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Primary Research Paper

Effects of electroshocking on macroinvertebrate drift in three cold water streams

Lance M. Kruzic[1,3], Dennis L. Scarnecchia[1,]* & Brett B. Roper[2,4]
[1]*Department of Fish and Wildlife Resources, University of Idaho, Moscow, Idaho 83844-1136, USA*
[2]*U.S. Forest Service, Tiller Ranger District, Tiller, Oregon 97484, USA*
[3]*Present address: National Marine Fisheries Service, 2900 NW Stewart Parkway, Roseburg, Oregon 97232, USA*
[4]*Present address: U.S. Forest Service, Forest Sciences Laboratory, 860 North, 1200 East, Logan, UT 84321 USA*
*(*Author for correspondence: E-mail: scar@uidaho.edu)*

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Abstract

The effect of electroshocking and walking on the substrate on macroinvertebrate drift was evaluated in three streams located in southwestern Oregon, USA. A randomized block experimental design was used to determine treatment (electroshocking and walking, electroshocking-only, walking-only) and drift distance effects on the number, biomass, and length of macroinvertebrates drifting up to 30 m downstream. In all streams, electroshocking caused significantly ($p < 0.05$) greater number of macroinvertebrates to drift compared to merely walking on the substrate. The differences among treatments decreased the farther downstream the macroinvertebrates drifted. No significant difference ($p > 0.05$) was observed in mean biomass between electroshocking and walking on the substrate among the drift distances. The longest macroinvertebrates were collected from the electroshocking treatment at the shortest drift distance (2.5 m) in all of the streams. The length of macroinvertebrates collected between electroshocking and walking on the substrate were similar at drift distances of 10 m and greater and represented predominately the smaller, poor swimming taxa.

Introduction

Electroshocking is a common and effective sampling technique for collecting data on species composition, abundance and distribution of fishes in streams (Simonson & Lyons, 1993; Crozier & Kennedy, 1995). Many studies have shown deleterious effects on fishes from electroshocking (Sharber & Carothers, 1988; McMichael, 1993; Hollender & Carline, 1994; Dwyer & White, 1997). Few studies, however, have determined or assessed the impacts from electroshocking on stream macroinvertebrates.

Elliot & Bagenal (1972) showed an increase in invertebrate drift from electroshocking (and wading) a Lake District stream, England. Nearly all taxa found in the bottom samples were also found in the drift samples following electroshocking. The electroshocker was responsible for increase in drift of Plecoptera, Ephemeroptera and *Gammarus pulex*. Disturbance of the substrate from walking by the operators increased the drift of Trichoptera, Coleoptera, Diptera and *Polycelis felina* (Planaria). The drift nets used in the study by Elliott & Bagenal (1972) sampled only a portion of the water column. Bisson (1976) also showed an increase in total macroinvertebrate drift during electroshocking (without wading); nearly all taxa exhibited elevated drift rates. However benthic macroinvertebrate biomass was not significantly depressed immediately after electroshocking. Bisson's (1976) study did not examine the effects of substrate disturbance on invertebrate drift.

The studies by Elliott & Bagenal (1972) and Bisson (1976) showed conclusively that electroshocking activities have an impact on aquatic macroinvertebrates. However, it is not clear how much of the effect of electroshocking activity is a result of the electrical shock itself and how much a result of the human disturbance (walking in the streams) that commonly accompanies electroshocking. More information is also needed on the distance that macroinvertebrates drift after electroshocking. Our objectives were to: (1) differentiate the effects of electroshocking and substrate disturbance (walking) on macroinvertebrate drift and (2) determine how far macroinvertebrates drift downstream.

Study sites

The study was conducted in riffle habitats (classified according to Hankin & Reeves, 1988) of three different streams over the period August 1–4, 1995. Jackson Creek and Lonewoman Creek are located within the Upper South Umpqua River basin, southwestern Oregon, USA. Sun Creek is located in the Klamath River basin within Crater Lake National Park, southwestern Oregon, USA, 100 km southeast of the South Umpqua River basin. Elevation at the study sites ranged from 400 m at Jackson Creek to 1975 m at Sun Creek. Physical and water quality characteristics of the three streams are described in Table 1.

Jackson Creek and Lonewoman Creek contained both resident and anadromous fish species in the families Salmonidae, Cyprinidae and Cottidae. The study section within Upper Sun Creek contained no known fish as a result of an impassable fish barrier and previous fish eradication to remove non-native fish (M. Buktenica, Biologist Crater Lake National Park, personal communication).

Methods

Macroinvertebrates were sampled with 500 μm mesh drift nets with an opening of 0.093 m^2. Nets were attached to two metal rebar stakes hammered into the streambed and permanently fixed at that location for the entire study. In Sun and Lonewoman Creeks, three drift nets were evenly spaced across the channel (Figure 1). In Jackson Creek, five drift nets were evenly spaced across the channel. Each drift net sampled the entire water column at the location of the net. The proportion of the stream width at the location of the drift nets that was sampled is reported in Table 1.

Three treatments were established in Sun Creek: (1) electroshocking and walking on the substrate, (2) walking-only and (3) electroshocking-only. The walking-only treatment was conducted in the same manner as the electroshocking and walking treatment but the electroshocker was turned off. The electroshocking-only treatment was conducted by standing on the streambank and electroshocking each transect with as little contact of the electroshocking probe with the substrate as possible. In Lonewoman and Jackson Creeks, only the electroshocking and walking and

Table 1. Characteristics of the three stream sections during the study period

Characteristic	Stream		
	Sun	Lonewoman	Jackson
Stream order	1	3	5
Mean width (m)[a]	2.67	5.85	13.24
Mean depth (m)[a]	0.19 (0.02)	0.23 (0.03)	0.26 (0.02)
Discharge (m^3/s)[b]	0138	0.156	0.4
Gradient (%)	5.5	4.1	2
Conductivity (μS)[c]	10	75	100
Temperature (°C)[c]	8	14	20
Mean substrate size (mm)[d]	60.6 (7.2)	235.3 (24.6)	172.6 (12.8)
Mean stream velocity at nets (m/s)	0.65 (0.09)	0.20 (0.14)	0.61 (0.16)
Proportion stream width sampled	0.34	0.14	0.15

Values in parentheses are standard errors.
[a]Width and depth measurements were taken at five locations evenly spaced across each transect and at the location of the block nets.
[b]Discharge was measured with a Price type 'mini' current meter.
[c]Temperature and conductivity were taken between 1300 and 1500 h.
[d]Substrate size was determined by Wolman (1954) pebble counts taken perpendicular to the stream channel.

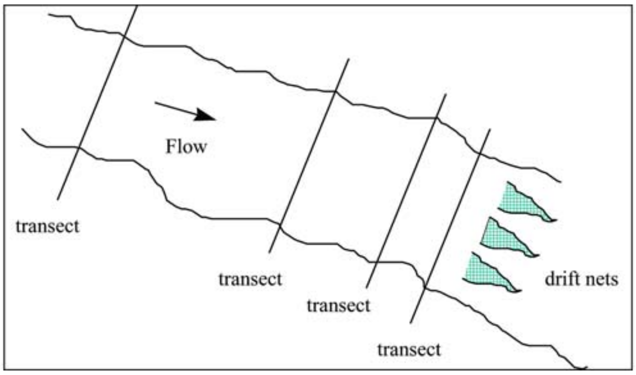

Figure 1. Diagram of the treatment transect distances and the location of the drift nets used in each of the three streams.

walking-only treatments were applied because the streams were too wide to apply the electroshocking-only treatment while standing on the streambank.

Four transects perpendicular to the stream channel at 2.5, 5, 10 and 20 m upstream of the drift nets were used for the treatments on Sun Creek and Lonewoman Creek (Fig. 1). Transect distances upstream of the drift nets in Jackson Creek were 2.5, 10, 20 and 30 m. These transect distances were chosen in hopes of being able to detect the expected exponential decline in the number of invertebrates drifting downstream. For each stream, the treatment and transect orders were randomly selected in a randomized block experimental design. Transects were designated as blocks. This approach was used to account for potential differences in invertebrate density among transects and to provide a more sensitive test for treatment effects (Zar, 1984). Treatment time depended on the channel width with approximately the same treatment effort/m applied to all three streams. Sun Creek, the smallest of the three streams, had a 45 s treatment time (11 s per pass). Lonewoman Creek had a 1-min treatment time (15 s per pass). Jackson Creek had a 3-min treatment time (45 s per pass). In all of the streams, nets were checked 7 min after the end of treatment application. The total time (treatment time and checking the nets) before beginning the next treatment was 15 min for Sun and Lonewoman Creeks and 20 min for Jackson Creek. These amounts of time allowed processing, preserving and labeling the specimens collected in the drift nets before starting the next treatment.

In each of the streams, prior to the start of the experiment and immediately following application of all treatments, the drift nets were placed in the channel for the same amount of time as used for the treatments (i.e. 15 min in Sun and Lonewoman creeks; 20 min in Jackson Creek). These pre- and post-treatment controls provided information on the number of invertebrates drifting naturally in the stream before and after application of the electroshocking and walking treatments.

Two people participated in the application of all treatments. One person carried a gasoline-powered Smith-Root 15A backpack electroshocker and the other person walked close to the electroshocker. For each transect, the two people crossed the channel four times (passes) in applying each treatment. Both people wore hip waders without additional footing devices (e.g. studded or felt soles). The electroshocker setting used was 90Hz at 900 V except in Sun Creek where the voltage was increased to 1200 V because of low conductivity of the water (10 μS).

For all treatments, nets were pulled at the same time and contents from each drift net were put into whirl paks, labeled and preserved with isopropyl alcohol. All nets were cleaned between treatments and all were placed back into the stream at the same time. After all of the treatments had been applied, three Surber bottom samples (500 μm mesh) were collected upstream of the study site to compare with taxa collected in the treatments.

For each drift net sample all insects were enumerated, identified to the family level (Merritt & Cummins, 1984), and measured for length under the microscope. After all specimens had been identified the entire drift net sample was weighed (wet weight) to the nearest 0.001 g.

The total number of macroinvertebrates collected for each treatment and transect in each stream was analyzed using a χ^2 test of independence. To determine if a difference existed among transects for each treatment, the total number of macroinvertebrates observed at each transect was compared to the expected number at each transect (25% of the total at each of the four transects). A χ^2 test of independence was also used to determine if differences existed in the length of macroinvertebrates collected among transects. Differences in mean weight of macroinvertebrates among transects and treatments were tested for significance using an analysis of variance (ANOVA) for a randomized block design (Zar, 1984). Total weight for each transect and treatment was not used because individual macroinvertebrate weights were not recorded, only the weight of the entire sample for each drift net. All tests were conducted at the 0.05 level of significance.

Results

All macroinvertebrate taxa collected in the Surber bottom samples were also collected in the treatment samples. In all of the streams, fewer taxa were collected in the Surber samples than in the treatment samples. The number of Surber samples taken from each stream (3) was insufficient to provide an accurate assessment of the taxa not affected by the treatments.

Sun Creek

The number of macroinvertebrates collected in the drift nets differed significantly among treatments and transect distances (Fig. 2; $p < 0.05$). The

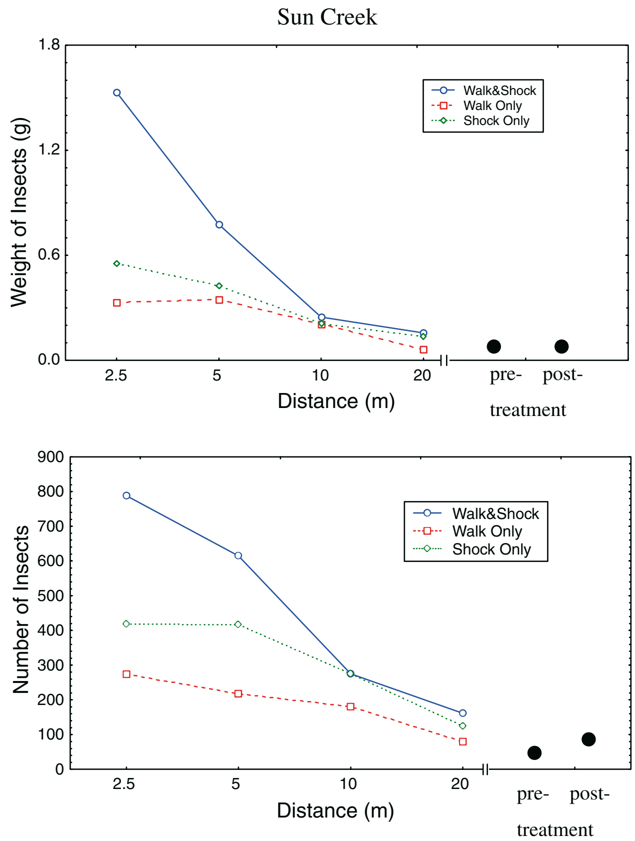

Figure 2. The number and weight of macroinvertebrates collected in each of the three treatments in Sun Creek.

electroshocking and walking and electroshocking-only treatments resulted in significantly more macroinvertebrate drift than the walking-only treatment ($p > 0.05$); the electroshocking and walking and electroshocking-only treatments were not significantly different, however ($p < 0.05$). Significantly more macroinvertebrates were collected from the 2.5 and 5 m transects than the 10 and 20 m transects. The total number of macroinvertebrates collected in the pre- and post-treatment controls were 38 and 92, respectively.

Nemourids (Plecoptera) and chironomids (Diptera) generally constituted the highest proportions of macroinvertebrates collected at all four transect distances (Table 2). Baetidae, Heptageniidae and Nemouridae constituted 46–66% of the total number collected at 2.5 and 5 m. At 20 m, Chironomidae constituted the highest proportion (27–55%) of macroinvertebrates collected in each of the three treatments.

No significant differences ($p > 0.05$) occurred in the mean weight of macroinvertebrates among treatments and transects (Fig. 2). At the 10 and 20 m transects, the mean weight of macroinvertebrates in all three treatments were similar (Fig. 2). At 2.5 m, the mean weight per organism was 0.0060 g. In contrast, the mean weight of macroinvertebrates collected in the pre- and post-treatment controls were 0.045 and 0.085 g, respectively.

Significant differences ($p < 0.01$) existed in the length of macroinvertebrates collected among transects. The longest macroinvertebrates (up to 39 mm) were collected from the 2.5 m transect closest to the drift nets. The range of macroinvertebrate lengths for all treatments was similar at the 10 and 20 m transects (1–20 mm).

Lonewoman Creek

Significantly more macroinvertebrates were collected in the electroshocking and walking treatment than in the walking-only treatment (Fig. 3; $p < 0.05$). For the electroshocking and walking treatment, significantly ($p < 0.001$) more macroinvertebrates were collected from the 2.5 m transect than the other three transects. The numbers of macroinvertebrates collected were similar at all transects for the walking-only treatment ($p > 0.05$). For the electroshocking and walking treatment, the numbers of macroinvertebrates collected were similar at the 5, 10, and 20 m transects. The total numbers of macroinvertebrates collected in the pre- and post-treatment controls were 3 and 7, respectively.

Baetidae were found in high proportions in all treatments and transects (Table 3). Other mayflies such as Ephemerellidae and Heptagenidae were found in relatively high proportions compared to other taxa at 2.5 and 5 m. At the 20 m transect, the greatest proportion of macroinvertebrates collected were Baetidae and Chironomidae (Table 3).

No significant differences occurred in the mean weight of macroinvertebrates among treatments and transects (Fig. 3; $p > 0.05$). For the walking-only treatment, the mean weight of macroinvertebrates collected was nearly identical at all transects. For the electroshocking and walking treatment, weight decreased from 0.19 g at 2.5 m to 0.04 g at 5 m. At 2.5 m, the weight per organism was 0.002 g. The mean weights of macroinvertebrates collected in the pre- and post-treatment controls were the same (0.001 g).

The length of macroinvertebrates collected among transects was not significantly different ($p > 0.05$). The range of macroinvertebrate lengths was greatest for the electroshocking and walking treatment at the 2.5 m transect (range 1–35 mm). The range of macroinvertebrate lengths for the other transects was much less (range 1–15 mm) and nearly identical between treatments.

Jackson Creek

Significantly more macroinvertebrates were collected in the electroshocking and walking treatment than in the walking-only treatment (Fig. 4; $p < 0.05$). The number of macroinvertebrates collected from the 2.5 and 5 m transects were significantly higher than the two more distant transects for both treatments ($p < 0.025$). The total number of macroinvertebrates collected in the pre- and post-treatment controls were 13 and 16, respectively.

Baetidae and Heptagenidae were found in relatively high proportions compared to other taxa in both treatments and at all four transects (Table 4). At 30 m, many of the macroinvertebrates collected

Table 2. Relative proportions of the total abundance of macroinvertebrates collected in each treatment for Sun Creek

Taxa	Control		2.5 m			5 m			10 m			20 m		
	Pre	Post	S&W	W	S	S&W	W	S	S&W	W	S	S&W	W	S
Ephemeroptera														
Ephemerellidae	0.11	0.01	0.08	0.03	0.05	0.05	0.12	0.03	0.04	0.02	0.01	0.03	0.04	0.08
Baetidae	0.11	0.05	0.23	0.17	0.14	0.16	0.21	0.07	0.04	0.10	0.04	0.03	0.09	0.07
Siphlonuridae		0.01		0.01	0.00	0.05	0.01	0.01	0.04	0.01				0.02
Heptageniidae	0.03	0.07	0.15	0.10	0.14	0.14	0.07	0.13	0.25	0.17	0.39	0.06	0.03	0.11
Leptophlebiidae	0.03	0.02	0.05	0.03	0.07	0.04	0.06	0.03	0.04	0.08	0.04	0.05	0.01	0.02
Plecoptera		0.01											0.01	0.01
Peltoperlidae	0.05	0.03	0.13	0.09	0.05	0.05	0.06	0.02	0.05	0.09	0.05	0.02	0.03	0.05
Nemouridae	0.16	0.26	0.21	0.19	0.32	0.35	0.25	0.44	0.23	0.17	0.32	0.14	0.07	0.20
Chloroperlidae		0.02	0.02	0.01	0.03	0.01	0.01	0.03	0.01	0.03	0.01	0.01	0.03	0.01
Perlodidae			0.03	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.00			
Trichoptera													0.01	
Rhyacophilidae	0.03	0.01	0.02	0.03	0.00	0.01	0.03	0.01	0.02	0.05	0.00	0.05		0.02
Limnephilidae	0.00	0.01	0.00	0.00	0.01	0.01	0.02	0.01	0.01	0.01	0.00	0.02	0.03	0.01
Hydropsychidae	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01		0.01
Uenoidae	0.05	0.04	0.00	0.09	0.02	0.00	0.00	0.01	0.01	0.02	0.00	0.03		0.03
Diptera	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.01	0.01
Chironomidae	0.39	0.35	0.07	0.19	0.13	0.08	0.11	0.19	0.19	0.23	0.11	0.45	0.55	0.27
Simulidae	0.03	0.04	0.00	0.01	0.01	0.00	0.01	0.00	0.03	0.02	0.01	0.02	0.07	0.04
Terrestrial		0.05		0.01	0.00	0.00	0.00	0.01	0.01			0.03	0.01	
Other				0.01	0.00	0.01	0.01	0.00	0.02	0.01		0.01	0.01	0.05
Total Number	38	92	767	272	423	614	217	416	284	181	275	158	75	122

(S&W = electroshocking and walking; W = walking-only; S = electroshocking-only).

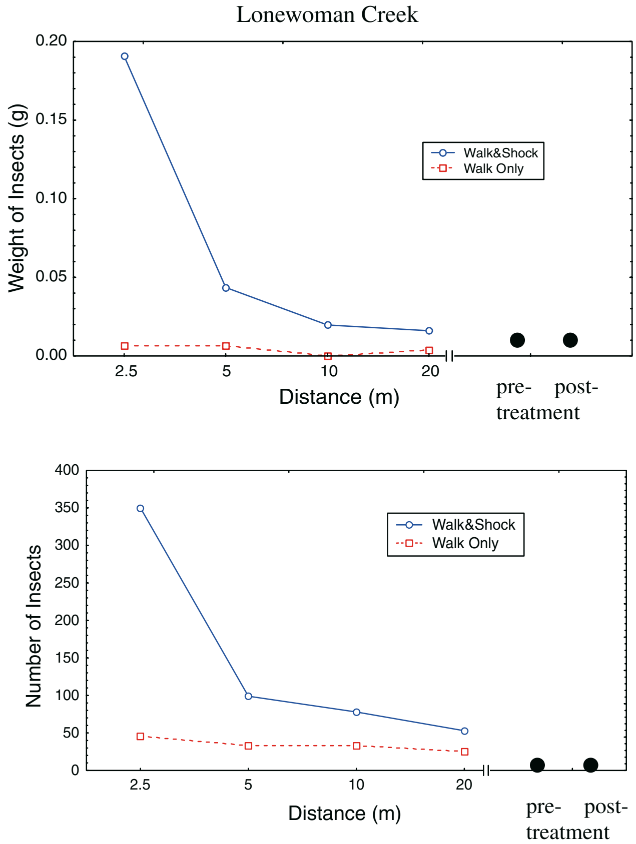

Figure 3. The number and weight of macroinvertebrates collected in each treatment in Lonewoman Creek.

were mites (acaria) and psephenids (Coleoptera) larvae (classified as 'other' in Table 4).

The mean weight of macroinvertebrates among treatments and transects was not significantly different for Jackson Creek ($p > 0.05$; Fig. 4). For the walking-only treatment, the weights at each transect were similar. For the electroshocking and walking treatment a steady decline in weight was observed from 2.5 to 30 m. At 2.5 m the weight per organism was 0.002 g. In contrast, the mean weights of macroinvertebrates collected in the pre- and post-treatment controls were greater (0.008 and 0.017 g, respectively).

The length of macroinvertebrates collected among transects was not significantly different (Fig. 4; $p > 0.05$). The range of macroinvertebrate lengths was greatest for the electroshocking and walking treatment at the 2.5 and 10 m transects (1–39 mm). The range of macroinvertebrate lengths were similar in each treatment for all of the other transects (1–15 mm).

Discussion

Electroshocking and walking on the substrate stimulated increased drift of macroinvertebrates in all of the streams. Increased drift of invertebrates from electroshocking and walking on the substrate was also found by Elliott & Bagenal (1972). Bisson (1976) showed a tenfold increase in macroinvertebrate drift with nearly all macroinvertebrate taxa experiencing elevated drift rates. Elliott (1971) showed that macroinvertebrate drift induced from electroshocking caused a 5% reduction in the total benthos in the sampling area immediately afterwards. Taylor et al. (2001) found electroshocking to be an effective technique for obtaining large numbers of invertebrates quickly. Electroshocking

Table 3. Relative proportions of the total abundance of macroinvertebrates collected in each treatment for Lonewoman Creek

Taxa	Control		2.5 m		5 m		10 m		20 m	
	Pre	Post	S&W	W	S&W	W	S&W	W	S&W	W
Ephemeroptera									0.02	
Ephemerellidae	0.33		0.02	0.07	0.04	0.08	0.21		0.06	
Baetidae	0.66	0.50	0.62	0.33	0.50	0.45	0.30	0.41	0.31	0.20
Siphlonuridae			0.02		0.06	0.03	0.05		0.13	
Heptageniidae			0.11	0.11	0.16		0.08	0.04	0.06	0.08
Leptophlebiidae				0.04	0.02		0.01			
Plecoptera			0.02		0.01		0.01	0.04	0.04	
Peltoperlidae			0.01	0.02	0.01			0.07	0.02	
Nemouridae			0.09	0.09	0.05	0.05	0.06	0.04	0.08	0.12
Chloroperlidae			0.02	0.02	0.01	0.05	0.03			
Perlodidae			0.00	0.02	0.03		0.05			
Pteronarcyidae			0.00							
Trichoptera		0.25	0.01	0.02	0.03	0.05	0.04		0.04	0.16
Rhyacophilidae			0.02	0.02	0.01	0.05	0.01	0.11	0.04	0.08
Limnephilidae			0.00	0.02	0.02					0.04
Hydropsychidae			0.01	0.04	0.01		0.01		0.04	
Diptera			0.01	0.02		0.05	0.01		0.02	
Chironomidae			0.02	0.04	0.02	0.10	0.08	0.11	0.10	0.16
Simulidae			0.01	0.02			0.01	0.11	0.04	0.04
Coleoptera										
Adult			0.00		0.01	0.03	0.01			
Elmidae		0.25	0.01	0.02		0.08	0.01	0.00	0.02	0.04
Other				0.07				0.07		0.08
Total number	3	7	351	46	96	40	77	27	52	25

(S&W = electroshocking and walking; W = walking-only).

provided estimates of invertebrate population size and diversity comparable to more traditional sampling techniques such as Surber sampling and Hess sampling.

In our study, differences in drift among the treatments were small at 20 m in all of the streams. In Lonewoman Creek, the number and weight of macroinvertebrates declined more than threefold from 2.5 to 5 m. This appreciable decline may have been due to the relatively large substrate size and aquatic vegetation which enhanced reattachment. In Jackson Creek, absence of a decline in numbers from 2.5 to 10 m was probably a result of the relatively high current velocity and discharge of this stream compared to the other streams which carried macroinvertebrates further downstream (Table 1).

The effects of electroshocking on macroinvertebrate drift apparently varied depending upon macroinvertebrate size and morphology. Electroshocking and walking on the substrate resulted in only a short drift distance of large macroinvertebrate taxa such as Pteronarcyidae (Plecoptera). They were collected only from the 2.5 m transect and generally only for the electroshocking and walking treatment. They were evidently able to settle back to substrate quickly. Smaller, lighter weight macroinvertebrates such as Chironomidae exhibited longer drift distances and constituted the majority of macroinvertebrates collected at

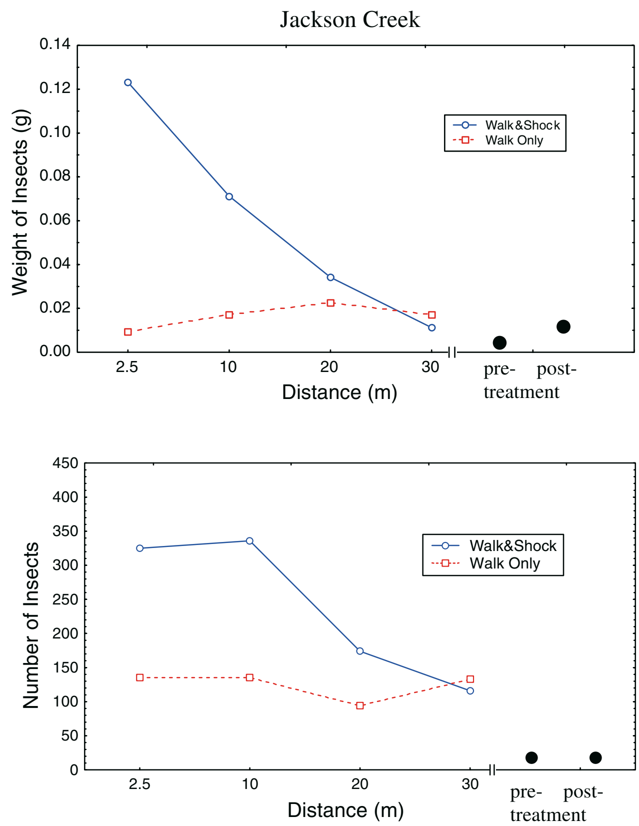

Figure 4. The number and weight of macroinvertebrates collected in each treatment in Jackson Creek.

the farthest treatment transects. Elliott (1971) and Elliott & Bagenal (1972) also reported the differential ability of macroinvertebrate taxa to return back to the stream bottom. Elliott (1971) stated that the chironomids were small, poor swimmers and incapable of rapid reattachment when they came into contact with a stone or plant, whereas larger, swimming insects did not drift as far because of rapid reattachment back to the substrate.

Several factors may explain why the body lengths of macroinvertebrates collected among transect distances differed significantly only for Sun Creek. The section of Sun Creek sampled was a high elevation, cold, headwater habitat where the macroinvertebrate community was later developing than the other two streams. Many of the taxa had not hatched from the stream as evidenced by the large, well-developed wing pads on the nymphs. In Lonewoman Creek and Jackson Creek, water temperature was warmer (Table 1) and the majority of insects had already hatched as evidenced by small nymphs with undeveloped wing pads and abundant exuviae collected in all of the samples. The remaining macroinvertebrate community in both of these streams were in an earlier instar stage than macroinvertebrates in Sun Creek (Merritt & Cummins, 1984). As there was little difference among treatments and transects, especially for the walking-only treatment, perhaps the smaller insects were not capable of returning to the stream bottom over any of the transect distances used in this study, resulting in approximately the same number caught from all transects.

In streams where electroshocking is used for fish sampling (Crozier & Kennedy, 1995) on a broad scale (i.e. electroshocking stream reaches) or used to estimate invertebrate density and diversity (Taylor et al., 2001), these findings suggest that disturbance to the macroinvertebrate community is minimal and short-lived with no treatment differences detected 20 m downstream, especially if

Table 4. Relative proportions of the total abundance of macroinvertebrates collected in each treatment for Jackson Creek

Taxa	Control		2.5 m		10 m		20 m		30 m	
	Pre	Post	S&W	W	S&W	W	S&W	W	S&W	W
Ephemeroptera										
Ephemerellidae	0.08		0.03	0.26	0.06	0.04	0.05	0.03	0.06	0.03
Baetidae	0.15	0.25	0.39	0.11	0.29	0.31	0.25	0.27	0.14	0.19
Siphlonuridae			0.00	0.05	0.02	0.01	0.03	0.02	0.01	
Heptageniidae	0.15	0.13	0.30	0.12	0.27	0.15	0.24	0.05	0.26	0.13
Leptophlebiidae	0.08		0.02	0.01	0.00	0.02	0.04			
Plecoptera										
Peltoperlidae									0.01	
Nemouridae		0.06	0.03	0.01	0.03	0.01	0.07		0.06	0.06
Chloroperlidae			0.00	0.02	0.01		0.01			
Perlodidae			0.00		0.02		0.03		0.01	0.01
Pteronarcyidae			0.01		0.00					
Trichoptera			0.01	0.01	0.01	0.01	0.01			0.01
Rhyacophilidae	0.08	0.13	0.02		0.01	0.02	0.01		0.01	
Limnephilidae			0.01	0.01	0.00		0.02	0.03	0.03	0.02
Hydropsychidae			0.01	0.02	0.03	0.03	0.02	0.04	0.04	0.07
Diptera			0.01	0.05	0.00	0.06	0.02	0.06	0.03	0.06
Chironomidae	0.15	0.13	0.05	0.04	0.01	0.06	0.04	0.03	0.05	0.07
Simulidae	0.08	0.06	0.05	0.07	0.03	0.12	0.02	0.07	0.06	0.05
Coleoptera										
Adult		0.13	0.04	0.04	0.09	0.04	0.05	0.16	0.04	0.03
Elmidae		0.13	0.01	0.06	0.03	0.05	0.02	0.12	0.06	0.11
Terrestrial	0.23		0.00	0.01	0.02		0.01	0.05	0.02	
Other			0.02	0.12	0.09	0.09	0.09	0.05	0.14	0.15
Total number	13	16	322	137	336	127	174	95	109	131

(S&W = electroshocking and walking; W = walking-only).

conducted later in the season when most of the macroinvertebrates have hatched. However, the mortality rates of invertebrates exposed to electroshocking remains to be evaluated.

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