from an altitude of approximately 9000 to 4300 feet, a gradient of about 671 feet per mile. The fall is much steeper than that of South Willow Creek but the section of stream chosen for the survey had a gradient of approximately 300 feet per mile. Farmington Creek runs over metamorphic quartzites and schists and is less alkaline than the other streams studied.

On August 13, 1923 a terrific flood swept this canyon. It removed all traces of the road and made cuts in the existing Lake Bonneville deltas to a depth of forty feet. Tons of boulders and debris were strewn over fertile sections of Salt Lake Valley. Highways and railroads were obstructed with flood material in such quantities that it required weeks of intense labor to remove them.

On July 10, 1930 another flood from Farmington canyon did equally as much damage. A description of these floods is given in a bulletin published by the United States Department of Agriculture and written by Bailey, Forsling and Becraft (1934).

The creek has suffered several small floods since 1930 but these were of little consequence. The last flood reported occurred during Aug-

ust, 1933. It did very little damage but scoured vegetation and bottom organisms from the stream channel. All fish were either removed or suffocated by the accompanying mud flow. During the study no fish were found in the stream thus allowing a direct comparison with South Willow Creek.

The section of Farmington Creek selected for sampling began at the intake of the Utah Power and Light Company pipe-line which removes most of the water from the stream. From this point the section extended upstream 1.4 miles. Square foot samples were taken every 200 yards along this course.

Three visits were made to Farmington Creek, one on September 29, 1934 at which time seven samples were taken from the lower part of the section. Seven samples were procured from the upper part November 6, 1934. All equipment had to be transported on foot which necessitated two visits for food samples and one for a chemical analysis of the water. The latter was taken October 13, 1934.

PHYSICAL DATA

The air temperature ranged from 16.1 to 20.0°C. September 29, 1934. Water temperature fluctuated between 9.4 and 12.8°C. between the hours of 1:30 and 3:30 p. m. on the above. On November 6, 1934, the air temperature on the stream ranged from 3.9 to 6.6°C. and water temperature from 3.9 to 4.4°C. between the hours of 3:15 and 5:10 p. m.

The bottom was predominantly gravel. In the upper four stations shifting gravel was prevalent. The channel of the stream was poorly defined and a good deal of erosion was taking place. Gravel was dominant between stations 5 and 14. Quantities of sand and rubble



FIG. 4

The Boulder Deposition and Type of Bottom in Farmington Creek.

TABLE VII.

NUMBERS OF ORGANISMS PER SQUARE FOOT IN SAMPLE TAKEN FROM FARMINGTON CREEK,
SEPTEMBER 29, AND NOVEMBER 6, 1934

Sample No.	Simuliidae	Ephem- erida	Trichop- tera	Chiro- nomidae	Pleco- ptera	Other Diptera	Oligo- chaeta	Nema- toda	Coleop- tera	Tipul- idae	Total Number
1	13	44	8	7	....	3	....	....	....	....	75
2	13	18	6	3	....	....	....	....	....	....	40
3	22	21	7	4	....	2	....	....	1	....	57
4	86	31	11	4	....	3	....	....	....	....	135
5	106	82	78	7	5	....	1	....	....	....	279
6	466	101	60	53	6	8	17	....	....	....	711
7	335	183	75	33	8	1	....	1	....	....	636
8	282	219	26	37	5	....	....	2	....	....	571
9	367	187	79	109	16	16	1	12	11	....	798
10	723	223	36	161	9	15	....	1	3	1	1172
11	19	196	8	9	4	1	....	....	....	....	237
12	467	142	66	41	1	....	....	....	....	....	717
13	12	136	10	3	30	2	1	....	....	2	196
14	433	94	64	21	4	2	....	....	....	1	619
Totals	3344	1677	534	492	88	53	20	16	15	4	6243
Ave.	239	120	38	35	6	4	2	1	1	....	446
% of Total.....	53.56	26.86	8.55	7.88	1.41	0.85	0.32	0.26	0.24	0.06	....

were also present. Some boulders were in the stream and ranged from 1 to 5 feet in diameter. (Fig. 4).

The average width of the stream was 6.7 feet, the average depth 0.25 feet. Its flow was found to be 5.2 cubic feet per second.

CHEMICAL DATA

Chemical analysis of the water in Farmington Creek on October 13, 1934 at 2:00 P. M. with the air temperature at 8.3°C. and the water temperature at 9.4°C. was as follows: Dissolved oxygen 10.25 parts per million; Free carbon dioxide 2.1 parts per million; Phenolphthalein alkalinity 0.0 parts per million; Methyl Orange alkalinity 64 parts per million and a pH of 7.6.

BIOLOGICAL DATA

The total number of organisms in the fourteen square foot samples was 6243, an average of 446 per sample. Of this total Simuliidae constituted 53.56%, Ephemera 26.8%, Trichoptera 8.55%, Chironomidae 7.88%, Plecoptera 1.41%, Other Diptera 0.85%, Oligochaeta 0.32%, Nematoda 0.25%, Coleoptera 0.24%, and Tipulidae 0.06%. (Table VII).

The total volume of the fourteen samples was 16.39 cc., an average of 1.17 cc. per square foot. Of this total Trichoptera constituted 38.31%, Simuliidae 33.07%, Ephemera 16.65%, Tipulidae 5.0%, Other Diptera 2.8%, Plecoptera 2.32%, Coleoptera 1.22%, Chironomidae 0.49%, Oligochaeta 0.12% and Nematoda a volume too small to measure. (Table VIII.)

The total weight of all organisms taken in the Farmington Creek survey was 18.04 grams. The average per square foot was 1.28 grams. Using this figure, the grams per acre equal 53,974.6 or 123.42 pounds per acre.

CITY CREEK

City Creek is located in Salt Lake County, Utah. It drains westward from the Wasatch Mountains toward Great Salt Lake. The stream has a gradient of 250 feet per mile, descending from 7300 to 4500 feet in a distance of eleven miles. In order that pollution might be held at a minimum, the city purchased most of the stream and its watershed. Salt Lake City enforces strict sanitary measures and allows no grazing, hunting, wood removal or fishing on the watershed. This protection has kept the stream in good condition.

TABLE VIII.

VOLUMES OF ORGANISMS PER SQUARE FOOT IN SAMPLES TAKEN FROM FARMINGTON CREEK,
SEPTEMBER 29 AND NOVEMBER 6, 1934

Sample No.	Trichoptera	Simuliidae	Ephemeroidea	Tipulidae	Other Diptera	Plecoptera	Coleoptera	Chironomidae	Oligochaeta	Nematoda	Total Volume	Total Weight
1	0.08	0.02	0.06	....	neg.	....	....	neg.	....	....	0.16	0.18
2	0.02	0.02	0.02	....	....	....	....	neg.	....	....	0.06	0.09
3	0.05	0.02	0.03	....	neg.	....	0.01	neg.	....	....	0.11	0.16
4	0.10	0.10	0.02	....	neg.	....	....	neg.	....	....	0.22	0.26
5	0.60	0.10	0.04	....	....	0.01	....	neg.	0.01	....	0.76	0.98
6	0.55	0.35	0.10	....	0.02	0.03	....	neg.	neg.	....	1.05	1.20
7	1.50	0.25	0.40	....	neg.	0.05	....	0.01	....	neg.	1.76	1.87
8	0.40	0.80	0.40	....	....	0.02	....	0.01	....	neg.	1.63	1.74
9	1.00	0.95	0.36	....	0.30	0.06	0.14	0.01	0.01	neg.	2.83	2.89
10	0.31	0.90	0.30	0.24	0.07	0.01	0.05	0.02	....	neg.	1.90	1.99
11	0.07	0.10	0.30	....	0.01	0.02	....	neg.	....	....	0.50	0.60
12	1.00	1.00	0.20	....	....	0.04	....	0.02	....	....	2.26	2.58
13	0.05	0.01	0.30	0.40	0.04	0.12	....	neg.	neg.	....	0.92	0.92
14	1.00	0.80	0.20	0.18	0.02	0.02	....	0.01	....	....	2.23	2.58
Totals	6.28	5.42	2.73	0.82	0.46	0.38	0.20	0.08	0.02	neg.	16.39	18.04
Ave.	0.45	0.39	0.19	0.06	0.03	0.03	0.01	0.01	....	neg.	1.17	1.28
% of Total.....	38.31	33.07	16.66	5.00	2.80	2.32	1.22	0.49	0.12	neg.	....	....

Floods have not molested City Creek since August 2, 1930. At this time J. C. Alter (1930) reports that a flood washed large quantities of gravel and mud from the stream. He also states that the total precipitation for the month referred to was 2.5 times normal.

PHYSICAL DATA

The section of City Creek selected extends from lower Rotary Park down stream 1.5 miles. Fourteen stations were spaced 200 yards apart. These data were collected October 17 and 26, 1934. On the first date the lower nine stations were taken. Between the hours of 11:30 a. m. and 4:30 p. m. the air temperature ranged from 18.3 to 19.4°C. while the water temperature remained at 9.0°C. At each station travertine covered the bottom and this is probably true for the whole stream. City Creek has an average width of 10.1 feet and an average depth of 0.38 feet. The water flow at the time of this study was 4.5 cubic feet per second.

CHEMICAL DATA

The chemical features of City Creek on October 17, 1934 at 11:30 a. m. were as follows: Air temperature 18.3°C.; water temperature 7.7°C., free carbon dioxide 0.0 parts per million, dissolved oxygen 10.3 parts per million, phenolphthalein alkalinity 6.0 parts per million, methyl orange alkalinity 189 parts per million. The pH was 8.0.

BIOLOGICAL DATA

The total number of organisms taken in the survey of City Creek was 5730, averaging 382 per square foot. Of this total Ephemera constituted 44.92%, Plecoptera 18.11%, Turbellaria 11.75%, Chironomidae 9.56%, Trichoptera 6.13%, Other Diptera 5.07%, Coleoptera 1.73%, Simuliidae 1.33%, Oligochaeta 0.94%, Gastropoda 0.24%, Tipulidae 0.17%, and Nematoda 0.04%.

The total volume of organisms was 16.15 cc. with an average of 1.076 per square foot. Of this total volume Ephemera constituted 32.14%, Tipulidae 22.29%, Plecoptera 14.43%, Trichoptera 13.80%, Turbellaria 12.07%, Other Diptera 1.99%, Chironomidae 0.99%, Simuliidae 0.68%, Coleoptera 0.49%, Gastropoda 0.31%, Oligochaeta 0.19% and Nematoda a volume too small to measure.

The total weight of all organisms taken in the City Creek survey was 17.12 grams, an average of 1.14 grams per square foot. The number of grams per acre was 49,715.0 or 109.62 pounds.

TABLE IX.

NUMBERS OF ORGANISMS PER SQUARE FOOT IN SAMPLES TAKEN FROM CITY CREEK,
OCTOBER 17 AND 26, 1934

Sample No.	Ephem-erida	Plecop-tera	Turbel-laria	Chiro-nomidae	Trichop-tera	Other Diptera	Coleop-tera	Simul-iidae	Oligo-chaeta	Gastro-poda	Tipul-idae	Nema-toda	Total Number
1	92	124	65	12	20	8	....	2	....	....	1	2	326
2	74	82	14	45	30	....	11	1	42	9	....	....	308
3	62	30	55	38	15	18	8	8	....	5	....	....	239
4	62	76	53	100	17	32	13	....	....	....	4	....	357
5	26	43	96	105	36	102	19	1	....	....	....	....	428
6	114	195	52	57	13	12	4	1	....	....	....	....	443
7	165	124	32	14	25	27	7	....	9	....	5	....	408
8	67	13	34	84	38	36	5	....	....	....	....	....	277
9	102	51	32	38	25	21	....	2	....	....	....	....	271
10	161	12	16	16	10	10	1	3	....	....	....	....	229
11	162	71	75	8	34	7	6	5	....	....	....	....	368
12	335	94	41	7	26	1	1	49	....	....	....	....	554
13	219	37	16	15	16	11	12	1	1	....	....	....	328
14	476	12	33	6	24	4	....	1	1	....	....	....	557
15	457	74	59	8	22	2	12	2	1	....	....	....	637
Totals	2574	1038	673	548	351	291	99	76	54	14	10	2	5730
Ave.	172	69	45	36	23	19	7	5	4	1	1	....	382
% of Totals.....	44.92	18.11	11.74	9.56	6.13	5.08	1.73	1.33	0.94	0.24	0.17	0.03	....

TABLE X.

VOLUMES OF ORGANISMS PER SQUARE FOOT IN SAMPLE TAKEN FROM CITY CREEK,
OCTOBER 17 AND 26, 1934

Sample No.	Ephem- erida	Tipul- idae	Pleco- ptera	Trichop- tera	Turbel- laria	Other Diptera	Chiro- nomidae	Simul- iidae	Coleop- tera	Gastro- poda	Oligo- chaeta	Nema- toda	Total Volume	Total Weight
1	0.30	0.25	0.25	0.09	0.20	0.01	neg.	neg.	....	....	....	neg.	1.10	1.30
2	0.10	....	0.35	0.25	0.04	....	0.01	neg.	neg.	0.03	0.03	....	0.81	0.85
3	0.10	....	0.06	0.10	0.20	0.02	0.01	0.01	neg.	0.02	....	....	0.52	0.53
4	0.10	0.75	0.15	0.05	0.15	0.03	0.06	....	0.01	....	....	....	1.30	1.37
5	0.07	....	0.10	0.20	0.20	0.10	0.03	neg.	0.02	....	....	....	0.72	0.74
6	0.20	....	0.40	0.09	0.15	0.02	0.01	neg.	neg.	....	....	....	0.87	0.93
7	0.30	2.60	0.35	0.20	0.15	0.04	neg.	....	neg.	....	neg.	....	3.64	3.69
8	0.17	....	0.03	0.25	0.15	0.03	0.02	....	neg.	....	....	....	0.65	0.70
9	0.20	....	0.08	0.15	0.08	0.02	0.01	neg.	....	....	....	....	0.54	0.56
10	0.35	....	0.06	0.09	0.03	0.01	0.01	neg.	neg.	....	....	....	0.55	0.60
11	0.30	....	0.18	0.15	0.25	0.01	neg.	neg.	neg.	....	....	....	0.89	0.91
12	0.70	....	0.10	0.20	0.10	neg.	neg.	0.10	neg.	....	....	....	1.20	1.43
13	0.50	....	0.08	0.12	0.06	0.02	neg.	neg.	0.03	....	neg.	....	0.81	0.82
14	1.00	....	0.02	0.16	0.09	0.01	neg.	neg.	....	....	neg.	....	1.28	1.30
15	0.90	....	0.12	0.13	0.10	neg.	neg.	neg.	0.02	....	neg.	....	1.27	1.39
Totals	5.29	3.60	2.33	2.23	1.95	0.32	0.16	0.11	0.08	0.05	0.03	neg.	16.15	17.12
Ave.	0.35	0.24	0.15	0.15	0.13	0.02	0.01	0.007	0.005	0.003	0.002	....	1.07	1.14
% of Total.....	32.14	22.29	14.43	13.80	12.07	1.98	0.99	0.68	0.49	0.31	0.19	....	....	....

MILL CREEK

Mill Creek is located near the center of Salt Lake County and drains westward from the Wasatch Mountains. It is about ten miles long. The water in the lower five miles is utilized for power projects. The upper five miles of stream have a gradient of about 150 feet per mile. Mill Creek's watershed is under supervision of the Wasatch National Forest. The section of Mill Creek covered by the survey extended from the upper power conduit intake upstream one mile. Ten stations were taken in this distance at 0.1 mile intervals.

From records available the author was unable to ascertain the time of the last flood in Mill Creek but the appearance of the stream bed indicates that it has not been severely flooded for several years.

PHYSICAL DATA

Between the hours of 11:30 a. m. and 3:10 p. m. on October 27, 1934 the air temperature ranged between 12.8 and 17.2°C. Water temperature ranged between 7.2 and 8.3°C. The bottom was predominately gravel. Some rubble was present but was usually mixed with gravel. Sand and silt were found sparingly in a few places. The average width of Mill Creek was 11.9 feet while the average depth was 0.32 feet. At the time of the survey the rate of flow was 4.4 cubic feet per second.

CHEMICAL DATA

On October 27, 1934 at 11:20 a. m. the air temperature was 16.6°C. and the water temperature 7.7°C. The water of Mill Creek contained 10.6 parts per million of dissolved oxygen, no free carbon dioxide, 11.0 parts per million phenolphthalein alkalinity, 161 parts per million methyl orange alkalinity and had a pH of 8.0.

BIOLOGICAL DATA

In ten samples a total of 16,732 organisms were taken during the survey of Mill Creek. The average per square foot was 1,673.2. Of the total number Trichoptera constituted 66.24%, Ephemera 11.56%, Chironomidae 8.21%, Turbellaria 3.69%, Oligochaeta 2.77%, Other Diptera 2.56%, Gastropoda 2.21%, Plecoptera 2.09%, Coleoptera 0.45%, Pisidium 0.13%, Nematoda 0.05%, and Simuliidae 0.03%.

The total volume of the organisms taken in the ten samples was 29.9 cubic centimeters. Of this total the average per square foot was 2.99 cc. Trichoptera constituted 75.31% of the total volume, Ephemera 6.69%, Turbellaria 6.12%, Other Diptera 3.67%, Gastropoda 3.38%, Plecoptera 2.50%, Oligochaeta 1.57%, Chironomidae 0.50%,

TABLE XI.

NUMBERS OF ORGANISMS PER SQUARE FOOT IN SAMPLES TAKEN FROM MILL CREEK,
OCTOBER 27, 1934

Sample No.	Trichoptera	Ephemeroidea	Chironomidae	Turbellaria	Oligochaeta	Other Diptera	Gastropoda	Plecoptera	Coleoptera	Pisidium	Nematoda	Simuliidae	Total Number
1	121	157	138	79	17	207	....	7	2	....	....	1	729
2	360	299	22	34	23	46	7	24	5	5	....	....	825
3	44	72	15	5	27	18	....	16	3	....	....	....	200
4	804	270	298	54	159	27	13	138	5	....	2	....	1770
5	309	81	54	22	12	15	7	10	6	....	1	....	517
6	2296	167	137	38	60	16	78	18	7	2	....	....	2819
7	2418	259	16	97	14	15	48	12	17	....	....	....	2896
8	1154	131	73	69	31	43	132	19	9	9	....	....	1670
9	1176	243	103	73	25	9	68	48	10	....	4	4	1763
10	2401	256	518	146	95	33	17	58	12	6	1	....	3543
Totals	11083	1935	1374	617	463	429	370	350	76	22	8	5	16732
Ave.	1108	194	137	62	46	43	37	35	8	2	1	....	1673
% of Total	66.24	11.56	8.21	3.62	2.77	2.56	2.21	2.09	0.45	0.13	0.05	0.03	....

TABLE XII.

VOLUMES OF ORGANISMS PER SQUARE FOOT IN SAMPLES TAKEN FROM MILL CREEK,
OCTOBER 27, 1934

Sample No.	Trichoptera	Ephemera	Turbellaria	Other Diptera	Gastropoda	Plecoptera	Oligochaeta	Chironomidae	Coleoptera	Simuliidae	Pisidium	Nematoda	Total Volume	Total Weight
1	0.40	0.15	0.30	0.60	....	0.01	0.01	0.06	neg.	neg.	....	....	1.53	1.64
2	0.45	0.20	0.10	0.20	0.02	0.05	0.04	0.01	neg.	....	neg.	....	1.07	1.26
3	0.12	0.10	0.01	0.04	....	0.03	0.05	neg.	neg.	....	....	....	0.35	0.39
4	2.70	0.35	0.10	0.06	0.03	0.10	0.15	0.03	neg.	....	....	neg.	3.52	3.96
5	0.90	0.14	0.07	0.04	0.02	0.03	0.01	0.01	neg.	....	....	neg.	1.22	1.38
6	4.60	0.09	0.25	0.01	0.20	0.06	0.01	0.01	0.01	....	neg.	....	5.24	6.25
7	3.90	0.15	0.30	0.03	0.16	0.10	0.02	neg.	0.01	....	....	....	4.67	5.58
8	2.00	0.12	0.25	0.08	0.25	0.02	0.06	0.01	0.01	....	neg.	....	2.80	3.30
9	2.55	0.50	0.20	0.01	0.30	0.15	0.01	neg.	0.01	0.02	....	neg.	3.75	4.04
10	4.90	0.20	0.25	0.03	0.03	0.20	0.11	0.02	0.01	....	neg.	neg.	5.75	6.61
Totals	22.52	2.00	1.83	1.10	1.01	0.75	0.47	0.15	0.05	0.02	neg.	neg.	29.90	34.41
Ave.	2.25	0.20	0.18	0.11	0.10	0.08	0.05	0.02	neg.	neg.	neg.	neg.	2.99	3.44
% of Total.....	75.31	6.69	6.12	3.68	3.38	2.51	1.57	0.50	0.17	0.06	neg.	neg.	....	....

Coleoptera 0.17%, Simuliidae 0.06%, Nematoda and Pisidium a volume too small to measure.

The total weight of all organisms taken in the ten samples was 34.41 grams an average of 3.44 grams per square foot. Using this average there were 149,890 grams or 330.5 pounds per acre of bottom area.

SUMMARY AND CONCLUSIONS

The average number of organisms in South Willow Creek for the first survey was 152, for the second 1040 and for the third 803. The average volumes and weights of organisms for the three surveys were: First, 0.30 cc. or 0.36 grams per square foot; second, 1.57 cc. or 1.74 grams per square foot and third, 1.79 cc. or 1.97 grams per square foot.

The average numbers of organisms per square foot in Farmington, City and Mill creeks were 446, 382 and 1673 respectively (Fig. 5).

The average volumes of organisms per square foot in Farmington, City and Mill Creeks were 1.17 cc., 1.07 cc., and 2.99 cc., respectively.

The average weights of organisms per square foot in Farmington, City and Mill Creeks were 1.28 grams (123.42 pounds per acre), 1.14 grams (109.62 pounds per acre) and 3.44 grams (330.51 pounds per acre) respectively (Fig. 5).

The average number of organisms for the first survey of South Willow Creek was 294 below Farmington Creek, 230 below City Creek and 1,521 below Mill Creek. In the second survey the average was 594 above Farmington Creek, 668 above City Creek and 633 below Mill Creek.

The average volume per square foot for the first survey of South Willow Creek was 0.87 cc. below that of Farmington Creek, 0.77 cc. below City Creek and 2.69 cc. below Mill Creek. That of the second survey was 0.40 cc. above Farmington Creek, 0.50 cc. above City Creek and 1.42 cc. below Mill Creek. The third survey was 0.62 cc. above Farmington Creek, 0.72 cc. above City Creek and 1.20 cc. below Mill Creek.

Hazzard (1934B) in a quantitative food study on three Utah streams of the Wasatch mountains, states: "The average number of organisms per square foot in July, August and September (1933) was: Mill Creek 44.3, 249.4 and 165.9; Big Cottonwood 40.3, 128.2 and 107.5; Little Cottonwood 368.2, 545.0 and 389.7, respectively."

"The average weight of all stations during July August and September (1933) was: Mill Creek 0.56, 1.05 and 0.76 grams; Big Cottonwood 0.45, 0.66 and 1.35 grams; Little Cottonwood 4.43, 3.65 and 2.46 grams respectively. The average weight of all samples was found to be 1.69 grams."

Pate (1932) gives an average of 1.25 grams per square foot for coarse gravel. Higgins (1933) in a report concerning Needham's studies of the Sierra trout streams in California gives an average of "137 pounds per acre" (1.43 grams per square foot).

A comparison of the averages obtained from South Willow Creek with those given above shows the first survey markedly deficient in numbers and weights per square foot (Fig. 5). The second survey increased in average numbers and weights per square foot over those given by Hazzard. It also increased 30.32 pounds per acre over Needham's averages for Sierra streams. The third survey shows an increase in average numbers and volumes over Hazzard's results. The average weight per square foot of the third survey increased over that of the second and over that of Hazzard, Needham and Pate. (Fig. 5).

Average weights per square foot of Farmington and City Creeks compare favorably with those of Hazzard, Needham and Pate. However, they range slightly lower than the latter. The average weight for Mill Creek is far above all others cited in this study and exceeds those weights given by Hazzard for the same stream during the summer of 1933.

From the data presented it is concluded:

1. That floods of eroding proportions definitely destroy stream populations.

2. That the period of recovery when considered only from the standpoint of numbers, volumes and weights per unit area was indeed rapid (three months) in South Willow Creek. This rapidity of recovery would not be characteristic of a stream in which unmolested areas were not present, nor would it be the same at seasons of the year unfavorable to reproduction of bottom forms. Furthermore, no fish were present in South Willow Creek to remove the invertebrate fauna, but this factor is minimized by the absence of fish from Farmington Creek. Carnivorous types of bottom organisms were removed by the flood thus lessening their influence on the herbivores.

3. That in the recovery of fauna in South Willow Creek those forms with the shorter life cycles became reestablished first.