AQUATIC MACROPHYTES, ORGANIC DETRITUS, AND DEPOSITED SEDIMENT OF UPPER SILVER CREEK, BLAINE COUNTY, IDAHO AND ITS TRIBUTARIES STALKER AND GROVE CREEKS

by

C. Yvonne Manuel-Faler

Department of Biology
Idaho State University
Pocatello, Idaho 83209

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A BASELINE STUDY OF THE AQUATIC ECOLOGY OF UPPER SILVER CREEK, 1981-82

I. Aquatic macrophytes, organic detritus, and deposited sediment
   By: C. Yvonne Manuel-Faler

II. Benthic invertebrates
   By: G. Wayne Minshall and C. Yvonne Manuel-Faler

III. Fish populations
   By: J.S. Griffith

DEPARTMENT OF BIOLOGY
Idaho State University
Pocatello, Idaho 83209

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INTRODUCTION

Beginning in June 1981 a study was undertaken to establish a monitoring program for deposited sediment and aquatic plants (macrophytes) in Upper Silver Creek and its tributaries. The purpose was to obtain quantitative baseline information on sediment depths and the variety and abundance of aquatic plants so that in combination with comparable data on benthic macro-invertebrates and fish, present conditions and subsequent changes in the stream ecosystem could be assessed. The study was conducted at six locations: three on Silver Creek proper and three on its tributaries, Stalker and Grove Creeks, during June, August, and November 1981 and May 1982.

Description of Study Sites

Station 1 (Upper Stalker Creek, Fig. 1a), is downstream of the Patton Drain and is a few hundred meters upstream from the Hunting Cabin. The sampling site is on a straight reach of the stream, which at this point flows almost parallel to the hillslope to the south. Metal stakes, driven into the ground 5 m from the streambank on each side and serving as permanent markers, are 14.9 m apart. The stream channel is relatively narrow (4.9 m) and deep (1 m) and is "U" shaped with vertical banks and a flat streambed. Deposited sediment, a mixture of fine sand, bits of broken mollusc shells, and decaying plant material (organic detritus) covers the streambed, which consists of pebble-size rocks more or less consolidated in a matrix of calcareous gravel and fines. Light

Figure 1. Photographs of sampling sites 1 to 6, taken in August, 1981.

Site 1. Upper Stalker Creek

Site 2. Lower Stalker Creek

Site 3. Grove Creek

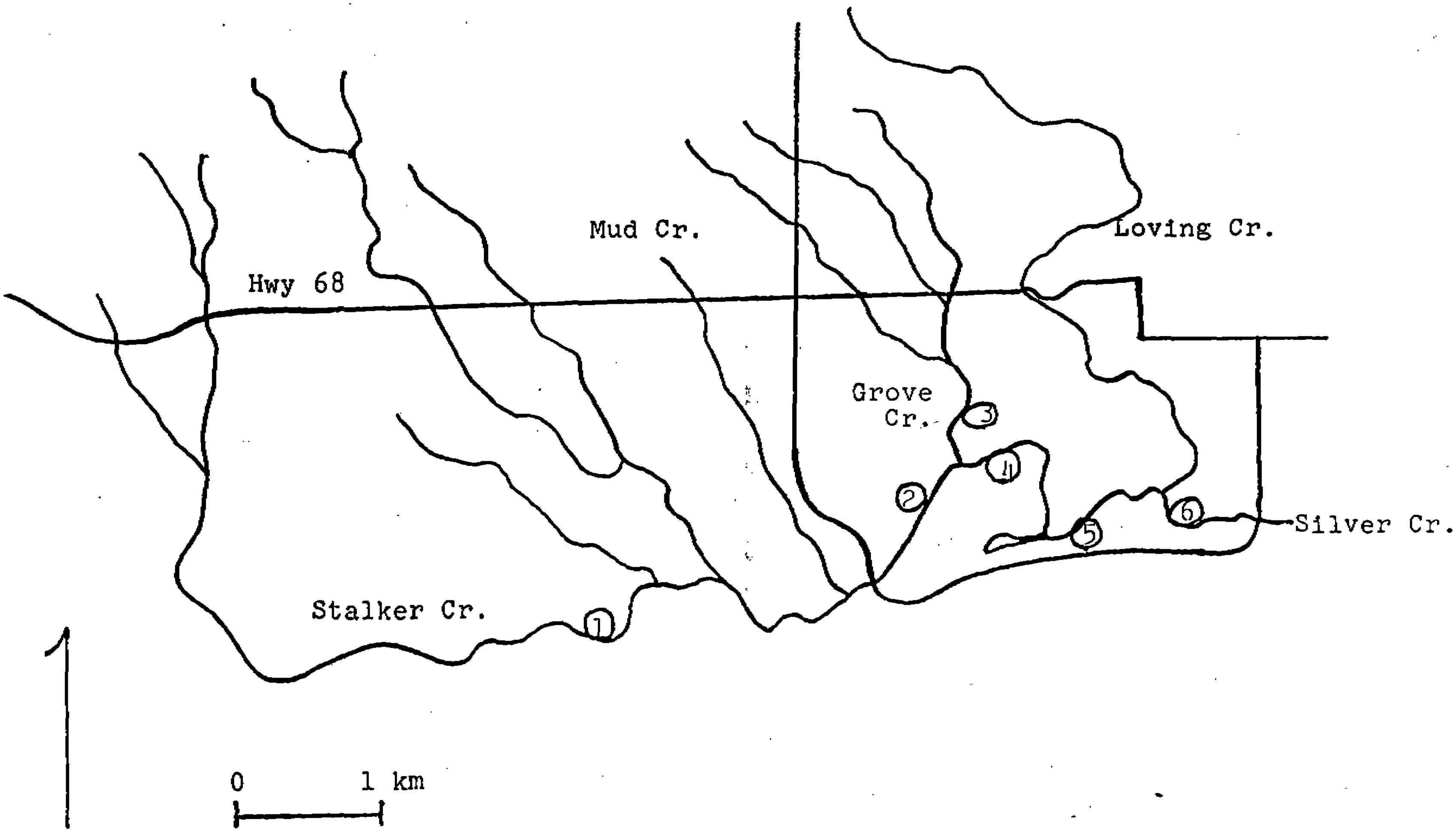
Site 4. Upper Silver Creek

Site 5. Middle Silver Creek

Site 6. Lower Silver Creek

UPPER SILVER CREEK

Circled numbers indicate sampling stations for macrophyte, sediment and invertebrate analysis, 1981-82.



reaching the stream is restricted by bank shading and riparian vegetation, and plant growth within the stream is sparce.

Station 2 (Lower Stalker Creek, Fig. 1b), is 300-400 m downstream from the Pumpkin Road Bridge and downhill from the corner of the Conservancy corral. The sampling site can be reached either by floating downstream from the bridge or by driving to the corral and descending the steep brushy slope that constitutes the right (south) margin of the stream. Metal stakes are 19.9 m apart and are 4 m from either side of the stream except when the water level is down; then the streamwidth decreases and the distance from the water margin to the stake increases due to the sloping nature of the south bank. The stream is 11.9 m wide and over 1 m deep. The streambed is covered with sediment. Because the stream is relatively wide sufficient light is available to support the growth of aquatic plants, which were present in luxurious profusion in June, 1981 when the site was established.

Station 3 (Grove Creek, Fig. 1c), is about 600 m upstream of the confluence of Stalker and Grove Creeks. The transect for sampling is approximately 15 m downstream from the upper fence crossing the creek on the McMahan property. The concrete fence posts serve as points of reference and metal stakes were not used to mark the transect line. The stream is wide (26 m) and fairly shallow (< 50 cm). The streambed consists of pebbles, gravel, and fines which are loosely consolidated in some spots but which are cemented by calcium carbonate deoposits in others. A relatively high percentage of the streambed is exposed, the remainder being covered by plants and/or sediment. Potamogeton, Chara, Veronica, and Bryophytes, the predominent aquatic plants, tend to grow in clumps which alternate with exposed streambed to form a mosaic or heterogenous pattern.

Station 4 (Upper Silver Creek, Fig. 1d), is located on Conservancy property 100 m downstream from the confluence of Stalker and Grove Creeks. Metal stakes, driven into the ground on either side of the stream, are 38.7 m apart. The stream channel from bank to bank is 28.7 m wide. Although the depth of the stream channel is only about 1 m, water sometimes stands 10 to 20 cm deep on the marshy banks of the stream and the water depth within the channel may exceed 120 cm. When this study was begun in June 1981, the gravel substratum of the streambed was blanketed with deposited sediment which, in turn, was covered almost totally by a dense, diverse stand of aquatic macrophytes that persisted through November, 1981. However, in May, 1982 sediment had been scoured from many areas and the stream was almost completely devoid of plants.

Station 5 (Middle Silver Creek, Fig. 1e), is about 250 m downstream from Sullivan Slough and is identical with station 4 in the sediment study Manuel et al. (1979). The stream is 36.5 m wide at this station and the distance between stakes is 46.5 m. Water depth generally ranges between 50 and 80 cm. Usually most of the stream bed is overlain with fine sediment with some patches of exposed gravel. _Chara vulgaris_ and _Potamegeton pectinatus_ are the predominant aquatic plant taxa.

Station 6 (Lower Silver Creek, Fig. 1f), is about 100 m downstream from the confluence of Loving Creek with Silver Creek.

Metal posts marking the station are 31.6 m apart while the distance between streambanks is 21.6 m. The channel is about 1 m deep but water depth exceeds 1 m during spring runoff when the surrounding area is flooded. Sampling is especially difficult at station 6 because of the combination of swift current and deep water. During the early part of this study about 20% of the streambed was erosional and free of deposited sediment and the average depth of sediment was lower than at stations 4 and 5. The plant community, moderate in abundance, is dominated by Chara.

METHODS

Field Procedures

Stream width was measured at each sampling site, and on each sampling date water depth, sediment depth, and the abundance of aquatic plants were measured at 10 points spaced approximately equidistant apart on each of two transects.

Aquatic macrophytes and organic detritus, together with aquatic invertebrates were collected using a Hess net (390 µm mesh) that was modified for use in water up to 1.5 m deep. The net enclosed a 1/16 m^2 area of the streambed, and plants, macroinvertebrates, and organic detritus within the water column and in the substrate to a depth of 8–10 cm were included in a sample.

After collection, samples were put into glass jars, preserved in 10% formalin solution, and transported to the laboratory for processing. Four samples were collected at each station on each of the four sampling dates for a total of 16 samples per site.

Laboratory Procedures

Samples were removed from jars, placed on a 250 µm mesh screen, and rinsed to remove excess formalin. Macroinvertebrates were separated and removed for further processing and aquatic plants were sorted, identified, dried at 60° C, and ashed at 450° C to determine organic weight. The remaining organic detritus was combined, dried, and ashed to determine organic weight.

Data Analysis

Macrophyte biomass was compared with respect to station and sampling date by ANOVA and t-test.

RESULTS AND DISCUSSION

Deposited Sediment and Water Depth

Mean water depth exceeded 100 cm at 4 of the 6 sampling sites in either June or August (Table 1). If discharge were the only factor affecting changes in water level, then highest levels at each site should occur on or about the same date. Since they did not, it is reasonable to assume that other factors, such as the abundance of aquatic plants and, in the case of station 6, the influence of the Purdy Dam may have had a significant affect on water level. By November, water levels were down at all sites, and lowest values were recorded in May. At that time there were few plants at any site and discharge was probably the overriding factor affecting water level throughout the system.

Sediment depths at individual points ranged from 0 on at least one sampling date at all stations except Upper Stalker Creek to 86 cm at Lower Stalker Creek in August. Mean depths for each sampling ranged from 2 cm at station 6 in November to 36 cm at station 1 in August (Table 2). For the year, (averaging the four sampling dates) Stalker Creek had the highest values for sediment depth (31 and 24 cm at stations 1 and 2, respectively) and Grove Creek had the lowest (5 cm). Sediment depths at the Upper Silver Creek site were intermediate between those of Stalker and Grove Creeks, while sediment depths at stations 5 and 6 were only slightly higher than in Grove Creek. At four of the six sites maximun deposits of sediment occurred in August, and the mean depth for the six stations was 20 cm compared to 14 cm on each of the other three sampling dates.

Table 1. Mean depth (cm) of stream from the streambed to water surface and including sediment at stations 1 to 6 in June, August, and November, 1981 and May 1982.

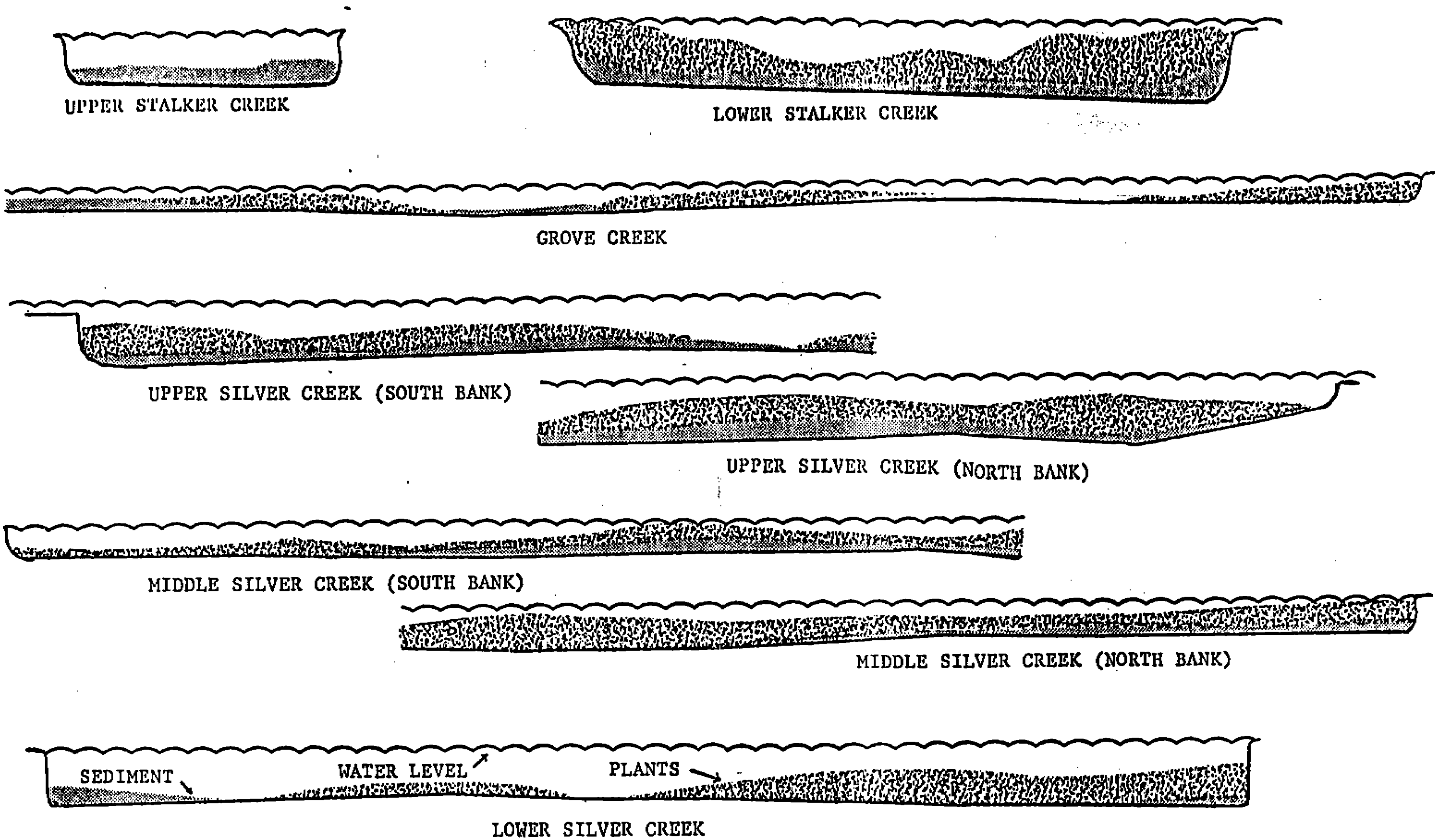
	Date			
Site	June	August	November	May
Upper Stalker	90	111	78	60
Lower Stalker	120	81	78	49
Grove Creek	38	43	40	39
Upper Silver	108	90	76	47
Middle Silver	61	58	48	39
Lower Silver	100	108	80	76
Mean	86	82	66	52

Stalker Creek

Water levels and sediment depths at station 1 are depicted graphically in Figure 2 which shows cross-sections of the sampling sites in June, 1981, and in Figure 3, which shows seasonal changes in a section of streambed. In May, 1981 the water was level with the streambank, the streambed was blanketed with loose sediment, and the sparse aquatic vegetation consisted mainly of a few shoots of Potamogeton. In August sediment depths were virtually unchanged from June but over half the streambed was now covered by a mixed stand of <u>Chara</u> and <u>Potamogeton</u> and the water level had increased by about 10 cm, flooding the grassy banks. By November most of the vegetation was gone and the water level, as well as the mean depth of sediment, had decreased slightly. The water level and sediment depths were even lower the following May. However, with the new shoots of <u>Potamogeton</u> emerging from the sediment, the condition of the stream appeared similar to that of the previous June.

The Lower Stalker Creek site is similar to Upper Stalker in that, compared to Grove Creek, the stream channel is relatively narrow and deep and is covered with deposited sediment (Fig. 4). It differs in that the water level was highest and abundance of vegetation (predominantly <u>Chara</u>) was greatest in June. By August plants as well as water level had decreased dramatically and sediment depths averaged 35 cm, a 90% increase over June. In November the water level was similar to the level in August but much of the sediment had eroded. The water was very turbid and it was impossible to see the few shoots of aquatic plants that persisted.

Figure 2. Cross-sectional profiles of Stations 1 to 6


UPPER STALKER CREEK
LOWER STALKER CREEK
GROVE CREEK
UPPER SILVER CREEK (SOUTH BANK)
UPPER SILVER CREEK (NORTH BANK)
MIDDLE SILVER CREEK (SOUTH BANK)
MIDDLE SILVER CREEK (NORTH BANK)
SEDIMENT
WATER LEVEL
PLANTS
LOWER SILVER CREEK

Scale= 1:100

Figure 3. Cross-sectional profile of Upper Stalker Creek in June, August, and November, 1981 and May, 1982

UPPER STALKER CREEK

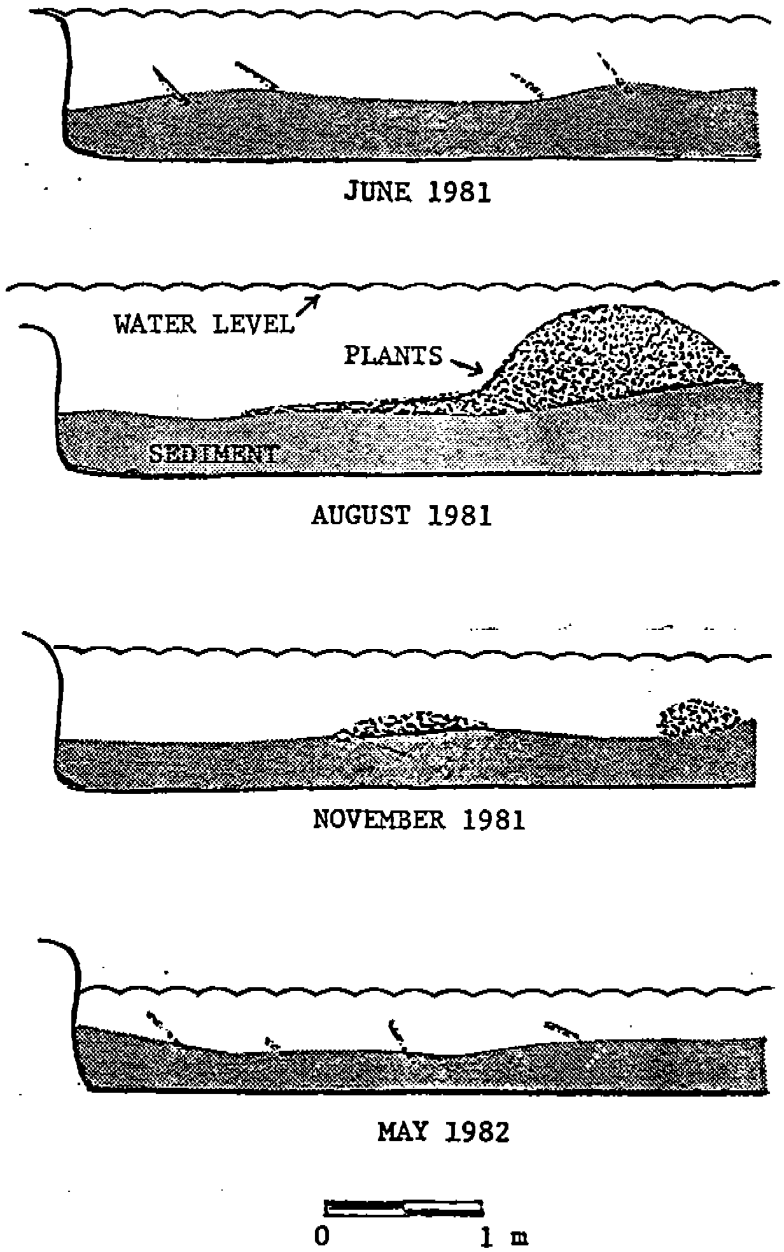
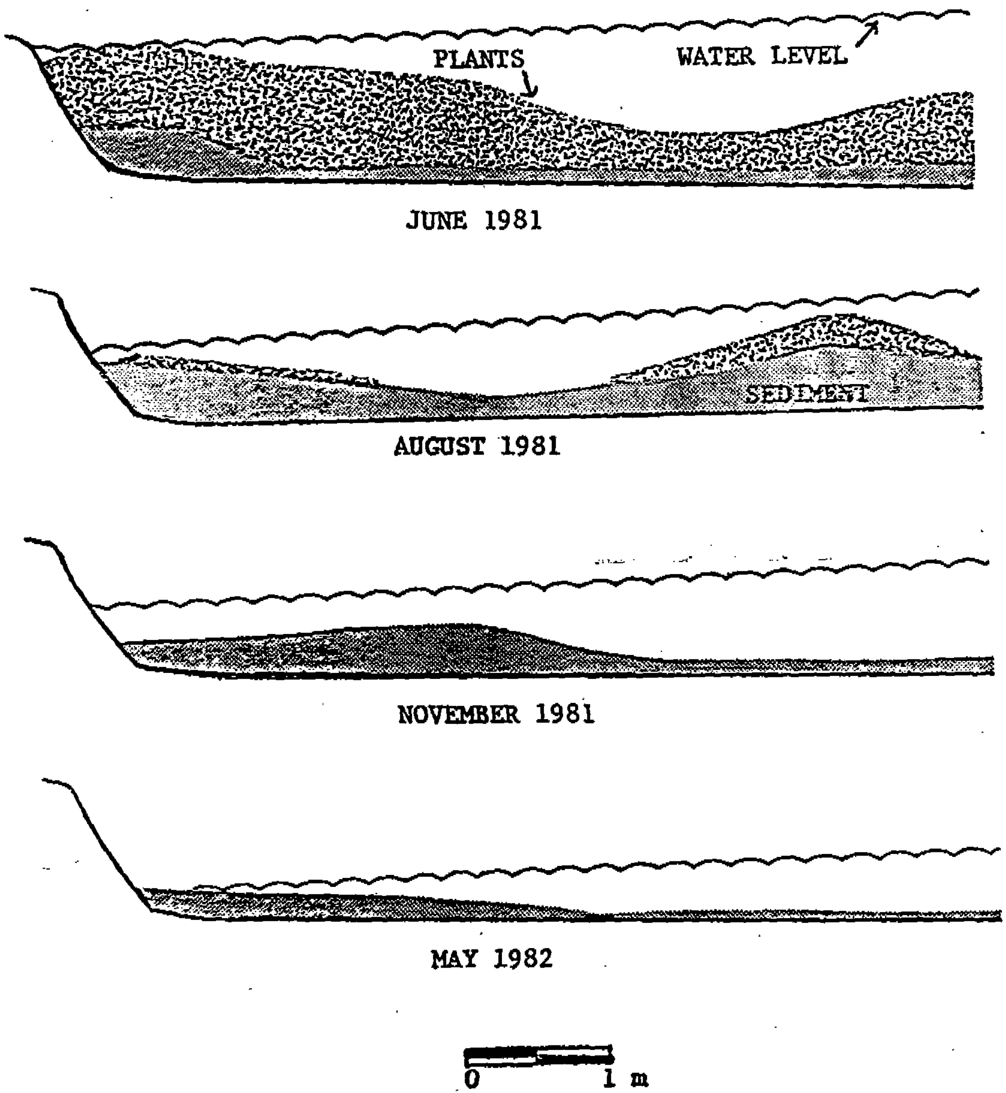


Figure 4. Cross-sectional profile of Grove Creek in June, August, and Novmber, 1981 and May, 1982.

LOWER STALKER CREEK



The water level was very low in May and muddy sediment was exposed on both sides of the channel. The gravel streambed was covered with sediment on all dates except May 1982, when about 5% was exposed.

Grove Creek

Water level did not vary much and values ranges from 38 to 42 cm on the four sampling dates (although greater depths occurred during runoff). A large percentage (25-35%) of the streambed was exposed throughout the year and the mean sediment depth exceeded 5 cm only in May when sediment built up on the west side of the stream (Table 2). A variety of aquatic plants were present in moderate abundance on all sampling dates.

Silver Creek

Morphological characteristics of the three sampling stations on Silver Creek are somewhat intermediate between those found in Stalker and Grove Creeks. This is especially true for station 4 (Upper Stalker). Changes in the stream profile at this site are indicated in Fig. 5, which shows the south bank and a 6.5 m cross-sectional view of the 28.7 m wide transect.

Station 5 is the widest of the six sampling sites and, as would be expected, fluctuations in discharge do not result in large changes in water levels. Nevertheless, the mean water depth declined on each sampling date from 61 cm in June 1981 to 39 cm in May 1982. Mean sediment depth was 5 cm in June, increased to 11 cm in August, then declined again in November and May. Some of the streambed was exposed on all sampling dates; the amount increased from 15% in August and November to 40% the following May.

Figure 5. Cross-sectional profile of Upper Silver Creek in June, August, and November, 1981 and May, 1982.

UPPER SILVER CREEK

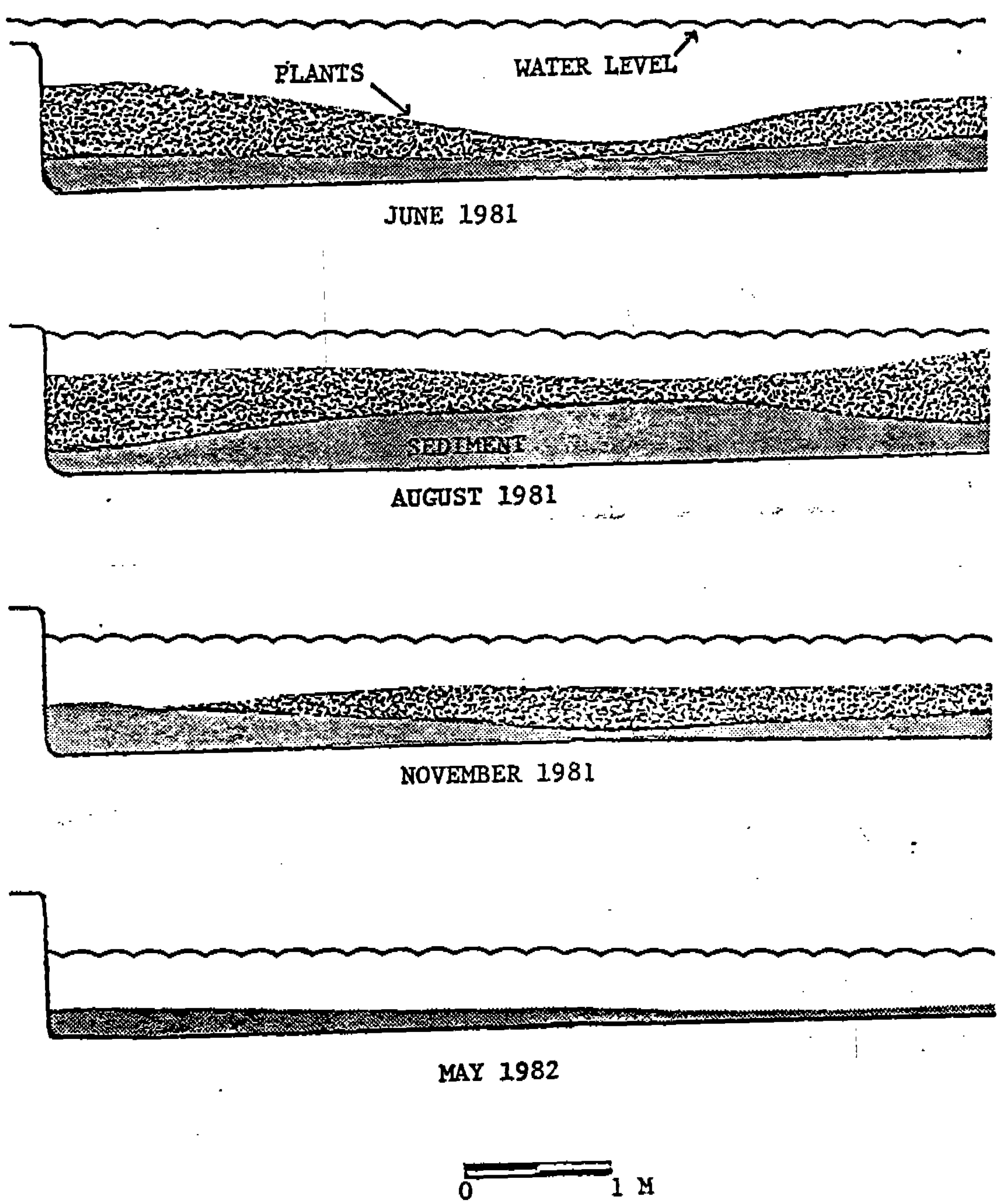


Table 3. Aquatic macrophytes found in Silver Creek and its tributaries during this study. Letters under site number represent sampling dates when plant was found at that particular site. J = June, A = August, N = November and M = May. "Other" indicates that the plant was not found at any of the sampling sites but was observed elsewhere in the stream during the study.

	Sampling Site 1	2	3	4	5	6
Bryophyta						
Fontinalis hypnoides	A	J	JANM	JAN	JANM	A
Amblystegium riparium var. fluitans	JA	N	JANM	JAN	A M	A
Charophata						
Chara vulgaris	JANM	JANM	JANM	JANM	JANM	JANM
Anthophyta						
Catabrosa aquatica			J			
Elodea canadensis				JANM	A	JAN
Hippuris vulgaris (other)						
Lemna minor (other)						
Myriophyllum sp.	J					
Potamogeton pectinatus	JANM	JANM	JANM	JANM	JANM	JANM
Ranunculus aquatilis	A	J		J		J
Rorippa nastertium-aquaticum (other)						
Veronica anagallis-aquatica		JA	JA	A		
Zannichellia palustris	J N		JA	N		A

Aquatic plants were abundant on the first three sampling dates and were present (but sparce) in May.

Station 6 (Lower Silver Creek) differs from station 5 in that it is only 21.6 m wide (compared to 36.5 at station 5) and is much deeper, with mean water depths ranging from 76 cm in May to 108 cm in August. It is similar to Station 5 in that the amount of deposited sediment was relatively small, ranging in depth from 2 cm in November to 11 cm in May. The increase in May could be due an to influx of sediment from Loving Creek during Spring runoff. The streambed was exposed on all sampling dates (10 - 20%).

Aquatic Macrophytes and Organic Detritus

Silver Creek is an ideal habitat for the growth of aquatic macrophytes: 1) the streambed provides suitable substrate for root attachment, either in deposited sediment or in sandy crevices between small pebbles and rocks, 2) the open canopy permits sufficient light to reach the stream, and 3) the high levels of calcium carbonate and other plant nutrients promote plant growth. Furthermore, during relatively mild winters, such as 1980-81, the water (emerging as springs at about 11 degrees C) remains several degrees above freezing and some of the plants (particularily *Chara*) over-winter in relatively high abundances.

Taxonomic Richness of Aquatic Plant Community

In this study 13 taxa were identified either at one of the sampling sites or elsewhere in the stream (Table 3). *Chara vulgaris* occurred at all sampling sites and was the most abundant macrophyte at all stations except Upper Stalker Creek, where

Potamogeton pectinatus was predominant. Potamogeton occurred at all sampling sites and was second to Chara in abundance in the stream as a whole. Zannichellia palustris superficially resembles Potamogeton, but the two plants can be easily separated when reproductive structures are present. Seeds from both taxa and vegetative propagules of Potamogeton were found in some of the samples. However, it was not always possible to separate the two taxa. Therefore, they were combined for biomass determinations and statistical analysis.

The two aquatic mosses, Fontinalis hypnoides and Amblystegium riparium var. fluitans also occurred at each of the six sampling sites. Sometimes they grew in monospecific clumps, but often they were found intertwined in the same mat. To avoid the tedious job of separating individual stems, these two plants were combined for analysis.

Elodea canadensis appeared in samples collected from Upper Stalker Creek and from the three stations on Silver Creek. When present, it sometimes grew in massive stands, however, because of its sporatic occurrance, it did not comprise a major fraction of the plant community at any site.

Of the remaining plants, Veronica anagallis-aquatica and Catabrosa aquatica appeared in moderate abundance in samples collected from Grove Creek and in trace amounts from several other sites, Ranunculus aquatilis was present but sparce at 4 sites, and Hippuris vulgaris, Lemna minor, and Myriophyllum were observed in the stream but not at any of the 6 sampling sites. These plants are important not because of any puissant affect they have on the ecosystem, but because their very presence, even in limited amounts, indicates that their minimum requirements for growth are met by the conditions in the stream.

Taxonomic richness is one criterian that can be used in comparing locations on Silver, Stalker, and Grove Creeks. Richness was greatest at station 4, where eight different plant taxa were identified. Next were stations 1 and 3 with seven species each. Six species were found at stations 2 and 6, while only 5 were identified at station 5. Of equal importance is the mean number of plant taxa found at each site. This ranged from 5.5 on Grove Creek down to 3.25 on Upper Stalker Creek. The order, from highest to lowest is Station 3 > Station 4 > Station 6 = Station 4 > Station 5 > Station 2.

Macrophyte Abundance

The abundance of aquatic macrophytes at each sampling site on each of the four sampling dates in given in Table 4. Annual mean values ranged from a low of only 26 g/m^2 organic wt. at station 1 to 182 g/m^2 at station 4. The annual mean for Stalker Creek, based on the pooled samples from the two stations, was 42 g/m^2 compared to 80 g/m^2 in Grove Creek and 119 g/m^2 for Silver Creek (three sites pooled).

Chara accounted for 88% of all plant biomass in Grove and Silver Creek, and 85% in Stalker Creek. It was particularly abundant in June 1981 on Stalker Creek and at all three sampling sites on Silver Creek. By August, the levels of Chara had decreased at each of these four sites. At station 2 Chara was reduced from 212 g/m^2 in June to 23 g/m^2 in August. Generally,

Table 4. Aquatic macrophytes and organic detritus in samples collected at Silver Creek, Idaho June 1981 to May 1982. Mean (± S.D.) g/m^2 organic wt. N = 4.

a) Station 1 (Upper Stalker Creek)

	June 1981	August 1981	November 1981	May 1982	Mean
Chara	<1	11(22)	2(3)	<1	3
Potamogeton and/or *Zannichellia*	12(12)	52(39)	14(8)	1(1)	20
Fontinalis and/or *Amblystegium*	<1	<1	0	0	<1
Elodea	0	0	<1	0	<1
Veronica	0	0	0	0	<1
Catabrossa	0	0	0	0	0
Other plants	<1	<1	<1	<1	<1
Total plants	12(12)	63(30)	16(6)	1(1)	23
Organic detritus	236(133)	117(98)	302(87)	107(66)	190
Total Organic	248(144)	179(177)	317(83)	108(67)	213

b) Station 2 (Lower Stalker Creek)

	June 1981	August 1981	November 1981	May 1982	Mean
Chara	212(79)	23(24)	8(14)	<1	61
Potamogeton and/or *Zannichellia*	<1	2(4)	<1	<1	<1
Fontinalis and/or *Amblystegium*	<1	0	<1	0	<1
Elodea	0	0	0	0	0
Veronica	<1	<1	0	0	<1
Catabrosa	0	0	0	0	0
Other plants	<1	<1	<1	<1	<0
Total plants	212(79)	25(23)	8(14)	<1	62
Organic detritus	75(66)	70(40)	67(88)	146(130)	90
Total organic	287(144)	95(59)	75(101)	146(130)	152

Table 4 continued
c) Station 3 Grove Creek

	June 1981	August 1981	November 1981	May 1982	Mean
Chara	75(101)	99(77)	83(65)	22(39)	70
Potamogeton and/or *Zannichellia*	<1	<1	9(17)	<1	2
Fontinalis and/or *Amblystegium*	11	7	1	1	5
Elodea	0	0	0	0	0
Veronica	<1	3	0	0	1
Catabrosa	5	0	0	0	1
Other plants	<1	<1	<1	<1	<1
Total plants	91(115)	109(81)	96(70)	23(42)	80
Organic detritus	67(79)	46(45)	76(53)	125(76)	78
Total organic	158(154	155(123)	170(121)	149(83)	158

d) Upper Silver Creek

	June 1981	August 1981	November 1981	May 1982	Mean
Chara	285(127)	240(116)	51(49)	1(1)	144
Potamogeton and/of *Zannichellia*	11(14)	45(59)	35(52)	<1	23
Fontinalis and/of *Amblystegium*	<1	<1	<1	0	<1
Elodea	<1	19(38)	42(57)	1(1)	16
Veronica	0	<1	0	0	<1
Catabrosa	0	0	0	0	0
Other plants	<1	<1	<1	<1	<1
Total plants	297(117)	304(68)	128(108)	1(1)	182
Organic detritus	68(34)	65(12)	88(15)	92(87)	78
Total organic	365(105)	369(69)	215(109)	93(86)	260

Table 4 continued

e) Middle Silver Creek

	June 1981	August 1981	November 1981	May 1982	Mean
Chara	181(69)	136(98)	157(136)	9(14)	121
Potamogeton and/or *Zannichellia*	1(2)	8(12)	8(7)	3(5)	5
Fontinalis and/or *Amblystegium*	<1	<1	<1	<1	<1
Elodea	0	<1	0	0	<1
Veronica	0	0	0	0	0
Catabrosa	0	0	0	0	0
Other plants	<1	<1	<1	<1	<1
Total plants	182(71)	144(102)	165(139)	12(19)	126
Organic detritus	135(54)	120(73)	141(96)	102(67)	124
Total organic	318(29)	264(162)	306(216)	114(78)	250

f) Lower Silver Creek

	June 1981	August 1981	November 1981	May 1982	Mean
Chara	126(134)	25(23)	46(44)	1(1)	50
Potamogeton and/or *Zannichellia*	<1	<1	<1	<1	<1
Fontinalis and/or *Amblystegium*	0	<1	<1	0	<1
Elodea	<1	<1	1(1)	0	<1
Veronica	0	0	0	0	0
Catabrosa	0	0	0	0	0
Other plants	<1	<1	1(2)	<1	<1
Total plants	126(134)	25(23)	47(44)	1(1)	50
Organic detritus	58(33)	44(24)	114(47)	92(87)	77
Total organic	184(151)	69(41)	160(37)	93(86)	127

the pattern of growth of aquatic plants in temperate waters results in relatively low plant densities in the spring and early summer, followed by an increase during the summer, and finally, a decrease in the fall (Westlake,1965). Data reported by Francis and Bjomn (1979) indicate that the growth sequence of Chara in Silver Creek in the summer of 1977 followed this pattern. Even in the present study, the growth of Chara at stations 1 and 3 is fairly typical. What factor(s) then, caused the deviation from this sequence of plant growth in Lower Stalker Creek and Silver Creek during the summer of 1981?

The most plausable explaination for the high levels of Chara in the stream in June is that a large fraction of the plant biomass produced the previous summer (1980) persisted through the winter. The winter of 1980-1981 was mild and water temperatures were sufficiently high to prevent dieback at most sampling sites, However, bank shading and the relatively low levels of water flow at station 1 may have resulted in water temperatures at or near 0 C and caused plant death at that particular site. In other years, low ambient temperatures may reduce water temperatures in the whole stream system (with the possible exception of Grove Creek, where water temperature in the winter is several degrees higher than in Stalker and Silver Creek, Manuel et al. 1979) to levels insufficient to maintain plants.

Although the mild temperatures of the preceeding winter can account for the high levels of Chara observed in June 1981, it is necessary to seek another explaination for the demise of Chara in mid-summer of the same year. One possibility is that the dense mats of vegetation prevented light from reaching lower parts of the plant mass. Chara is not a vascular plant and therefore there is minimal translocation of photosynthetic products from one part of the plant to another. Lack of nutrients may result in death of plants close to bottom of the plant bed. Also, Chara does not have true roots and its hold in the sediment is tenuous; a relatively small force may be all that is needed to loosen the whole plant bed and send it rolling downstream. Unfortunately, I did not witness this during the present study. The massive beds of Chara that I measured in June were already gone by the time I returned to Silver Creek for the August sampling. However, I did observe this in Wilson Creek (a tributary of Grove Creek) in 1979. It is consistent with the reports of fishermen who say that the vegetation in Silver Creek goes in cycles, that it "builds up for awhile and then rolls over".

Potamogeton and Zannichellia were pooled for analysis because reproductive structures needed for positive identification were not present in every sample collected. Together, these plants were second in abundance to Chara, and at Station 1 they accounted for more than half the total plant community. Potamogeton initiates seasonal growth in the spring with the development of new shoots from dormant buds that have overwintered buried in the sediment. The germination of seeds also contributes abundance of this plant. Plant growth is usually rapid with maximum biomass attained by mid-summer. In late summer a large proportion of the stems break off and float downstream. In contrast, Zannichellia is typically seen in streams in the fall. Because of the differences in the seasonal growth patterns of these two plants, it seems reasonable to assume that *Potamogeton* was responsible for most of the plant biomass attributed to the two species in June and August, but that most of the biomass found in November was *Zannichellia*.

The aquatic mosses *Fontinalis* and *Amblystegium* were found at each sampling site but were abundant only at station 3, where mean biomass decreased from 11 gm/m^2 in June to <1 g/m^2 in May.

Elodea, present at four sites, was abundant only at station 4, where levels increased from <1 g/m^2 in May to 42 g/m^2 in November to give an annual mean of 16 g/m^2.

The abundance of aquatic plants changed dramatically between sampling dates at some stations, but in Grove Creek moderate amounts of plant biomass were present at all four sampling periods. This condition no doubt reduces stress on the faunal community, and is, in turn, a reflection of more benign physical conditions, such as a reduced sediment load and higher water temperatures in the winter.

Organic Detritus

Organic detritus is the non-living remains of once living organisms. It the primany food source for many aquatic invertebrates, and is, therefore, an extremely important component of aquatic ecosystems. Dead aquatic plants form the bulk of the organic detritus in Silver Creek, and this material exists in varing stages of degradation, from course, easily identified fragments to very fine material, and finally to dissolved material. In this study dissolved organic material was not sampled nor considered.

The amount of organic detritus varied among stations, with the highest mean value at station 1 (190 g/m^2). Station 5 had a mean of 124 g/m^2 while at the other stations mean values ranged from 77 to 90 g/m^2. The high levels of detritus at station 1 do not necessarily reflect high availability of food for aquatic fauna, however, since some of it may exist in forms that are not readily consumed and/or metabolized.

Statistical Analysis of Aquatic Plants and Organic Detritus

The appearance of the streambed and of the samples collected suggested that there were differences among sites in the quality and quantity of plants and detritus. Seasonal differences are to be expected in plants in temperate waters and are important to this study only if the expression of seasonal differences varied amoung the sites. Two-Way Analysis of Variance (ANOVA) was used to test for the mathmatical significance of differences due to sampling site and sampling date(Table 5).

Anova indicated that for Chara, differences could be attributed to both sampling site and sampling date. However, since there was a significant interaction between these two factors (the effect of one modified the effect of the other) no further statistical analysis of this plant was carried out.

For Potamogeton/Zanichellia, the effects due to site and date were both significant, and since the interaction of these two factors was not significant, differences among sampling sites were tested using the Student t-test. For the four sampling dates

Table 5. Results of analysis of variance (ANOVA) test of the significance of two factors, the sampling site and the sampling date, and the possible interaction of these two factors on the biomass of aquatic macrophytes and organic detritus in Silver Creek and its tributaries, Grove and Stalker Creek. "p" values greater than 0.05 are not considered to be significant.

	Site	Date	Interaction
Chara	$p < 0.001$	$p < 0.001$	$p = 0.001$
Potamogeton and/or *Zannichellia*	$p = 0.011$	$p = 0.001$	$p = 0.190$
Total plants	$p < 0.001$	$p < 0.001$	$p = 0.001$
Organic detritus	$p = 0.086$	$p < 0.001$	$p = 0.105$
Total organic (plants + detritus)	$p < 0.001$	$p = 0.002$	$p = 0.100$

combined, there were no statistical difference among stations 2, 3, and 6, or among stations 1, 4, and 5, but the first three were significantly higher than each of the last three.

The other aquatic plants were not tested individually, but ANOVA test of the total biomass of aquatic plants indicated that site and sampling date differences were both significant factors in the variability of plants in the stream and that there was interaction between the two factors.

In contrast to the plants, organic detritus did not vary significantly among sampling dates. However, site differences were highly significant. Values were significantly higher at station 1 than at all other stations execpt station 5. Station 5, in turn, was significanly higher than stations 3 and 6. There were no differences among the remaining 4 stations.

Comparison With Other Studies on Silver Creek

Francis and Bjornn (1979) reported a mean sediment depth of 12 cm in 1977-1978 in a reach of Silver Creek beginning about 500 m downstream of station 4 of the present study and ending about 200 m upstream from our Station 6. This area is roughly comparable to our stations 4 through 6. In the present study mean values for sediment depth for these three sites ranged from 14 cm in August to 7 cm in November, for an annual mean of 10 cm. These values suggest that there has been a small reduction of sediment levels. Manuel et al. (1979) measured sediments depths of 8 cm in November 1978 and 9.6 cm in May 1979 at the site of the present station 5. The more resent measurements (cm in November 1981 and

6 cm in May 1982) provide further evidence that there may be a net reduction in sediment levels in Silver Creek.

We have included only 13 taxa in our list of aquatic plants compared to 29 listed by Francis and Bjornn (1979). Their list included filamentous algae and semi-aquatic plants such as cattail and the rushes. Also, they recognized two species of Amblystegiaceae (Amblystegium tenax and Drepanocladus fluitans). None of the moss specimens examined in the present fit Flowers (1973) description of these two taxa. The only moss we found other than Fontinalis conformed reasonably well to the Flower's description of Amblystegium riparium var. fluitans. Since Francis and Bjornn did not mention Zannichellia it is assumed that its distinction from Potamogeton was overlooked and that the two taxa were combined for analysis.

As in the present study, Francis and Bjornn reported that Chara was the most abundant aquatic plant. They found that in August, Chara, where present, had a biomass of 3.2 kg/m^2 dry wt. (equivalent to approximately 1 kg organic wt.) Multiplying by the percentage of streambed covered (36%) gives a mean biomass of 1.15 kg/m^2 dry wt. or about 360 g/m^2 organic wt. This is somewhat higher than the maximum values (285 g/m^2) we found at station 4 in the summer of 1981. The differences can be attributed to differences in sampling techniques and or normal variation in plant densities.

SUMMARY AND CONCLUSIONS

Channel and water depths were greatest at stations 1, 2, 4, and 6. These stations also showed the greatest fluctuation in water levels. Values for mean sediment depth were highest in Stalker Creek (28 cm), with Silver Creek next (10 cm). Grove Creek had a mean sediment depth of only 5 cm. A relatively large amount of streambed was exposed in Grove Creek and the middle Silver Creek site and the amount of exposed streambed at the upper and lower Silver Creek sites was intermediate between these and Stalker Creek.

There is some evidence that sediment levels have been reduced in Silver Creek during the past few years, however, the potential for sediment accural will continue so long as a large reservoir of loose sediment exists in Stalker Creek.

Chara was the predominant aquatic plant at all sampling sites except Upper Stalker Creek, where it was second to *Potamogeton* in abundance. These plants are frequently found growing together in slow flowing, calcareous streams (Manuel-Faler 1981) if loose sediment is available anchoring. *Potamogeton* developes long roots and underground stems that penetrate the sediment; *Chara* does not form true roots, but the lower parts of the plant serve as holdfasts. Francis and Bjornn (1979) noted that *Chara* provides a good habitat for invertebrates since it does not grow well in gravel they concluded that a certain amount of silt was necessary in Silver Creek. We agree with their observations but differ with the implication that *Chara* and therefore sediment is good for

Silver Creek. Chara is not eaten by most invertebrates, in fact it is selected against (Gaevskaya 1969, Koslucher and Minshall 1973). The physical shelter provided by Chara could be provided by other, more palatable plants, if the conditions in the stream promoted their growth (Gregg 1981). Furthermore, not only does Chara grow in sediment and trap sediment, it may actually increase that total volume of sediment in the stream through the biological precipitation of calcium carbonate.

Potamogeton is very tolerant of certain types of water pollution (Westlake, 1961) and where it is the only plant present there is reason to suspect that conditions exist that prevent the growth of other plants. Fortunately, that is not the current situation at most sites on Silver Creek. Lower Loving Creek is an exception. Although this site was not included in the present study, when we were collecting samples during the sediment study in 1978-1979 (Manuel et al. 1979) we found a massive monospecific stand of Potamogeton that extended from the confluence with Silver Creek upstream to the Conservancy bridge. This reach of stream was heavily blanketed with sediment, which provided ideal rooting substrate for Potamogeton, but is unsuitable for many other aquatic plants.

At this point it appears that the aquatic plant community is "healthiest" in Grove Creek, where sediment levels are low and plant diversity is highest. The accumulation of deposited sediment in Stalker Creek inhibits the growth of some aquatic plants such as mosses and Ranunculus and serves as a source of sediment for Silver Creek. It appears that Silver Creek would benefit from any action taken (such as bank stabilization and the construction of sediment traps) that would reduce the amount of sediment entering Stalker Creek.

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BENTHIC INVERTEBRATES OF UPPER SILVER CREEK, IDAHO AND ITS TRIBUTARIES STALKER AND GROVE CREEKS

by

G. Wayne Minshall and C. Yvonne Manuel-Faler

Department of Biology
Idaho State University
Pocatello, Idaho 83209

INTRODUCTION

Beginning in June 1981 a study was undertaken to establish a monitoring program for benthic macroinvertebrates (potential trout food organisms) in Upper Silver Creek and its tributaries. The purpose was to obtain quantitative base line information on invertebrate standing stocks so that, in combination with comparable data on aquatic macrophytes and fish, present conditions and subsequent changes in the stream ecosystem could be assessed. In addition, it was intended that an assessment of seasonal changes in invertebrate abundance be made at key sites along with an evaluation of the Silver Creek system's ability to provide invertebrate food for trout and other gamefish. The study was conducted at six locations, three on Silver Creek proper and three on its tributaries: Stalker and Grove Creeks, during June, August, and November 1981 and May 1982.

The study sites were those previously described on pages 1 - 4.

METHODS

Field Procedures

Aquatic invertebrates, together with macrophytes and organic detritus, were collected using a Hess net (390 um mesh) that was modified for use in water up to 1.5 m deep. The net enclosed a 1/16 m^2 area of the streambed, and organisms within the water column and in the substrate to a depth of 8 to 10 cm were included in a sample.

After collection, samples were put into glass jars, preserved in 10% formalin solution, and transported to the laboratory for processing.

Four samples were collected at each station on each of the four sampling dates for a total of 96 samples.

Laboratory Procedures

Samples were removed from jars, placed on a 250 um mesh screen, and rinsed to remove excess formalin. Aquatic macrophytes and organic detritus were separated and removed for further processing and the invertebrates were sorted, identified to the lowest taxonomic level feasible, and counted.

Data Analyses

Invertebrate data were analyzed with respect to sampling date and sampling station on the basis of individual taxa as well as functional groups. Analysis was facilitated by the use of the SPSS computer programs for analysis of variance (ANOVA) and student t-test.

RESULTS AND DISCUSSION

Taxonomic Richness

A total of 63 taxa were recognized during this study (Tables 1-4). Of these, four (Cicadellidae, Hydracarina, Lepidoptera, and Unknown Diptera) represented a mix of species, none of which were common, and which could not be or did not warrant assignment to a functional-feeding group. These constituted the "Other" category and did not exceed 1% of the total abundance at any station. Consequently they were not considered further. Of the remaining 59 taxa, no more than half (and frequently less) were found at any given station on any particular date (Table 5). Grove Creek almost always supported the highest number of taxa although it was exceeded by one in taxonomic richness by the adjacent ("upper") Silver Creek station in November. The two Stalker Creek stations generally supported a low variety of taxa and frequently were the lowest in richness. However, in August the third highest number of taxa were collected from Upper Stalker Creek and on two occasions (June, August) the lower main Silver Creek station matched the Stalker Creek sites for low richness. Generally there was a difference of between 5 to 11 taxa between the station having highest richness and that having the lowest values, although in May the difference was 17. The Upper Silver Creek station usually supported the second highest number of taxa indicating the positive influence of Grove Creek. However, values declined downstream and the lowest richness values for the main Silver Creek stations usually occurred at the most downstream location (station 6).

Numerical Abundance

Mean total abundance for the four collecting dates ranged from about 3200 to 14,200 individuals per square meter (Table 5). The two Stalker Creek stations had the lowest mean annual abundance and Grove Creek the highest. Mean annual abundance at the upper and middle Silver Creek stations was closer to that of Grove Creek but the lower Silver Creek value was intermediate between the values for these three stations and the Stalker Creek sites reflecting adverse conditions caused by the inflow from Loving Creek.

The nine most commonly occurring taxa in this study are listed in Table 6. They accounted for 90% or greater of the mean numbers of organisms collected during the year at all stations except Grove Creek and upper Silver Creek where they made up 88 and 83% of the total abundance, respectively.

Analysis of variance (ANOVA) indicated significant differences in abundance among stations for 24 taxa including 8 of the 9 most abundant ones (Table 7). Comparison of results between stations for the nine most abundant taxa by means of a t-test indicated that most of the significant differences were between abundances at stations 1 and 2 and those of each of the remaining sites (Table 8). The number of taxa showing significant differences from sites other than stations 1 and 2 was ≥ 4 regardless of whether the stations were immediately adjacent or not. None of the ľable 5   Richness (number of taxa), total abundance (numbers/m^2), and Shannon-Weiner (H') diversity (log_e) values for the six Silver Creek study sites described in this report.

	1	2	3	4	5	6
:hness[1]						
June 1981	19	21	29	27	25	19
August 1981	23	21	26	25	23	21
November 1981	18	20	28	29	23	23
May 1982	10	16	27	19	19	21
tal Abundance[2]						
June 1981	3420	9824	25,408	17,548	28,044	13,828
August 1981	2616	7344	9380	16,108	9824	6564
November 1981	5780	3448	9716	11,128	9244	7080
May 1982	1008	1972	12,296	5218	8088	6724
$\bar{x}$	3206	5647	14,200	12,500	13,800	8549
versity						
June 1981	0.92	1.82	1.40	1.85	1.48	1.67
August 1981	1.33	1.25	1.30	1.94	1.51	1.36
November 1981	1.37	1.35	1.64	1.55	1.55	1.78
May 1982	1.16	1.59	1.38	1.32	1.61	1.62

[1] Excluding "Other"

[2] Including "Other"

Table Results of t-test comparisons of abundances between stations for the nine most abundant ta

	1 vs 2	1 vs 3	1 vs 4	1 vs 5	1 vs 6	2 vs 3	2 vs 4	2 vs 5	2 vs 6	3 vs 4	3 vs 5	3 vs 6	4 vs 5	4 vs 6	5 vs 6
June															
Chironomidae			*	*			**	*	*						
Tubificidae															
Gammarus lacustris		*		**	*						**				
Baetis			*	*											
Ephemerella inermis		*	*				*	***							
Pisidium				***		*									
Helicopsyche borealis	**		*	**	*										
Hirudinea			*												
Flumenicola												*			
August															
Chironomidae		*	***				***			*			*		
Tubificidae											*				
Gammarus lacustris		**	***		**					**				**	
Baetis		*	*			*	*				*	*		*	
Ephemerella inermis															
Pisidium										*	*				*
Helicopsyche borealis	**		***		*		**		*						
Hirudinea	*		*	*	*								*		
Flumenicola															
November															
Chironomidae								*							
Tubificidae															
Gammarus lacustris															
Baetis		*	*	***		*									
Ephemerella inermis			***				***						*	***	
Pisidium		*	*									**		**	
Helicopsyche borealis		*			*										
Hirudinea					*				*						
Flumenicola		*	*												
May															
Chironomidae			**	*			*	*							
Tubificidae															
Gammarus lacustris				*											
Baetis		**		**											
Ephemerella inermis				***	**			***	**						
Pisidium															
Helicopsyche borealis	*	**		*											
Hirudinea	*			*			*	*					*		
Flumenicola	*					*									

* = significant, p 0.05; ** - highly significant, p 0.01; *** very highly significant, p 0.001.

taxa examined appeared to show consistent significant differences between stations over the four collection periods.

Biotic Diversity

The numerical dominance of a few taxa among all of those represented at a site also is evident from an examination of the Shannon-Wiener diversity (H') values (Table 5). In no case did H' exceed 2. H' values between 1 and 2, as found in this study for Upper Silver Creek and its tributaries, generally are found in relatively homogeneous aquatic environments and frequently are associated with enriched or intermediately polluted conditions. Lowest diversity values for any given date generally were found at the upper Stalker Creek station. Highest values occurred on two occasions at the upper Silver Creek station and twice at the lower Silver Creek station.

Seasonal Differences in Richness, Abundance, and Diversity

Benthic invertebrate community structure varied considerably among seasons (Tables 1-5). This is confirmed by ANOVA (Table 7) which showed significant differences in abundance among seasons for 16 taxa including six of the nine most abundant. In general, greatest total abundance occurred in June 1981 and least in May 1982 (Table 5). Richness also generally was least in May and highest in either August (stations 1,2) or November (stations 4,6) although Grove Creek and middle Silver Creek supported slightly more taxa in June than in either of those two months. The top four and seventh most abundant taxa generally fol-

Table 7. Results of ANOVA between season and location for 65 taxa of benthic invertebrates from Silver Creek, Idaho 1981-1982 ($p < 0.05$). An asterix indicates that the taxon is among the nine most abundant.

A. Significant Differences Among Seasons Only

Ceratopogonidae
Hemiptera

B. Significant Differences Among Stations Only

*Flumenicola
Brachycentrus
Empididae
Ephemerella grandis
Hydracarina
Oecetis
*Tubificidae
Optioservus
Ostracoda
Simulium

C. Significant Differences Among Seasons and Stations

*Baetis
*Chironomidae
Cinygmula
Dicranota
Enallagma
*Ephemerella inermis
*Gammarus lacustris
*Helicopsyche borealis
*Hirudinea
Hyallela
Hydroptila
Paraleptophlebia
Rhyacophila
Tricorythodes

In contrast, May 1982 was preceeded by a cold winter with heavy snow pack and subsequent high runoff (mean discharge for January-May 1982 = 5.31 ($\pm$ 0.89 SD) m^3/S). The latter conditions appear to have adversely affected the benthic flora and fauna resulting in reduced standing crops and richness. These results illustrate the need to evaluate conditions over a series of years (e.g., 5-10) in order to establish the full range of responses to be expected under normal variations in natural conditions. Only then can the less obvious changes in stream conditions resulting from management efforts or pollution be recognized with confidence.

Functional Feeding Group Relationships

The functional feeding group composition (Cummins 1973; Merritt and Cummins 1978) of the benthic invertebrate community at each of the Silver Creek sampling stations is summarized in Table 9. In general, collectors predominated at all stations followed by scrapers, then shredders, and then predators. However, at station 2 in June and station 3 in August scrapers were more abundant than collectors. At station 2 in August shredders exceeded both collectors and scrapers in abundance and in November shredders were more abundant than scrapers. Also, at stations 1 and 3 in June; 5 in July; and 2,5 and 6 in May predators were slightly more numerous than shredders.

Among the collectors, the sediment miners constituted the main subgroup (Table 9) and generally accounted for 30 to 50% of the total abundance. However, the apparent

Table 9. Functional feeding group composition (as percents of total abundance) of the benthic invertebrate community in Silver Creek.

	1	2	3	4	5	6
June 1981						
Scrapers	1	46	22	24	10	12
Collectors	(94)	(29)	(70)	(62)	(72)	(65)
Gatherers	1	5	26	19	12	12
Miners	82	20	40	39	56	47
Filterers	11	4	4	4	4	6
Shredders	1	21	3	8	12	17
Predators	3	3	6	6	6	6
August 1981						
Scrapers	11	2	46	21	15	13
Collectors	(84)	(40)	(43)	(61)	(56)	(65)
Gatherers	5	0	9	15	2	5
Miners	52	32	20	32	44	57
Filterers	27	8	14	14	10	3
Shredders	3	48	7	11	13	13
Predators	1	9	3	7	16	8
November 1981						
Scrapers	13	8	27	9	17	27
Collectors	(73)	(68)	(62)	(80)	(61)	(47)
Gatherers	0	0	13	2	1	1
Miners	47	55	39	63	51	37
Filterers	26	13	10	15	9	9
Shredders	11	18	3	4	15	14
Predators	3	5	6	7	7	11
May 1982						
Scrapers	2	23	9	12	16	18
Collectors	(95)	(66)	(85)	(85)	(75)	(68)
Gatherers	5	12	38	22	17	27
Miners	45	39	41	33	49	21
Filterers	45	15	6	30	9	20
Shredders	2	2	4	2	2	5
Predators	2	8	1	2	7	9

predominance of the miners is offset somewhat by their small size and in terms of biomass they frequently were exceeded in importance by the filterers and/or gatherers (as well as by the grazers) (e.g., Table 10). Except for station 2 in August, the shredders and predators never accounted for a large proportion of the total abundance at any station (commonly 15 and 10%, respectively). The overall functional feeding group composition of the benthic invertebrate community appears to be dominated by the depositional nature of the stream bottom and the rich stands of aquatic macrophytes.

Comparison with Previous Studies of Silver Creek

During 1977, Francis and Bjornn (1979) conducted an inventory of the aquatic resources of the Nature Conservancy portion of Silver Creek which included quantitative sampling of the benthic invertebrates. They collected one sample each from gravel and aquatic vegetation in April and every three weeks from May 25 to November 7 using a Hess sampler with a 1.0-mm mesh net. The results of the two studies are not strictly comparable because of differences in mesh and sample size and the fact that Francis and Bjornn's samples were stratified by habitat and ours were not. In addition, interpretation is complicated by the fact that the location along the stream of the 1977 samples was not identified and may not have been standardized.

The results for the three months which coincided in the two studies are given in Table 11. We attempted to

Table 10. Estimated mean biomass (g AFDM/m^2) of the nine most abundant taxa in Silver Creek and total biomass in terms of both ash-free dry mass (AFDM) and wet weight (WW).

		1	2	3	4	5	6
Scrapers							
Baetis		0.36	2.26	10.29	6.36	2.61	1.02
Flumenicola		0.38	1.15	0.05	0.09	0.31	1.42
Helicopsyche borealis		0.00	0.09	0.11	0.14	0.25	0.19
Gatherer							
Ephemerella inermis		0.01	0.09	1.30	0.54	0.49	0.33
Miners							
Chironomidae		0.17	0.14	1.37	0.96	1.48	0.92
Tubificidae		0.04	0.04	0.04	0.06	0.08	0.03
Filterer							
Pisidium		0.36	0.22	0.06	0.52	0.30	0.31
Shredder							
Gammarus lacustris		1.43	18.40	4.65	10.26	17.58	10.12
Predator							
Erpobdella/Helobdella		0.21	1.02	2.02	1.13	3.91	2.32
Total	gAFDM/m^2	2.96	23.39	19.89	20.06	27.00	16.67
	gWW/m^2	3.85	30.41	25.86	26.08	35.10	21.67
	lb WW/acre	34	271	231	233	313	193

Silver Creek station (5) of the present study with those found in samples of vegetation within the Nature Conservancy boundaries in 1977 by Francis and Bjornn (1979).

	June 1977	June 1981	August 1977	August 1981	November 1977	November 1981
Ephemeroptera	11,870	3848	5183	976	5968	412
Baetis	1022	1136	1054	788	2097	384
Ephemerella	10,462	2640	3108	16	3333	28
Paraleptolebia	140	68	473	64		
Tricorythodes	247	4	548	108	538	
Odonata		4	11	16	806	
Euallagma/Ischnura		4		16	763	
Ophiogomphus			11		43	
Plecoptera	140		108		452	
Acroneuria	10				291	
Isogenus/Isoperla	108		108		161	
Nemoura	22					
Trichoptera	624	1372	366	1312	7452	1188
Brachycentrus	140	156	129	192	495	128
Helicopsyche	161	884	43	864	2419	408
Hydroptila	11	60	22	4	753	36
Hydropsyche		68	11	96	1194	288
Oecetis	237	144	75	152	1624	292
Protoptila/Hydroptila	54	60		4	54	36
Rhyacophila	22		86		807	
Traiaenodes					108	
Coleoptera	1710		2387		7699	
Optioservus/Heterlimnius	1710		2387		7699	
Diptera	5914	14,444	7108	1548	46,204	1952
Chironomidae	5161	14,444	6011	1420	43,075	1936
Chelifera	172		43			
Clinocera	215		86			
Euparypus	75		22		806	4
Hemerodromia	10		22		1731	
Simulium	247		828	128	591	12
Non-insects	6968	6316	3129	5480	14,430	5278
Amphipoda	473	3056	237	1644	1086	1740
Hirudinea	215	312	161	1252	226	468
Gastropoda	720	132	473	44	2720	138
Oligochaeta	5559	2816	2226	2540	8882	2932
Pelecypoda		788		440		360
Total	27,237	28,044	18,247	9,824	83,011	9,244

overcome some of the differences in sampling design by utilizing the 1977 results for vegetation only and by assuming that the samples were collected somewhere between our upper and lower Silver Creek sites (≈ our station 5). (Ten of the twelve samples collected during this period in 1981 from station 5 contained substantial amounts of plant material).

Total abundances from the two studies were similar for June but were nearly two to ten times lower in August and November 1981 than reported for 1977. In the present study, notably fewer Ephemeroptera, Plecoptera, Diptera (except in June), Gastropoda, and Oligochaeta (except in August) and substantially more Trichoptera (except November), Amphipoda, and Hirudinea were found than in 1977. In addition, no Plecoptera were collected from station 5 in 1981 (although they were found elsewhere in Silver Creek) and no fingernail clams (Pisidium, Pelecypoda) were obtained in 1977. The total abundance of 83,011 recorded in November 1977 is higher than found anywhere in the Silver Creek system during 1981-1982 (maximum 66,832 at station 3 in June). The differences could not be tested for statistical significance because of the small sample size per date (N=1) in 1977.

Standing Crops of Potential Trout Foods

Numerical standing crops of benthic invertebrates (Table 6) at stations 3, 4 and 5 of Silver Creek are among the highest recorded for the Rocky Mountain region (Platts et al 1982) and possibly for the world (see Hynes 1970) while those of stations 1, 2 and 6 would fall in the category of "average" to "good". Most of the total abundance of invertebrates (80-95%) is concentrated among only a few taxa, most of which are highly regarded as food for trout (e.g., midges (Chironomidae), worms (Tubificidae), shrimp (Amphipoda), mayflies (Ephemeroptera especially Baetis and Ephemerella inermis) and leeches (Hirudinea)) which are functionally adjusted to the physical and organic resources (especially a largely depositional substratum and extensive macrophyte development) of the Silver Creek system. However, whether or not these foods are actually available to and being utilized by the trout was not ascertained as a part of this study. Francis and Bjornn (1979) examined a limited number of rainbow trout (57) and whitefish (9) stomachs and found that Ephemeroptera accounted for most of the fishes' food most of the time. Although, on occasion, Trichoptera, Diptera, or terrestrial insects were more abundant. But their efforts to determine whether the fish were actively selecting certain invertebrate food organisms or simply feeding in proportion to their abundance were hampered by their sampling design.

Mean biomasses represented by the invertebrate abundances were estimated from mean weights of the most abundant forms using data (G.W. Minshall and D.A. Bruns unpublished) from the Big Wood River (Table 10). When viewed in the context of biomass, the lower Stalker Creek station (2) appears to be more productive than indicated by the criterion of abundance and ranked second only to the middle Silver Creek location. UpperStalker Creek supported substantially lower standing crops of invertebrates (ca. 10x) than the other stations. Except for stations 1 and 6 the biomass values are higher than obtained by Needham (1938) for the average annual standing crop of riffles in Waddell Creek, California (196 lbs w.w./acre) but less than that recorded by Surber (1936) for riffles in Big Spring Creek, Virginia (485 and 643 lbs w.w./acre) or Needham (1938) in aquatic plant beds (e.g., Potamogeton 307-566, Chara 3553 lbs w.w./acre) or the Klamath River (5000 lbs w.w./acre).

Thus it appears that Silver Creek is much less productive in terms of weight of benthic invertebrates than might be expected from other published results. However, until actual rates of invertebrate productivity and/or drift and utilization are ascertained it cannot be determined whether food production in Silver Creek is in fact limiting to the trout populations. It could be that the lower than expected standing crops are indicative of rapid turnover and high utilization by trout or it could be a result of disturbance of the stream bottom and trampling of the plant beds by fishermen.

CONCLUSIONS AND RECOMMENDATIONS

Of the six locations investigated during this study, Grove Creek would be rated "best" and upper Stalker Creek would be considered "worst" in terms of habitat for and production of benthic invertebrates. Within Silver Creek proper, our results show a progressive degradation of conditions over the three locations examined. In particular, the entrance of Loving Creek just above the lower Silver Creek site is associated with a marked decline in taxonomic richness, total abundance, and Shannon-Weiner diversity in the main stream. Nine taxa accounted for 83-94% of the mean numbers of organisms collected. This dominance of the community by a few taxa, coupled with exceptionally high numerical standing crops, are in keeping with the relatively homogeneous habitat, depositional substratum, and extensive macrophyte development associated with Silver Creek. These conditions, in concert with the large, dependable volume of clear, cold, nutrient rich water probably have been largely responsible for the productivity of Silver Creek as a trout stream. However, deviation of the benthic community away from conditions found at Grove Creek and in streams outside of the Silver Creek watershed is indicative of varying degrees of imbalance (pollution) within the drainage basin and suggests a major reason for a possible decline in the stream's potential carrying capacity. In particular, the standing crop biomass values of the benthic invertebrates suggests a reduced capacity of Silver Creek to sustain levels of production expected from comparison with other streams of a comparable nature. The results of this study also indicate a need for continued monitoring of biotic (macrophytes, invertebrates, fish) and environmental conditions on a long term basis. This information is needed to establish the full range of responses to be expected under natural conditions (some of the extent of which have been illustrated by the present study) as well as to provide a standard against which to evaluate various management efforts and suspected cases of pollution. In general, it appears that late summer-autumn would be most favorable for the collection on annual monitoring samples and that the time of collection should be standardized to be as near the same date each year as possible.

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FISH POPULATIONS OF UPPER SILVER CREEK, IDAHO

by

J. S. Griffith

Department of Biology
Idaho State University
Pocatello, Idaho 83209

INTRODUCTION

In October of 1981 the fish population of The Nature Conservancy portion of Silver Creek was sampled to assess its status and especially evaluate changes that may have occurred since the implementation of catch-and-release regulations in 1977. Since the size and depth of the stream necessitates elaborate efforts to quantitatively estimate fish abundance, we instead collected trout from throughout the upper stream system to evaluate growth, condition and hook scarring. These data could then be compared with those gathered in 1976-77 to determine if changes have occurred.

DESCRIPTION OF STUDY SITES

Seven study sections on upper Silver Creek (Fig. 1) were utilized to gather fish population data. These were:

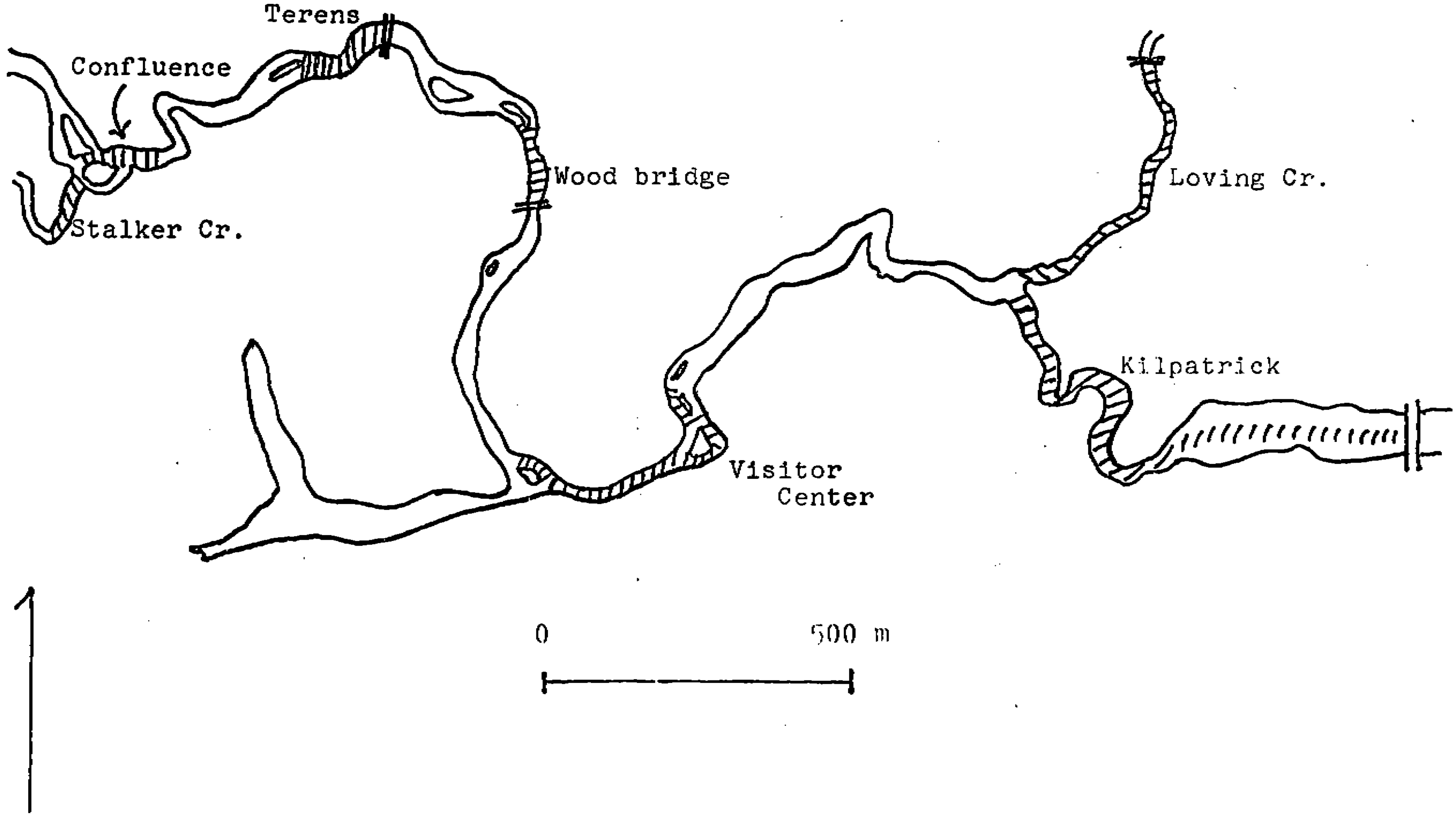
1. Stalker Creek - the 50 m portion of Stalker Creek immediately above its confluence with Grove Creek.

2. Confluence - the 50 m portion of Silver Creek immediately below its origin at the confluence of Grove and Stalker Creek.

3. Terens - from lower end of island below McMahan house to Teren footbridge.

4. Wood bridge - 120 m portion of Silver Creek immediately above the wooden bridge located between Terens and mouth of Sullivan Slough.

Figure 1. Location of study sections (crosshatched areas) utilized to gather fish population data.


Terens
Confluence
Stalker Cr.
Wood bridge
Loving Cr.
Kilpatrick
Visitor Center
0
500 m

5. Visitor Center - from mouth of Sullivan Slough to head of island approximately 400 m downstream.

6. Loving Creek - from INC bridge downstream to confluence with Silver Creek.

7. Kilpatrick - from mouth of Loving Creek downstream to Kilpatrick bridge.

METHODS

We collected fish by electrofishing on 17-19 October 1981 using an aluminum drift boat and 2500-watt generator. A longhandled anode also functioned as a dipnet and the boat was used as the cathode. A single pass was made downstream through each section except in Loving Creek where the boat was moved upstream. Water temperature ranged from 4.9 to 10.0 C during sampling. Fish were measured (total length) and weighed and scale samples were taken from rainbow trout. Scales were examined on a scale projector at a magnification of 42X and lengths at each annulus were back-calculated from the body-scale relationship. Scale samples used by Thurow (1978) were also obtained and a sample was examined to establish that scale-reading techniques were similar between years.

RESULTS AND DISCUSSION

A total of 287 rainbow trout (Salmo gairdneri) were collected (Table 1). A total of 33 brook trout (Salvelinus fontinalis) were also taken. A total of 19 mountain whitefish (Prosopium williamsoni) were collected in the Terens, Wood bridge, Visitor Center and Kilpatrick sections. A few sculpin, suckers and dace were observed but not collected.

It appears that there has been a shift in species composition since 1976, with an increase in brook trout, assuming that all species were equally vulnerable to sampling during both collection periods. Thurow (1978) found that brook trout comprized 2% of all game fish taken in electrofishing in Silver Creek above Kilpatrick bridge in spring, summer, and fall of 1976. He also found more whitefish (39% of all game fish) than were collected in 1981, but this probably reflects an abundance of young-of-the-year fish in spring and summer.

In all sections except Kilpatrick, we generally appeared to representatively sample the size range of fish present, although it is probable that a few of the largest fish in the deeper portions of the Confluence and Visitor Center sections, where large trout were concentrated, evaded capture.

In the Kilpatrick section, electrofishing was not effective due to water depth. In November 1981, three

Table 1. Numbers of fish collected and incidence of hook scarring in upper Silver Creek, 17-18 October 1981. Four bridgelip suckers were taken in the Stalker Creek section. NC = not checked.

Section	rainbow trout by age-group							brook trout	
	I	II	III	IV	V	total	hook scars	number	hook scars
Stalker Creek	2	21	10	2	0	35	3	4	0
Confluence	0	30	3	3	1	37	3	8	0
Terrans	3	25	9	1	0	38	2	1	0
Wood bridge	3	20	9	3	0	35	3	7	1
Visitor Center	4	44	11	2	1	62	4	10	11
Loving Creek	2	23	25	9	3	62	12	4	0
Kilpatrick	0	8	3	6	1	18	NC	4	NC
ALL	14	171	70	26	6	287		38	

observers equipped with wet suits and snorkels floated that section. Underwater visibility was inadequate to permit an accurate count of all fish, but numerous (more than a dozen) rainbow trout larger than 1.5 kg were observed.

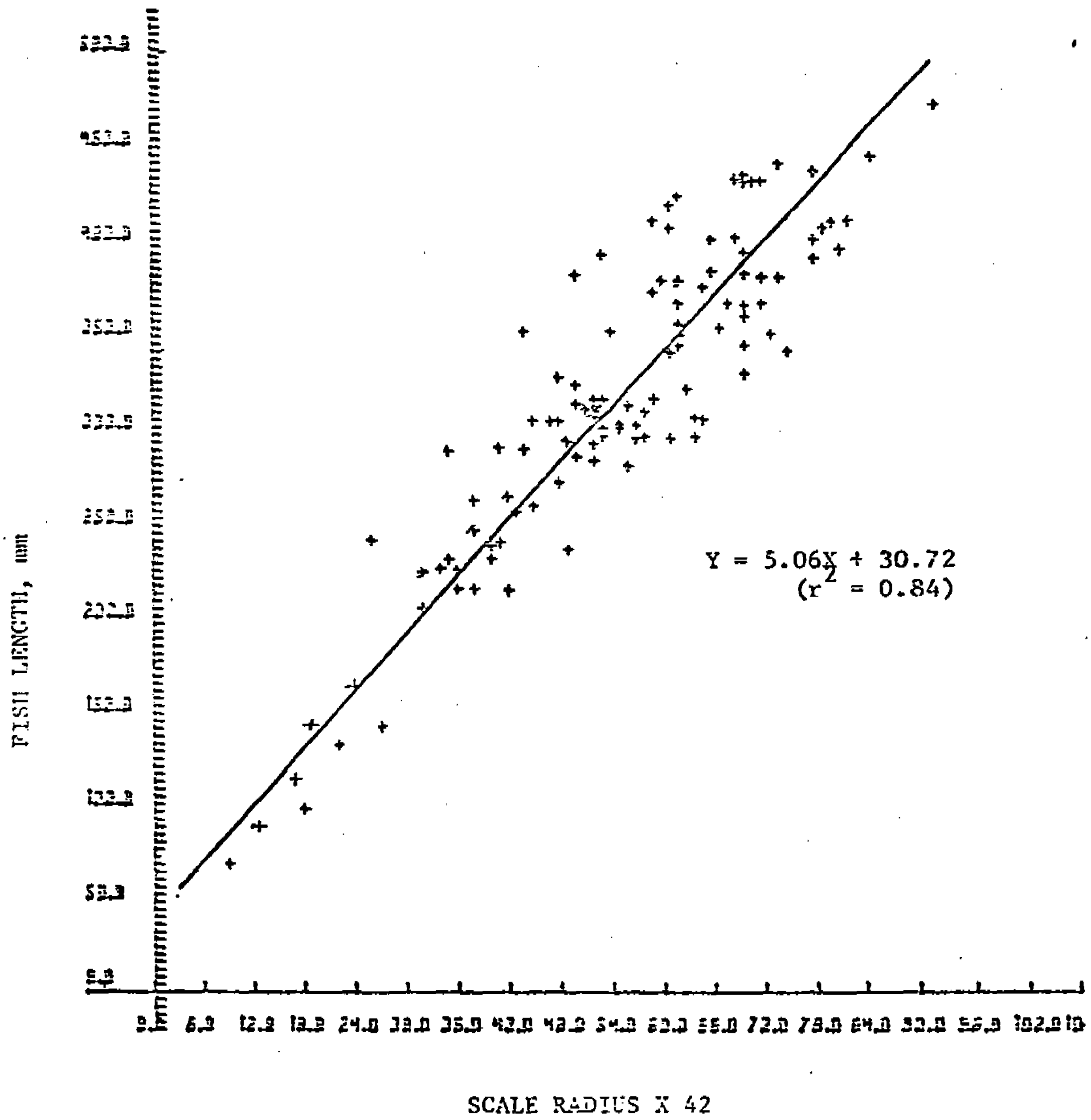
Size of mountain whitefish captured in 1981 ranged from 112-430 mm, with most 200-300 mm. Brook trout were generally smaller than rainbows, with 10 fish smaller than 200 mm, 16 between 200 and 300 mm, and 8 longer than 300 mm. The largest brook trout captured was 347 mm. No brook or rainbow trout were of hatchery origin. The largest rainbow trout handled was 471 mm in length and weighed 1135 gm.

Significant hook scars, normally damage to the maxillary or premaxillary of the upper jaw, were observed in 10% of the rainbow and 6% of the brook trout collected (Table 1). In addition, two fish had flies imbedded in their jaws and one fish was blind in one eye, possibly from hook damage.

A regression of scale radius against length of fish at capture (Fig. 2) gave a linear body-scale relationship of length = 5.06 x scale radius + 30.72 (r^2 = 0.84). This equation was used to back-calculate average fish length at the end of each growing season.

These calculated lengths showed excellent growth (Table 2), especially for the first two years. Average total length of fish at the end of the first growing season was 132 mm,

Figure 2. Body-scale relationship for upper Silver Creek rainbow trout collected in October 1981.



FISH LENGTH, mm
Y = 5.06X + 30.72
(r^2 = 0.84)
SCALE RADIUS X 42

Table 2. Back-calculated lengths of rainbow trout collected in upper Silver Creek, 17-18 October 1981.

		calculated length at end of growing season				
age at capture	number	1	2	3	4	5
I	8	142.2				
II	125	132.0	261.7			
III	51	131.3	260.8	338.7		
IV	24	132.4	258.6	339.5	391.6	
V	6	137.1	221.5	294.9	361.6	417.32
weighted mean	214	132.40	259.95	335.69	385.60	417.32
Thurow, 1976-77	77	111.99	207.67	279.68	348.99	-
IFG 1952	11	132.1	274.3	386.1	477.5	548.6
Firehole River (Benson et al. 1959)	198	135	234	328	396	-

compared with total length values of 96 and 120 mm found by Thurow (1978) for fish collected in 1976 and 1977, respectively. This first-year growth calculated from 1981 fish is identical to that to that of a small sample of fish taken by Idaho Fish and Game in 1952 (as cited in Thurow 1978, Table 2).

Second-year growth was extremely rapid, with trout nearly doubling their length during this period. Size at the end of the second year for fish collected in 1981 was 260 mm, 52 mm longer than the average for 1976-77 fish. This size advantage of 1981 fish over 1976-77 trout continued for fish of ages 3 and 4, but did not match growth of 1952 trout.

Lengths back-calculated from 1981 data indicate growth faster than that recorded for most stream-dwelling rainbow trout. For 21 populations listed by Carlander (1969), the average calculated lengths at the ends of the first four growing seasons were 99, 196, 282 and 353 mm. The only comparable growth from other studies was for the naturally-heated waters of the Firehole River in Yellowstone National Park (Benson et al. 1959, Table 2).

The increase in fish size in the past several years appears to follow a trend possibly begun in 1977. Thurow's data for wild rainbow show an increase from 1976 to 1977 of 24, 24 and 17 mm at the ends of the first, second and third growing seasons, respectively. This may reflect, among other possible explanations, a change in regulations from general season to catch-and-release. Angling may be expected to crop the fastest-growing, most aggressive members of each vulnerable age-group. If angling mortality were eliminated or drastically reduced, the average size of fish in each of these age-groups would be expected to increase.

If the observed change has occurred for this reason, the increase in average size of fish at the end of their first year is an anomaly, since that age-group is not significantly affected by angling. In 1977, less than 10% of the fish caught (and released) in upper Silver Creek were 150-200 mm and almost no fish smaller than 150 mm entered the catch.

Assuming that growth is density-dependent, increased growth of underyearlings (or of any age-group) would be expected if numbers were reduced by factors such as predation. However, there has been no apparent increase in avian predation, and none of the fish species found in the study sections are substantially piscivorous.

An increase in food supply would be an alternate cause for the changes observed, but there is no evidence that this has occurred (p. 53, this report).

Average weights for rainbow trout were calculated from the length-weight relationship, log weight = 3.17 log length - 5.43 (r^2 = 0.98). Calculated weights at ages 2, 3, 4 and 5 were 170, 383, 595 and 765 gm, respectively. No weight data were collected in 1976-77. Summary data from Carlander (1969) suggests that these values for ages 2 and 3 are lighter than average and those for ages 4 and 5 are average, when compared with 30-40 other populations.

The average coefficient of condition (weight/length^3) for rainbow trout in 1981 showed no change from that reported for 1976 (Table 3). Coefficients of condition in 1981 were nearly identical for each size category.

Rainbow trout with hook scars did not exhibit a decrease in condition from the average. Coefficients of condition for seven hook-scarred trout 200-299 mm and for nine fish 300-380 mm were 1.0790 and 1.1498, respectively, higher than the average values for all fish of those sizes collected in 1981.

Table 3. Average coefficient of condition, K, ($K = \frac{weight}{length^3} \times 10^5$) of rainbow trout from upper Silver Creek in 1976 (Thurow 1978) and 1981.

size category, mm	October 1981			October-November 1976		
	avg. length	no.	K	avg. length	no.	K
200-299	252.8	88	1.003	250.9	15	0.992
300-380	335.1	54	1.0166	332.7	13	1.009
>380	412.2	34	1.0660	396.3	4	1.010

CONCLUSIONS AND RECOMMENDATIONS

The growth of rainbow trout in upper Silver Creek is excellent, especially during the initial two years. This is in part a function of good growing conditions during the spring and fall of the year. Is the food supply presently limiting the production of trout? It is possible to only speculate at this time, since little information is available on the direct relationship between Silver Creek trout and their sources of food. The predominance of smaller invertebrates, especially Chironomidae, in the benthos should favor the growth of smaller fish. Trout stomachs examined from July - November by Francis and Bjornn (1979) did not indicate this, as fish smaller than 250 mm had essentially the same diet as larger fish. Idaho Fish and Game file data summarized by Pettit provides stomach content data for trout (fish length not recorded) collected from April 1975 through March 1977. Mayflies, mostly Baetis, comprized 64-83% of diet during summer periods. In winter and spring, however, Chironomidae made up 68-70% of the numbers of items eaten.

The incidence of hook scarring is similar or less than that found for other populations of trout subject to intensive catch-and-release fisheries. At the present level of angling effort it is unlikely that angler-caused mortality is having a significant negative impact on trout growth or survival.

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A schedule should be established for periodic population estimation in the upper portion of Silver Creek. This will be an elaborate effort, ideally utilizing more than one boat and generator and block nets to isolate each stream section. At the same time, data on growth and incidence of hook scarring should be gathered. This procedure should be systematically repeated at intervals of about five years.

	02		20		40		39		56		47	
Filterers												
Pisidium	120	(98)	348	(202)	72	(102)	548	(740)	788	(694)	284	(168)
Brachycentrus americanus	152	(114)	8	(9)	376	(375)	20	(30)	156	(73)	44	(33)
Ostracoda					48	(96)	80	(160)	8	(16)		
Hydropsyche			4	(8)	88	(44)	4	(8)	68	(95)	48	(57)
Simulium	4	(8)	4	(8)								
Sphaerium	4	(8)										
Total	280	(216)	364	(206)	524	(486)	652	(751)	1020	(831)	376	(146)
%	11		4		4		4		4		6	
Shredders												
Gammarus lacustris	52	(73)	2704	(2748)	516	(361)	1532	(1308)	3056	(1304)	1880	(1245)
Hyallela azteca	8	(16)									188	(136)
Limnephilidae 2					120	(240)						
Haliplus			16	(23)			8	(9)				
Lara avara					4	(8)						
Limnephilidae 3												
Hesperophylax									4	(8)		
Limnephilidae 1	4	(8)					8	(9)	8	(16)		
Nemoura artica												
Onocosmoecus												
Phryganea cinerea												
Tipula												
Total	64	(80)	2720	(2737)	640	(549)	1548	(1298)	3068	(1314)	2072	(1344)
%	1		21		3		8		12		17	
Predators												
Erpobdella/Lobdella	60	(72)	156	(90)	212	(392)	264	(126)	312	(261)	276	(167)
Ceratopogonidae					524	(1016)	28	(38)	1164	(1361)	40	(48)
Enallagma	4	(8)	80	(87)			336	(299)	4	(8)	252	(316)
Oecetis					8	(16)	324	(144)	144	(101)		
Isoperla					188	(293)	20	(30)				
Rhyacophila acropedes					44	(27)	8	(16)				
Hesperocorixa	32	(64)			4	(8)						
Empididae	4	(8)	4	(8)	16	(23)						
Hesperoperla pacifica					4	(8)						
Rhantus							4	(8)				
edators												
Dicronotus												
Hemiptera			4	(8)			8	(9)				
Oreodytes												
Ophiogomphus occedentis												
Aeshna intercupta												
Total	100	(99)	244	(100)	1000	(927)	992	(496)	1624	(1415)	[illegible]	(479)
%	3		3		[illegible]		6		6		[illegible]	

Ceratopogonidae					524	(1016)	28	(38)	1164	(1361)	40	(48)
Enallagma	4	(8)	80	(87)			336	(299)	4	(8)	252	(316)
Oecetis					8	(16)	324	(144)	144	(101)		
Isoperla					188	(293)	20	(30)				
Rhyacophila acropedes					44	(27)	8	(16)				
Hesperocorixa	32	(64)			4	(8)						
Empididae	4	(8)	4	(8)	16	(23)						
Hesperoperla pacifica					4	(8)						
Rhantus							4	(8)				
edators												
Dicronotus												
Hemiptera			4	(8)			8	(9)				
Oreodytes												
Ophiogomphus occedentis												
Aeshna interrupta												
Total	100	(99)	244	(100)	1000	(927)	992	(496)	1624	(1415)	744	(479)
%	3		3		6		6		6		6	
Other	0		0		16	(23)	12	(15)	48	(76)	72	(124)
%	0		0		0		0		0		0	
Grand Total	3420	(2000)	9824	(5200)	25,408	(28,341)	17,548	(3849)	28,044	(12,259)	13,828	(8670)

Table 4 Mean ($\bar{x}$) and standard deviation of benthic invertebrate abundance (nos./m^2) arranged by functional group as collected from the six Silver Creek study sites described in this report in May 1982.

	1 $\bar{x}$	1 SD	2 $\bar{x}$	2 SD	3 $\bar{x}$	3 SD	4 $\bar{x}$	4 SD	5 $\bar{x}$	5 SD	6 $\bar{x}$	6 SD
Scrapers												
Baetis parvus/tricaudatus			228	(212)	592	(303)	384	(534)	672	(353)	340	(385)
Helicopsyche borealis			116	(80)	56	(28)	100	(140)	300	(222)	92	(85)
							52	(53)	112	(97)	112	(129)
Flumenicola [1] [2]	4	(8)	104	(65)	12	(15)	32	(64)	12	(24)	468	(453)
Physa					4	(8)						
Gyraulus					52	(24)	4	(8)				
Hydroptila					8	(9)					2	(4)
Optioservus quadrimaculatus					18	(26)	4	(8)			76	(152)
Euparyphus	4	(8)	2	(4)								
Promenetus									4	(8)		
Lymnaea					4	(8)						
Clinygmula											?	(4)
Cleptelmis			2	(4)								
Siphlonurus occidentalis					6	(12)	2	(4)	2	(4)		
Dubiraphia												
Oxythira												
Total	8	(9)	452	(305)	752	(316)	578	(448)	1102	(295)	1092	(859)
%	2		23		9		12		16		18	
Gatherers												
Ephemerella inermis	8	(9)	208	(183)	4528	(3912)	956	(1028)	1196	(273)	1140	(640)
Paraleptophlebia debilis					8	(9)	2	(4)			2	(4)
Optioservus quadrimaculatus					18	(26)	4	(8)			76	(152)
Euparyphus			2	(4)					4	(8)		
Chrysops	4	(8)									4	(8)
Tricorythodes minutus			12	(15)	24	(28)						
Ephemerella grandis					4	(8)						
Dubiraphia											?	(4)
Cleptelmis			?	(4)								
Siphlonurus occidentalis					6	(12)	2	(4)	?	(4)		
Caenis	4	(8)										
Lepidostoma												
Total	16	(0)	224	(201)	4588	(3922)	964	(1026)	1202	(277)	1224	(599)
%	5		12		38		22		17		27	
Miners												
Chironomidae	104	(110)	240	(201)	4376	(5146)	940	(397)	1992	(1286)	944	(1512)
Tubificidae	300	(272)	592	(941)	1084	(1152)	612	(663)	2496	(2279)	1008	(1574)
Total	404	(309)	832	(874)	5460	(6299)	1552	(518)	4488	(3440)	1952	(3074)
%	45		39		41		33		49		21	
Filterer[illegible]												
Pisidi[illegible]	548	(675)	244	(13[illegible])	172	(273)	1972	(2963)	440	(18?)	[illegible]92	(12?8)

Minèrs												
Chironomidae	104	(110)	240	(201)	4376	(5146)	940	(397)	1992	(1286)	944	(1512)
Tubificidae	300	(272)	592	(941)	1084	(1152)	612	(663)	2496	(2279)	1008	(1574)
Total	404	(309)	832	(874)	5460	(6299)	1552	(518)	4488	(3440)	1952	(3074)
%	45		39		41		33		49		21	
ilterers												
Pisidium	548	(675)	244	(136)	172	(273)	1972	(2963)	440	(182)	1092	(1238)
Brachycentrus americanus					40	(70)			160	(165)		
Ostracoda					620	(906)	20	(40)			460	(578)
Hydropsyche			24	(38)	4	(8)	12	(24)	40	(28)	16	(32)
Simulium							4	(8)	4	(8)		
Sphaerium												
Total	548	(675)	268	(158)	836	(1126)	2008	(2935)	644	(224)	1568	(1620)
%	45		15		6		30		9		20	
hredders												
Gammarus lacustris	16	(23)	32	(54)	412	(351)	48	(61)	104	(67)	264	(301)
Hyallela azteca												
Limnephilidae 2												
Haliplus											44	(88)
Lara avara												
Limnephilidae 3												
Hesperophylax												
Limnephilidae 1					8	(16)						
Nemoura artica												
Onocosmoecus			8	(16)								
Phryganea cinerea												
Tipula												
Total	16	(23)	40	(70)	420	(360)	48	(61)	104	(67)	308	(370)
%	2		2		4		2		2		5	
redators												
Erpobdella/Lobdella	12	(15)	60	(27)	124	(175)	16	(13)	308	(201)	428	(650)
Ceratopogonidae					4	(8)	4	(8)	56	(66)	4	(8)
Enallagma					4	(8)	12	(24)			4	(8)
Oecetis			84	(33)	32	(45)	36	(27)	164	(186)	132	(60)
Isoperla					8	(9)			8	(16)	4	(8)
Rhyacophila acropedes					12	(15)						
Hesperocorixa												
Empididae					4	(8)						
Hesperoperla pacifica												
Rhantus												

Predator[illegible]
Dicron[illegible]s

Oncosmoecus			8	(16)								
Phryganea cinerea												
Tipula												
Total	16	(23)	40	(70)	420	(360)	48	(61)	104	(67)	308	(370)
%	2		2		4		2		2		5	
redators												
Erpobdella/Lobdella	12	(15)	60	(27)								
Ceratopoganidae					124	(175)	16	(13)	308	(201)	428	(650)
Enallagma					4	(8)	4	(8)	56	(66)	4	(8)
Oecetis					4	(8)	12	(24)			4	(8)
Isoperla			84	(33)	32	(45)	36	(27)	164	(186)	132	(60)
Rhyacophila acropedes					8	(9)			8	(16)	4	(8)
Hesperocorixa					12	(15)						
Empididae												
Hesperoperla pacifica					4	(8)						
Rhantus												
Predators												
Dicronotus												
Hemiptera												
Oreodytes												
Ophiogomphus occedentis			8	(16)								
Aeshus interrupta												
Total	12	(15)	152	(50)	188	(221)	68	(56)	536	(266)	572	(682)
%	2		8		1		2		7		9	
Other	4	(8)	4	(8)	52	(46)	0	(0)	12	(15)	8	(16)
%	0		0		1		0		0		0	
Grand Total	1008	(1092)	1972	(499)	12,296	(11,145)	5218	(2740)	8088	(3153)	6724	(4865)

Table 3 Mean ($\bar{x}$) and standard deviation of benthic invertebrate abundance (nos./m^2) arranged by functional group as collected from the six Silver Creek study sites described in this report in November 1981.

	1 $\bar{x}$	1 SD	2 $\bar{x}$	2 SD	3 $\bar{x}$	3 SD	4 $\bar{x}$	4 SD	5 $\bar{x}$	5 SD	6 $\bar{x}$	6 SD
rapers												
Baetis parvus/tricaudatus			136	(240)	1272	(915)	620	(473)	384	(124)	260	(355)
Helicopsyche borealis			40	(53)	392	(302)	84	(99)	408	(635)	228	(170)
Flumenicola 1									128	(150)	208	(292)
Flumenicola 2			468	(304)	96	(118)	36	(27)	4	(8)	908	(1278)
Physa			24	(28)	4	(8)	4	(8)	4	(8)	8	(9)
Gyraulus			4	(8)			28	(46)			100	(200)
Hydroptila	120	(71)	4	(8)	668	(535)	64	(87)	36	(27)	108	(174)
Optioservus quadrimaculatus			4	(5)	8	(9)	4	(5)	8	(11)	4	(8)
Euparyphus	8	(9)			24	(28)			2	(4)		
Promenetus											24	(48)
Lymnaea	24	(21)			8	(16)						
Cinygmula												
Cleptelmis	4	(8)			6	(4)	4	(5)	8	(16)		
Siphlonurus occidentalis					14	(28)	6	(8)			30	(45)
Dubiraphia												
Oxythira							4	(8)				
Total	624	(340)	308	(301)	2432	(1537)	818	(543)	982	(704)	1878	(1209)
%	13		8		27		9		17		27	
therers												
Ephemerella inermis					1240	(1918)	104	(28)	28	(46)	8	(9)
Paraleptophlebia debilis					8	(16)	16	(32)				
Optioservus quadrimaculatus			4	(5)	8	(9)	4	(5)	8	(11)	4	(8)
Euparyphus					24	(28)			2	(4)		
Chrysops	8	(16)										
Tricorythodes minutus			8	(9)	52	(36)					12	(15)
Ephemerella grandis												
Dubiraphia												
Cleptelmis	4	(8)			6	(4)	4	(5)	8	(16)		
Siphlonurus occidentalis					14	(28)	6	(8)			30	(45)
Caenis												
Lepidostoma												
Total	12	(15)	12	(10)	1352	(1873)	134	(33)	46	(39)	54	(41)
%	0		0		13		2		1		1	
iners												
Chironomidae	432	(215)	264	(179)	2620	(2068)	3544	(3617)	1936	(1385)	2036	(1739)
Tubificidae	2676	(2913)	1688	(1325)	1348	(1502)	3680	(3609)	2932	(2316)	732	(454)
Total	3108	(2982)	1952	(1[illegible]3)	3968	(3449)	7224	(5751)	4868	(3646)	2768	(1920)
%	47		55		39		63		51		37	

%	0		0		13		2		1		1	
iners												
Chironomidae	432	(215)	264	(179)	2620	(2068)	3544	(3617)	1936	(1385)	2036	(1739)
Tubificidae	2676	(2913)	1688	(1325)	1348	(1502)	3680	(3609)	2932	(2316)	732	(454)
Total	3108	(2982)	1952	(1503)	3968	(3449)	7224	(5751)	4868	(3646)	2768	(1920)
%	47		55		39		63		51		37	
ilterers												
Pisidium	1424	(849)	392	(311)	88	(59)	168	(103)	360	(366)	560	(184)
Brachycentrus americanus	44	(42)	4	(8)	224	(250)	92	(98)	128	(195)		
Ostracoda					604	(775)	620	(945)				
Hydropsyche	24	(28)	44	(67)			356	(454)	288	(544)	84	(77)
Simulium					56	(46)	424	(721)	12	(15)		
Sphaerium												
Total	1492	(788)	440	(343)	972	(990)	1660	(965)	788	(708)	644	(154)
%	26		13		10		15		9		9	
hredders												
Gammarus lacustris	400	(383)	504	(556)	212	(153)	400	(335)	1708	(1855)	900	(646)
Hyallela azteca							20	(40)	32	(39)	52	(65)
Limnephilidae 2												
Haliplus	4	(8)	4	(8)			24	(38)	16	(32)		
Lara avara												
Limnephilidae 3			16	(32)	24	(48)			12	(15)	4	(8)
Hesperophylax	4	(8)										
Limnephilidae 1							8	(16)			4	(8)
Nemoura artica												
Onocosmoecus												
Phryganea cinerea							4	(8)				
Tipula	16	(32)										
Total	424	(399)	524	(573)	236	(186)	456	(400)	1768	(1827)	960	(694)
%	11		18		3		4		15		14	
redators												
Erpobdella/Lobdella	36	(33)	84	(94)	516	(626)	156	(163)	468	(555)	388	(200)
Ceratopoganidae					16	(32)	4	(8)				
Enallagma			64	(128)	28	(38)	464	(508)	28	(27)	148	(131)
Oecetis			48	(65)	32	(23)	192	(245)	292	(334)	236	(118)
Isoperla					20	(40)						
Rhyacophila acropedes												
Hesperocorixa			16	(32)								
Empididae					20	(24)	4	(8)				
Hesperoperla pacifica					4	(8)						
Rhantus												
Predat[illegible]s												
Dicro[illegible]otus	80	(96)										
Hemiptera												

Onocosmoecus												
Phryganea cinerea							4	(8)				
Tipula	16	(32)										
Total	424	(399)	524	(573)	236	(186)	456	(400)	1768	(1827)	960	(694)
%	11		18		3		4		15		14	
Predators												
Erpobdella/Lobdella	36	(33)	84	(94)	516	(626)	156	(163)	468	(555)	388	(200)
Ceratopoganidae					16	(32)	4	(8)				
Enallagma			64	(128)	28	(38)	464	(508)	28	(27)	148	(131)
Oecetis			48	(65)	32	(23)	192	(245)	292	(334)	236	(118)
Isoperla					20	(40)						
Rhyacophila acropedes												
Hesperocorixa			16	(32)								
Empididae					20	(24)	4	(8)				
Hesperoperla pacifica					4	(8)						
Rhantus												
Predators												
Dicronotus	80	(96)										
Hemiptera												
Oreodytes	4	(8)										
Ophiogomphus occedentis												
Aeshna interrupta							8	(16)				
Total	120	(122)	212	(319)	636	(640)	828	(846)	788	(904)	772	(201)
%	3		5		6		7		7		11	
Other	0		0		120		8		4		4	
%	0		0		1		0		0		0	
Grand Total	5780	(3239)	3448	(2548)	9716	(3539)	11,128	(7122)	9244	(5938)	7080	(924)

Table 2 Mean ($\bar{x}$) and standard deviation of benthic invertebrate abundance (nos./m^2) arranged by functional group as collected from the six Silver Creek study sites described in this report in August 1981.

	1 $\bar{x}$	1 SD	2 $\bar{x}$	2 SD	3 $\bar{x}$	3 SD	4 $\bar{x}$	4 SD	5 $\bar{x}$	5 SD	6 $\bar{x}$	6 SD
crapers												
Baetis parvus/tricaudatus	408	(469)	12	(24)	4128	(2610)	3428	(2510)	788	(848)	100	(95)
Helicopsyche borealis	4	(8)	40	(16)	184	(283)	140	(44)	864	(945)	396	(273)
Flumenicola 1	28	(20)	36	(30)	12	(8)	16	(32)	44	(51)	128	(214)
Flumenicola 2			8	(16)							8	(16)
Physa			36	(46)							4	(8)
Gyraulus							16	(32)				
Hydroptila	20	(30)	24	(31)	16	(23)	4	(8)	4	(8)		
Optioservus quadrimaculatus					28	(46)			4	(8)		
Euparyphus					4	(5)	2	(4)				
Promenetus												
Lymnaea	4	(8)	4	(8)								
Cinygmula												
Cleptelmis	4	(8)			16	(23)	2	(4)				
Siphlonurus occidentalis												
Dubiraphia			2	(4)								
Oxythira												
Total	368	(516)	162	(91)	4388	(2760)	3608	(2559)	1704	(1391)	636	261
%	11		2		46		21		15		13	
atherers												
Ephemerella inermis					92	(101)	156	(261)	16	(19)		
Paraleptophlebia debilis	72	(123)			508	(910)	2224	(1049)	64	(99)	36	(62)
Optioservus quadrimaculatus					28	(46)			4	(8)		
Euparyphus					4	(5)	2	(4)				
Chrysops			4	(8)								
Tricorythodes minutus	52	(42)			292	(210)	12	(24)	108	(109)	320	(237)
Ephemerella grandis					4	(8)						
Dubiraphia			2	(4)								
Cleptelmis	4	(8)			16	(23)	2	(4)				
Siphlonurus occidentalis												
Caenis												
Lepidostoma					4	(8)						
Total	128	(136)	6	(8)	948	(1081)	2396	(1064)	192	(173)	356	(299)
%	5		0		9		15		2		5	
Miners												
Chironomidae	396	(33)	384	(249)	1448	(861)	3396	(698)	1420	(1251)	3228	(2591)
Tubificidae	1216	(2178)	1960	(1658)	524	(933)	1484	(536)	2540	(1423)	900	(771)
Total	1612	(2203)	2344	(1881)	1972	(1729)	4880	(399)	3960	(2583)	4128	(2693)
%	52		32		20		32		44		57	
iltere[rs]												
Pisidium	296	(156)	460	(364)	84	(158)	808	(583)	440	(222)	116	(134)

Miners														
Chironomidae	396	(33)	384	(249)	1448	(861)	3396	(698)	1420	(1251)	3228	(2591)
Tubificidae	1216	(2178)	1960	(1658)	524	(933)	1484	(536)	2540	(1423)	900	(771)
Total	1612	(2203)	2344	(1881)	1972	(1729)	4880	(399)	3960	(2583)	4128	(2693)
%	52		32		20		32		44		57	
Filterers												
Pisidium	296	(156)	460	(364)	84	(158)	808	(583)	440	(222)	116	(134)
Brachycentrus americanus	80	(84)	4	(8)	428	(342)	116	(127)	192	(218)	32	(39)
Ostracoda					496	(502)	796	(1089)	4	(8)	8	(16)
Hydropsyche	4	(8)	28	(35)	4	(8)	232	(432)	96	(192)	52	(60)
Simulium	8	(16)			36	(62)	340	(575)	128	(256)		
Sphaerium	4	(8)										
Total	392	(93)	492	(372)	1048	(236)	2292	(641)	860	(488)	208	(166)
%	27		8		14		14		10		3	
Shredders												
Gammarus lacustris	56	(61)	3488	(3239)	560	(238)	1772	(486)	1560	(1406)	656	(243)
Hyallela azteca	4	(8)	84	(102)			4	(8)	84	(97)	32	(30)
Limnephilidae 2											4	(8)
Haliplus	4	(8)	12	(15)			12	(15)			16	(23)
Lara avara												
Limnephilidae 3									16	(23)	28	(46)
Hesperophylax	4	(8)										
Limnephilidae 1			16	(13)	4	(8)			8	(9)		
Nemoura artica					4	(8)						
Onocosmoecus												
Phryganea cinerea												
Tipula												
Total	68	(65)	3600	(3277)	568	(243)	1788	(486)	1668	(1518)	736	(298)
%	3		48		7		11		13		13	
Predators												
Erpobdella/Lobdella	16	(32)	308	(207)	360	(577)	240	(158)	1252	(828)	300	(185)
Ceratopoganidae					12	(24)	4	(8)	12	(15)		
Enallagma	4	(8)	384	(319)			568	(270)	16	(32)	148	(275)
Oecetis			44	(60)	4	(8)	248	(166)	152	(130)	40	(33)
Isoperla												
Rhyacophila acropedes							4	(8)				
Hesperocorixa	4	(8)										
Empididae					4	(8)						
Hesperoperla pacifica												
Rhantus												
Predators												
Dicronotus	4	(8)										
Hemiptera												
Oreody[illegible]	12	(24)										
Ophiogomphus occedentis												

·edators												
Erpobdella/Lobdella	16	(32)	308	(207)	360	(577)	240	(158)	1252	(828)	300	(185)
Ceratopoganidae					12	(24)	4	(8)	12	(15)		
Enallagma	4	(8)	384	(319)			568	(270)	16	(32)	148	(275)
Oecetis			44	(60)	4	(8)	248	(166)	152	(130)	40	(33)
Isoperla												
Rhyacophila acropedes							4	(8)				
Hesperocorixa	4	(8)										
Empididae					4	(8)						
Hesperoperla pacifica												
Rhantus												
·edators												
Dicronotus	4	(8)										
Hemiptera												
Oreodytes	12	(24)										
Ophiogomphus occedentis												
Aeshna interrupta												
Total	40	(61)	736	(508)	380	(596)	1064	(531)	1432	(972)	488	(343)
%	1		9		3		7		16		8	
Other	8	(9)	4	(8)	76	(95)	80	(91)	8	(9)	12	(24)
%	1		0		1		0		0		0	
Grand Total	2616	(3053)	7344	(3984)	9380	(6044)	16,108	(3321)	9824	(6098)	6564	(3346)

Table [illegible] Numbers per square meter of the nine m[illegible] abundant taxa found at the study locali[illegible]s.

		1	2	3	4	5	6
Chironomidae	June	1296	932	9840	4976	14,444	6100
	August	396	384	1448	3396	1420	3228
	November	432	264	2620	3544	1936	2036
	May	104	240	4376	940	1992	944
	x̄	557	455	4571	3214	4948	3077
Tubificidae	June	1580	736	2192	1724	2816	1188
	August	1216	1960	524	1484	2540	900
	November	2676	1688	1348	3680	2932	732
	May	300	592	1084	612	2496	1008
	x̄	1443	1244	1287	1875	2696	957
Gammarus lacustris	June	52	2704	516	1532	3056	1880
	August	56	3488	560	1772	1560	656
	November	400	504	212	400	1708	900
	May	16	32	412	48	104	264
	x̄	131	1682	425	938	1607	925
Baetis	June	8	2208	5764	2836	1136	468
	August	408	12	4128	3428	788	100
	November		136	1272	620	384	260
	May		228	592	384	672	340
	x̄	104	646	2939	1817	745	292
Ephemerella inermis	June	36	492	4504	3076	2640	1524
	August			92	156	16	
	November			1240	104	28	8
	May	8	208	4528	956	1196	1140
	x̄	11	175	2591	1073	970	668
Pisidium	June	120	348	72	548	788	284
	August	296	460	84	808	440	116
	November	1424	392	88	168	360	560
	May	548	244	172	1972	440	1092
	x̄	597	361	104	874	507	513
Helicopsyche borealis	June	4	676	492	1023	884	1176
	August	4	40	184	140	864	396
	November		40	392	84	408	228
	May		116	56	100	300	92
	x̄	2	218	281	338	614	473
Hirudin[illegible]	June	60	156	[illegible]	264	312	276
	August	16	308	360	240	1252	300

	November	1424	392	88	168	360	560
	May	548	244	172	1972	440	1092
	$\bar{x}$	597	361	104	874	507	513
Helicopsyche borealis	June	4	676	492	1023	884	1176
	August	4	40	184	140	864	396
	November		40	392	84	408	228
	May		116	56	100	300	92
	$\bar{x}$	2	218	281	338	614	473
Hirudinea	June	60	156	212	264	312	276
	August	16	308	360	240	1252	300
	November	36	84	516	156	468	388
	May	12	60	124	16	308	428
	$\bar{x}$	31	152	303	169	585	348
Flumenicola 1 & 2	June	8	1288	4	20	108	60
	August	28	44	12	16	44	136
	November	468	96	36		132	1116
	May	4	104	12	84	124	580
	$\bar{x}$	127	383	16	30	102	473
Grand $\bar{x}$ Subtotal		3003	5316	12,517	10,328	12,774	7726
% of Grand total		94	94	88	83	93	90

Table 1 — Mean ($\bar{x}$) and standard deviation of benthic invertebrate abundance (nos./m^2) arranged by functional group as collected from the six Silver Creek study sites described in this report in June 1981.

	1		2		3		4		5		6	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
rapers												
Baetis parvus/tricaudatus	8	(16)	2208	(2151)	5764	(8017)	2836	(1711)	1136	(918)	468	(506)
Helicopsyche borealis	4	(8)	676	(315)	492	(726)	1028	(631)	884	(417)	1176	(1115)
Flumenicola	8	(16)			4	(8)	20	(40)	108	(195)		
1			680	(1136)							44	(51)
2			608	(690)							16	(32)
Physa			4	(8)			164	(226)	4	(8)		
Gyraulus			104	(135)			16	(13)	4	(8)	4	(8)
Hydroptila	20	(40)			4	(8)	8	(9)	60	(120)		
Optioservus quadrimaculatus					80	(144)			10	(4)		
Euparyphus					30	(24)					8	(9)
Promenetus									38	(76)		
Lymnaea									20	(40)		
Cinygmula					12	(8)						
Cleptelmis					4	(5)	2	(4)				
Siphlonurus occidentalis												
Dubiraphia												
Oxythira												
Total	40	(53)	4280	2186	6390	8865	4074	(1759)	2264	(520)	1716	(1639)
%	1		46		22		24		10		12	
therers												
Ephemerella inermis	36	(42)	492	(404)	4504	(3385)	3076	(1819)	2640	(141)	1524	(1450)
Paraleptophlebia debilis			48	(39)	180	(349)	488	(667)	68	(126)	28	(36)
Optioservus quadrimaculatus					80	(144)			10	(4)		
Euparyphus					30	(24)			38	(76)	8	(9)
Chrysops	24	(38)										
Tricorythodes minutus			8	(9)			4	(8)	4	(8)		
Ephemerella grandis					4	(8)						
Dubiraphia												
Cleptelmis					4	(5)	2	(4)				
Siphlonurus occidentalis												
Caenis												
Lepidostoma					4	(8)						
Total	60	(46)	548	(412)	4806	(3846)	3570	(2373)	2760	(272)	1560	(1438)
%	1		5		26		19		12		12	
ners												
Chironomidae	1296	(1433)	932	(245)	9840	(15849)	4976	(2090)	14444	(8990)	6100	(3986)
Tubificidae	1580	(1523)	736	(732)	2192	(2138)	1724	(1736)	2816	(1588)	1188	(965)
Total	2876	(1803)	1668	(953)	12032	(15255)	6700	(2650)	17260	(10285)	7288	(4662)
%	82		20				39		56			

UPdATE 1984

STREAM PROFILES
****

JULY - 1984

SILT; AQUATIC MACROPHYTE & WATER DEPTHS

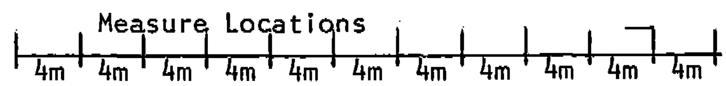
PROCEDURES FOR SILT MEASUREMENTS

1) Locate the 6 transect stations as described in "A Baseline Study of The Aquatic Ecology of Upper Silver Creek 1981-1982". Section 1 of the report.

2) Measure present stream width.

3) Determine sediment measuring locations.

$$\frac{\text{Stream Width}}{11} = \text{Measuring Interval} \qquad \text{Ex: } \frac{\text{44m Stream Width}}{11} = \text{4m Meas. Int.}$$

Ex: 

Stream width = 44m

4) At each sediment measure location measure:

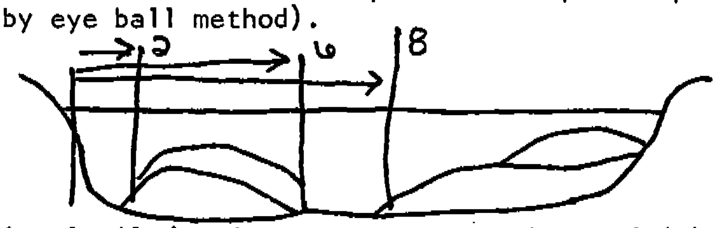
   a) depth from water surface to top of weed bed

   b) depth from water surface to top of silt;
   NOTE: Silt - weed interphase should be determined by sticking your hand down through weed bed until silt is felt.

   c) depth from water surface to solid bottom (rocks will usually be felt.)

*** A meter stick should be used for depth measurements.

5) Starting from one bank (south bank) measure bank to weed/silt bed distances and determine predominate plant species per weed bed (by eye ball method).



6) Additional silt/weed measurements may be needed in some weed beds for accurate mapping.

DATA SHEET

UPPER STALKER CREEK
STATION 1

	1981	1984
STAKE WIDTH	14.9m (48.9ft)	48.75ft
STREAM WIDTH	4.9m (16.1ft)	15.5ft
INTERVALS	1.6ft (1ft 7in.)	1.4

	WATER - WEEDS	WATER-SILT	WATER-BOTTOM
1.	---	107cm	116cm
2.	---	95cm	117cm
3.	---	76	115
4.	53cm	68	116
5.	60	64	118
6.	---	57	118
7.	---	55	112
8.	---	57	116
9.	---	67	114
10.	---	47	117

weeds
5' - 8'
POT.

NOTE: water over bank on south side.

LOWER STALKER CREEK
STATION 1

	1981	1984
STAKE WIDTH	19.9m (65.3ft)	
STREAM WIDTH	11.9m (39ft)	
INTERVAL (from south bank)		3'5"
NEW BANK		37'5"

1.	16cm	60cm	69cm
2.	45	77	80
3.	41	71	82
4.	41	57	86
5.	38	64	85
6.	50	73	87
7.	60	66	88
8.	83	95	99
9.	60	90	111
10.	45	79	116

Distance of Weed-Silt beds from south bank.

0-5'; 5'-23'; 27'-32'6"; 32'.6"-37'5"

POT. CH.-RAN. CH. POT.
POT.-VER. POT.

NOTE: 5'-23': CH. #1, POT. & RAN. tied for 2nd.)

GROVE CREEK
STATION 3

	1981	1984
STAKE WIDTH		
STREAM WIDTH	28m (91.8ft)	92'10"
INTERVALS	9.2ft (9ft s.5 in.)	

	WATER - WEEDS	WATER - SILT	WATER - BOTTOM
1.	0cm	31cm	57cm
2.	0	35	53
3.	9	47	64
4.	23	33	41
5.	8	28	41
6.	33	63	72
7.	25	41	70
8.	38	60	65
9.	--	--	49
10.	--	--	43

Distance of Weed-Silt.

2'-27';	30'-51';	52'6"-60'6";	63'-75';	83'-84'6";	89'-91'
CH.	CH.	CH.	CH.	CH. POT.	CH.

(small amounts of unknown) [arrows pointing to the CH. entries for 30'-51' and 52'6"-60'6"]

UPPER SILVER CREEK
STATION 4

	1981	1984
STAKE WIDTH		38.7m (126.9ft)
STREAM WIDTH	28.7m (94.1ft)	27.9m
INTERVALS from south bank	9.4ft	8'4"

1.	--	--	84cm
2.	52cm	59cm	70cm
3.	28	52	72
4.	--	--	70
5.	36	63	70
6.	63	--	80
7.	32	73	79
8.	--	--	75
9.	--	--	78
10.	11	47	50

(start south) Distance of Weed-Silt bed.

0-8';	15'-17';	19.5'-32.5';	34'-38';	40'-43';	44.5'-51'
POT. CH.	CH. POT. RAN.	CH. POT.	CH. POT.	CH. POT.	CH.

(cont;) 54'-60.5'; 62'-66'; 67.5'-74'; 80'-83.5'

54'-60.5'	62'-66'	67.5'-74'	80'-83.5'
CH.	CH.	CH. POT.	CH. POT.

MIDDLE SILVER CREEK
STATION 5

	1981	1984
STAKE WIDTH	46.5m (152.5ft)	149'7"
STREAM WIDTH	36.5m (119.7ft)	117'
INTERVALS from south bank	12ft.	10'7"

	WATER - WEEDS	WATER - SILT	WATER - BOTTOM
1.	46cm	50cm	58cm
2.	--	--	64
3.	17	54	61
4.	--	--	59
5.	--	--	81
6.	35	45	71
7.	--	--	64
8.	--	43	58
9.	--	--	60
10.	11	35	64

Distance of Weed-Silt beds.

0-9'	16.5'-21'	30'-37'	44'-51'	55'-72'	77'-90'	105.5'-111
POT.	POT. CH. RAN. ELO.	POT. CH.	CH.	POT. CH. ELO.	POT. CH.	POT.

LOWER SILVER CREEK
STATION 6

STAKE WIDTH	31.6m	
STREAM WIDTH	21.6m	75'.33
INTERVAL		6'10"

1.	56cm	69cm	103cm
2.	46	78	99
3.	--	91	97
4.	15	48	98
5.	--	95	110
6.	--	--	119
7.	72	79	125
8.	79	104	124
9.	100	115	122
10.	94	117	119

(start south bank) Distance of Weed-Silt beds.

0-8'	8'-12'	12'-14'6"	17'-20'	25'-29'6"	44'-51'
POT. ELO.	SILT.	POT. ELO. CH.	POT. ELO.	POT. ELO.	POT. CH. ELO.

54'6"-59'6"; 62'-69'; 71'6"-end

POT. CH.	POT.	POT. Duckweed	*water to weeds- zero.

NOTE: Water over south bank.

4' water-weeds, zero, water to silt 66', water to bottom 95'.

10' water-silt 92', water-bottom 94'.

18' water-weeds 49', water-silt 71', water-bottom 95'.

24' water-silt 84', water-bottom 97'.

31' water-silt 73', water-bottom 107'.

38' water-silt 109', water-bottom 111'.

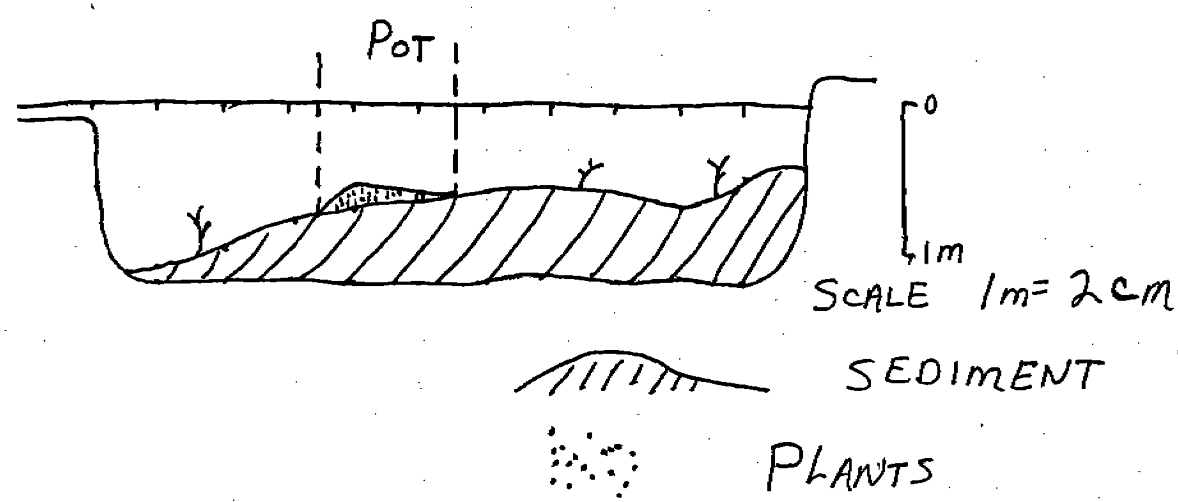
52' water-bottom 124'.

71' water-bottom 69'.

STATION 1 UPPER STALKER CR. JULY 24 84

STREAM WIDTH 4.7m

DISTRIBUTION OF PLANT SPECIES IN ORDER OF ABUNDANCE (EYE BALL)



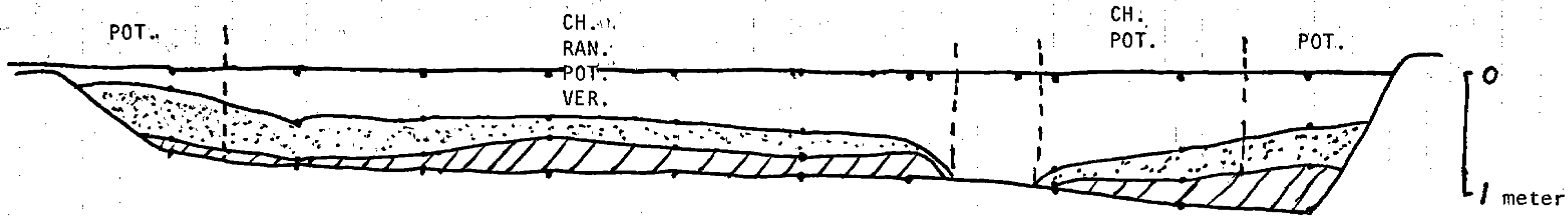
MEAN SEDIMENT DEPTH - 46.6 cm

MEAN DEPTH OF STREAM (INCLUDING SED.) - 115.9cm

PLANT SPECIES

<u>Potomogeton pictinatus</u> - POT.
<u>Chara vulgaris</u> - CH.
<u>Ranunculus aquatilis</u> - RAN.
<u>Fontinalis hypnoipes</u> - FONT.
<u>Veronica anagallis</u> - VER.
<u>Myriophyllum sp.</u> - MYR.
<u>Elo'ea canadensis</u> - ELO.

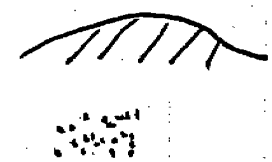
DISTRIBUTION OF PLANT SPECIES IN ORDER OF ABUNDANCE (EYE BALL)



Mean Sediment Depth- 17.1cm

Mean Depth of Stream (including Sed.)-90.2cm

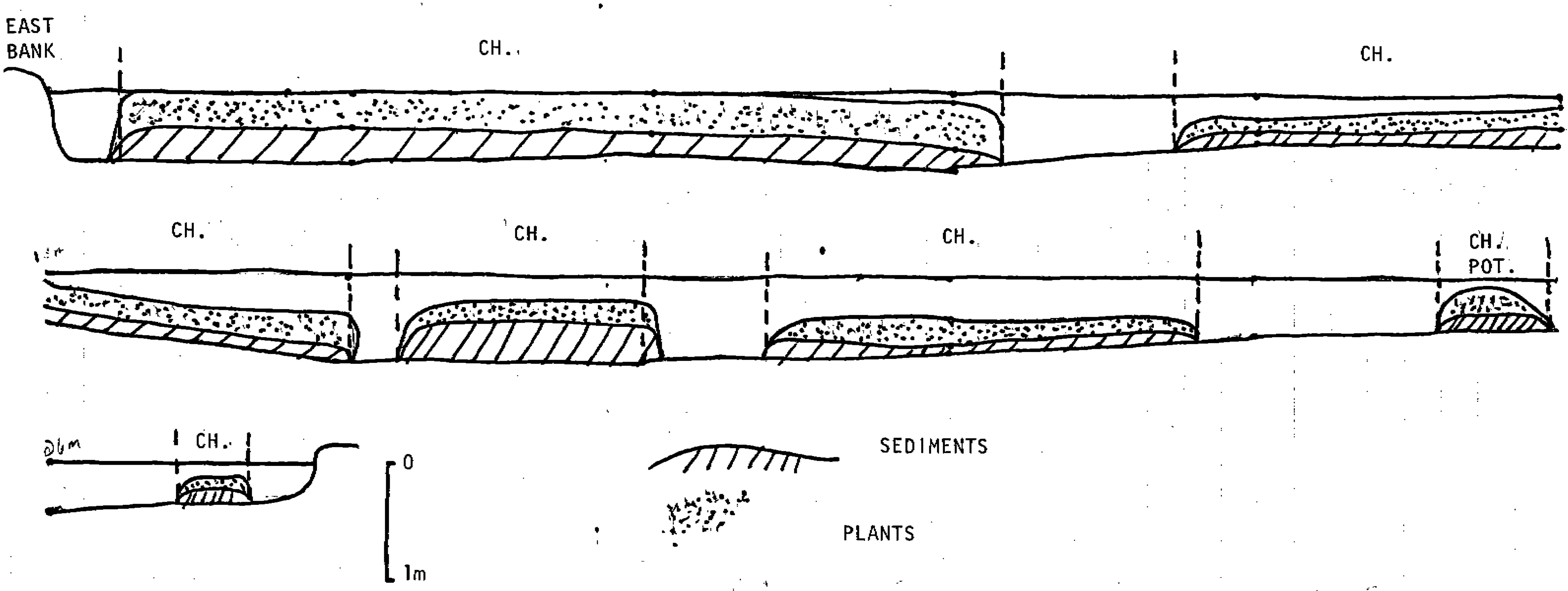
SCALE: 1m = 2cm



STATION- 2
LOWER STALKER CREEK
JULY 20, 1984
STREAM WIDTH- 11.4m

STATION 3 GROVE CREEK   JULY 24, 1984   STREAM WIDTH 28.3m

DISTRIBUTION OF PLANT SPECIES IN ORDER OF ABUNDANCE (EYE BALL)

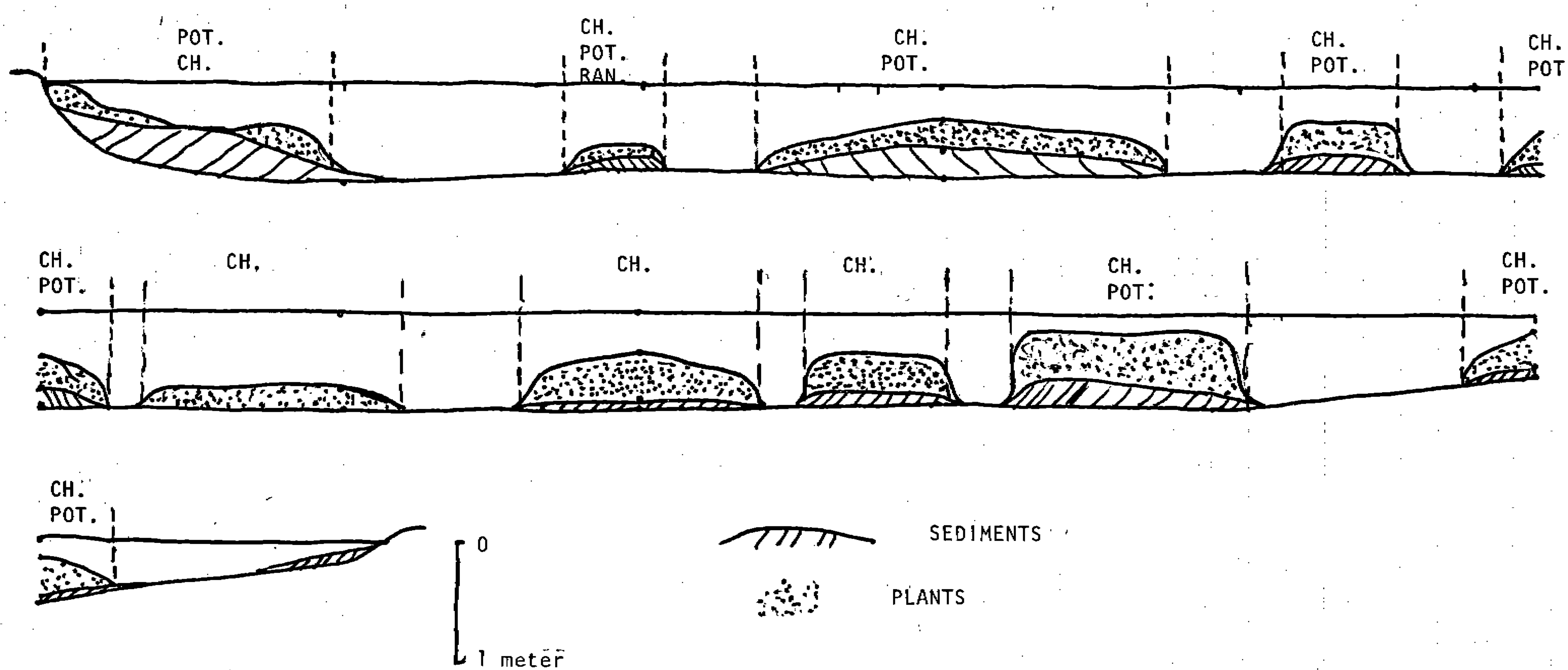


SCALE: 1m = 2cm

MEAN SEDIMENT DEPTH - 12.5cm
MEAN DEPTH OF STREAM (Including sed.) - 55.5cm

STATION 4 UPPER SILVER CREEK JULY 21, 1984 STREAM WIDTH 27.9m

DISTRIBUTION OF PLANT SPECIES IN ORDER OF ABUNDANCE (EYE BALL)



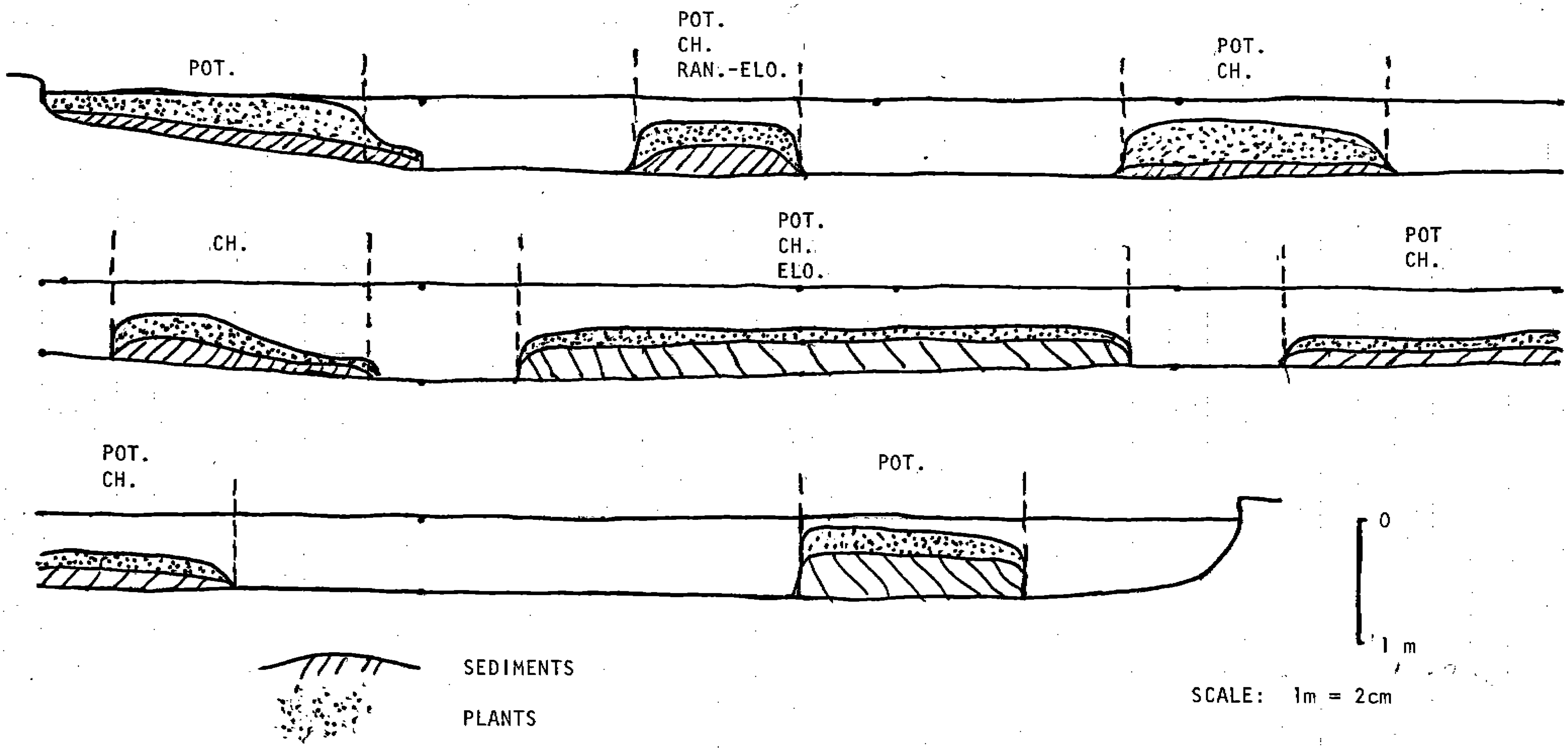
SCALE: 1m = 2cm

MEAN SEDIMENT DEPTH - 4.7cm

MEAN DEPTH OF STREAM (Including sed.) 72.8cm

STATION 5 MIDDLE SILVER CREEK JULY 20, 1984 STREAM WIDTH 35.7 m.

DISTRIBUTION OF PLANT SPECIES IN ORDER OF ABUNDANCE (EYE BALL)



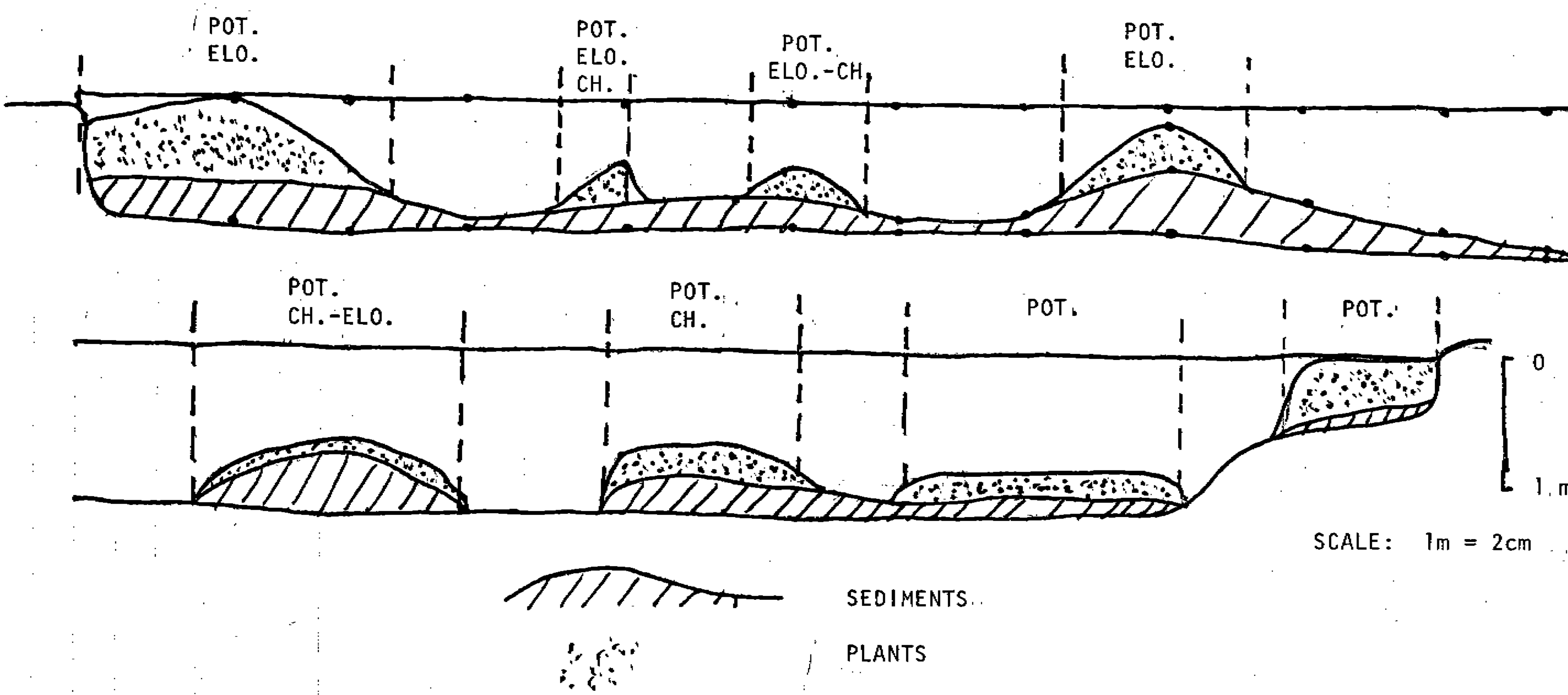
SCALE: 1m = 2cm

MEAN SEDIMENT DEPTH - 8.5cm

MEAN DEPTH OF STREAM (Including sed.) - 64cm

STATION 6 LOWER SILVER-CREEK · JULY 25, 1984 STREAM WIDTH - 23m

DISTRIBUTION OF PLANT SPECIES IN ORDER OF ABUNDANCE (EYE BALL)



MEAN SEDIMENT DEPTH - 20.1cm

MEAN DEPTH OF STREAM (Including sed.) - 111.6cm

MEAN SEDIMENT DEPTH

STATION 1.	46.6cm
2.	17.1
3.	12.5
4.	4.7
5.	8.5
6.	20.1