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

by

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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.

DESCRIPTION OF STUDY SITES

Station 1 (Upper Stalker Creek) is downstream of the Patton Drain and approximately 400-500 m upstream from the Hunting Cabin. The sampling site is on a straight reach of the stream, which flows almost parallel to the hill-slope 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.

Although the stream channel is well defined, the surrounding marsh is sometimes inundated to a depth of 10 to 20 cm.

Deposited sediment, a mixture of fine sand, bits of broken mollusk shells, and decaying plant material (organic detritus) covers most of the streambed, which consists of pebble-size rocks more or less consolidated in a matrix of calcarious gravel and fines. Light reaching the stream is restricted by bankshading and riparian vegetation and plant growth within the stream is sparce.

Station 2 (Lower Stalker Creek) is 400-500 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 positioned 4 m from either side of the stream except when the water level is down; then the stream width 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 fine (silty) deposited 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) 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 and gravel and fines which are loosely consolidated in some spots but which are cemented by $CaCO_3$ deposits in others. A relatively high percentage of the streambed is exposed, the remainder being covered by plants and/or sediment. Aquatic plants, moderate in abundance, tend to grow in clumps which are predominantly Potamogeton, Chara, or Veronica and which alternate with exposed streambed to form a mosaic or heterogeneous pattern.

Station 4 (Upper Silver Creek) is located on Conservancy property, 100 m downstream from the confluence 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

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 taxanomic 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

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
Scrapers												
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 1	8	(16)	680	(1136)	4	(8)	20	(40)	108	(195)	44	(51)
Flumenicola 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	
Gatherers												
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	
Miners												
Chironomidae	1296	(1433)	932	(245)	9840	(15,849)	4976	(2090)	14,444	(8990)	6100	(3986)
Tubificidae	1580	(1523)	736	(732)	2192	(2138)	1724	(1736)	2816	(1588)	1188	(965)
Total	2876	(1803)	1668	(953)	12,032	(15,255)	6700	(2650)	17,260	(10,285)	7288	(4662)
%	82		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)	28	(24)	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)				

Table 1 (cont.)

Predators												
Dicronotus												
Hemiptera			4	(8)			8	(9)				
Creodytes												
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 August 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
Scrapers												
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	
Gatherers												
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	

Table 2 (cont.)

August 1981

Filterers												
[illegible]	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	(39)
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												

Table 2 (cont.)

Predators												
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 5 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		2		3		4		5		6	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Scrapers												
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	
Gatherers												
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	
Miners												
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	

Table 3 (cont.)

November 1981

Filterers												
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	
Shredders												
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	
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												

Table 3 (cont.)

November 1981

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 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		2		3		4		5		6	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	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)
Flumenicola$^{1}_{2}$	4	(8)	104	(65)	12	(15)	52 32	(53) (64)	112 12	(97) (24)	112 468	(129) (453)
Physa												
Gyraulus					4	(8)						
Hydroptila					52	(24)	4	(8)				
OptioserVus quadrimaculatus					8	(9)					2	(4)
Euparyphus	4	(8)	2	(4)	18	(26)	4	(8)			76	(152)
Promenetus												
Lymnaea									4	(8)		
Cinygmula					4	(8)						
Cleptelmis			2	(4)							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												
Optioservus quadrimaculatus					8	(9)	2	(4)			2	(4)
Euparyphus			2	(4)	18	(26)	4	(8)			76	(152)
Chrysops	4	(8)							4	(8)		
Tricorythodes minutus			12	(15)	24	(28)					4	(8)
Ephemerella grandis					4	(8)						
Dubiraphia												
Cleptelmis			2	(4)							2	(4)
Siphlonurus occidentalis					6	(12)	2	(4)	2	(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	

Table 4 (cont.)

May 1982

Filterers												
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	
Shredders												
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	
Predators												
Erpobdella/Lobdella	12	(15)	60	(27)	124	(175)	16	(13)	308	(201)	428	(650)
Ceratopoganidae					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												

Table 4 (cont.)

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 [illegible] 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
Richness[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
Total 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
Diversity						
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"

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

Table 6 Numbers per square meter of the nine most abundant taxa found at the study locations.

		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

Table 6 (cont.)

		1	2	3	4	5	6
[illegible]	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 [illegible]. Results of t-test comparisons of abundances between stations for the nine most abundant taxa.

	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 these 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

lowed the pattern for total abundance although this was not always the case at all stations (Table 6). The remaining four taxa were not so consistent in this regard and commonly were most abundant or at least second most abundant in the May collections.

The seasonal variations noted were not surprising and generally were consistent with known differences in life history relationships and environmental conditions. However, they do emphasize the need to utilize data from similar times (months) when comparisons are being made between stations or conditions are being monitored over several years. In general, it appears that late summer-autumn would be most favorable for the collection of annual "monitoring" samples. Richness should be highest at this time and abundances should reflect conditions found over most of the annual cycle in Silver Creek (i.e., extending from the end of spring runoff in one year to the start of runoff in the next). In addition, field conditions at this time should be optimal for the collection of samples which will not be hampered by high flows or snow and ice.

Differences in richness, abundance, and diversity between the June 1981 and May 1982 collections (Table 6) are attributable largely to differences in weather conditions and subsequent runoff in the two years. The winter preceeding June 1981 was relatively mild with near normal snow pack and runoff (e.g., mean monthly discharge for the period January through May 1981 was 4.57 (± 1.01 SD) m^3/s).

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 (± 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

Table 11. Comparison of benthic invertebrate abundances from the middle 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).

	1977	1981	1977	1981	1977	1981
	June		August		November	
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 ($\approx$ 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, Pèlecypoda) 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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