Effects of Eroding Glacial Silt on the Benthic Insects of Silver Creek, Portage County, Ohio[1]

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ABSTRACT. **Between March and November 1984, Silver Creek, a small tributary of the Mahoning River in northeastern Ohio, eroded into and through a small lacustrine deposit of glacial silt. During this erosional/siltation episode, the stream was very turbid and siltation was observed at least 5 km below the source of silt. Only a few individuals of the caddisfly, *Neophylax,* the mayflies, *Isonychia* and *Stenonema,* and the snipe fly, *Atherix variegata,* were collected within the silted region. Siltation abated during the winter 1984-85; by late March 1985, substantial recolonization of the previously silted area was observed. The most abundant "pioneer" insects were chironomids, (*Larsia, Orthocladius, Microtendipes,* and *Stictochironomus*), black flies, (Simulidae), craneflies, (*Antocha*), horseflies, (Tabanidae), and caddisflies, (*Hydropsyche* and *Neophylax*). By late May 1985, recolonization of once silted areas was well advanced as indicated by a high degree of similarity in species composition and numbers of taxa between areas that were recently silted and never silted. Recolonization probably occurred mostly from downstream drift because species composition of undamaged upstream areas and of recolonized areas was very similar, and because recolonization occurred over winter when aerial/oviposition routes would have been minimal.**

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INTRODUCTION

Silt has variable effects on benthic insect communities (Hynes 1970). For a few species (e.g. certain chironomids) silt is a preferred habitat (Pinder 1986), but most investigators have shown that silt reduces the variety and abundance of aquatic insects (Chutter 1969, Nuttal and Bielby 1973, Minshall 1984). Silt changes the nature of coarse substrates by filling pore spaces, thereby reducing the number and variety of microhabitats available to aquatic insects. Silt also alters water currents over substrates and influences the availability of dissolved oxygen to benthic species. The quantity and quality of food available to benthic insects may be affected as siltation causes changes in macrophyte and periphyton communities. Silt clogs collecting mechanisms of filter-feeding insects (Lemly 1982), and renders substrates unsuitable for insects that rely on tarsal claws, anal hooks, and "suction-cup" bodies for maintaining their position in flowing water.

Silver Creek, a small headwater tributary of the Mahoning River in northeastern Ohio, occasionally erodes into lacustrine silts deposited during Wisconsinan glaciation. When this erosion occurs, the stream becomes milky in appearance, very turbid, and deposits of silt cover the river substrates for several kilometers downstream. After eroding through the glacial silts, Silver Creek becomes clear and the deposits of silt slowly wash away. The frequency of these erosional episodes never has been documented, but observations by long-time residents of the area indicate that these siltation episodes are not unusual events.

From March to October, 1984, an erosional/siltation episode occurred in Silver Creek. A qualitative examination of stream substrates during this episode revealed very few benthic insects 2.5 km below the source of glacial silts. Based on this observation, a semi-quantitative sampling program for benthic insects was initiated to determine the nature and severity of the impact of siltation on benthic insect communities along the stream. Before the sampling program began, most of the erosion stopped and the benthic insect communities started to recover. We report here the impact of silta-

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tion on benthic insect communities and the time required for recovery from the siltation episode.

STUDY AREA

Silver Creek originates at an elevation of approximately 337 m near the continental watershed divide separating the St. Lawrence and Ohio River systems. Silver Creek is only 8.2 km in length and empties into Eagle Creek at an elevation of 317 m. The watershed is 28.5 km^2 in area.

Land use in Silver Creek watershed is about 40% agricultural pastures and 50% second growth deciduous forest and old field vegetation. The small village of Hiram (population < 1000) occupies 1 km^2 in the west central part of the watershed. Treated sewage effluent from Hiram enters Silver Creek near the confluence with Eagle Creek, but was not a factor during the course of this investigation.

The source of eroding silt was located about 2.5 km northeast of Hiram, Ohio, near Norton Road (Fig. 1). Sample sites 1 and 2 were located 200 m upstream from the eroding silt. In this area, the stream during normal flow ranged from 1.5-3.0 m in width and had a maximum depth of less than 1 m. Riffle and pool habitats each consisted of a mixture of cobbles, gravel, and sand. Aquatic mosses and filamentous algae (mostly *Cladophora*) grew on the cobbles in the riffle.

Sample sites 3-6 were located about 4 km downstream from the source of eroding silt. During normal flows, the stream in this region ranged in width from 2 to 5 m and had a maximum depth of 1 m. Riffle and pool habitats consisting of cobbles, gravel, and sand were similar to the unsilted upstream habitats. During siltation episodes, a thin layer (several mm) of silt covered the natural substrates. Aquatic mosses and *Cladophora* grew on the cobbles in the riffle, but were mostly destroyed during the siltation episode.

MATERIALS AND METHODS

On 8 October 1984, benthic insects were collected from the silted area by brushing and agitating sediments so that dislodged insects drifted into a No. 30 soil sieve. Two persons worked independently in this fashion for 30 min. A similar method was used later on the same date to collect insects from an unsilted upstream region.

To compare benthic insect communities from silted and unsilted habitats, semi-quantitative samples were taken on 20 March, 1985 from sites 2 and 5. On 30-31 May, 1985, semi-quantitative samples were taken from sites 1 and 2 in the unsilted region and sites 3 through 6 in the silted region (Fig. 1). Four samples of approximately 0.05 m^2 each were taken with a modified shovel sampler (Prater et al. 1977) at each station on 20 March, 1985. Six samples were collected from each station on 30-31 May, 1985. Because substrate type strongly influences the species composition of benthic insect communities (Minshall 1984), similar substrates from a pool and a riffle at each station were sampled. A preliminary study indicated that up to 20 samples per station were necessary for a more precise quantitative study (Elliott 1977), but the labor required for such an effort was not practicable. For purposes of this analysis, biological data from sites 2 (unsilted) and 5 (silted) only will be compared. These sites will be referred to as stations A and B, respectively, (Fig. 1) in the discussion to follow.

Insects were separated from the substrates by agitating the samples in a bucket of water and quickly pouring the supernatant through a soil sieve, (No. 30) to remove the insects. In the laboratory, insects were sorted into major groups and preserved in a solution of 80% ethanol and 5% glycerine. They were then identified to the lowest taxonomic level practicable and enumerated. Insect communities above and below the source of eroding silt were compared with Sørensen's Coefficient of Similarity: $(C_s) = 2c/a + b$, where a = number of species in community A, b = number of species in community B, and c = number of species common to both communities (Sørensen 1948).

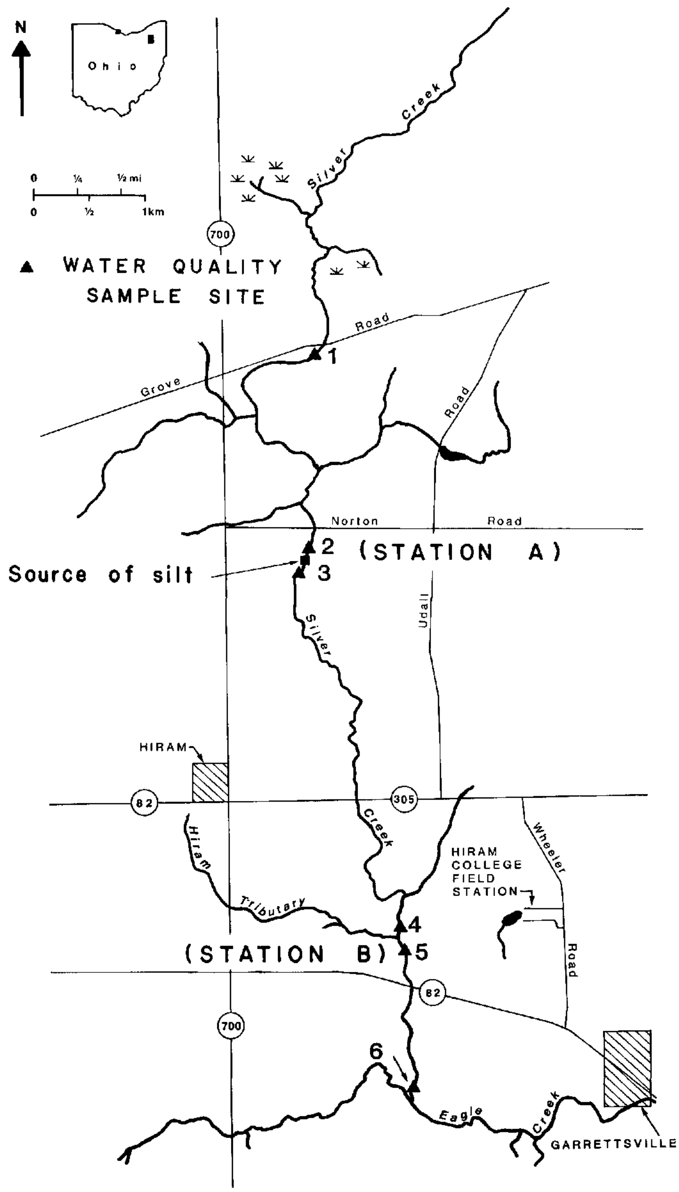

FIGURE 1. Map of Silver Creek, Portage County, Ohio showing location of sampling sites for benthic insects and point source of eroding glacial silt.

Water temperatures, conductivity, pH, total hardness, and dissolved oxygen were determined at all sampling locations on 30-31 May, 1985. Conductivity was measured downstream from the eroding source of silt on 8 and 13 October, 1984. All analyses were performed in accordance with *Standard Methods for the Examination of Water and Wastewater* (American Public Health Assn. 1980).

The composition of the eroding sediments was determined by thoroughly mixing 50 g of sediments in water and allowing the components to separate by differential sedimentation rates (Folk 1974). Three layers of sediments (clay, silt, and sand) were distinguished. These components were separated, dried, and weighed to determine the percentage composition of each component.

RESULTS AND DISCUSSION

The relatively few water quality data available indicated that Silver Creek, when not disturbed by eroding silt, was a moderately alkaline, hardwater stream with generally low turbidity (Table 1). Moderately low levels of dissolved oxygen (5.5-6.6 ppm) in late May indicated that dissolved oxygen may be an important limiting factor for aerobic aquatic life. Even lower concentrations would be expected with warmer water

TABLE 1
Water quality data for Silver Creek, Portage County, Ohio.
Unless otherwise indicated, values are for 30 May 1985.

Station No.	Conductivity (μmhos/cm)		pH (units)	Total hardness (mg/L as $CaCO_3$)	Dissolved Oxygen (mg/L)	Water Temperature (°C)
1		230	7.7	93	5.5	15.0
2		220	7.4	129	5.9	14.0
3	3000*	260	7.5	130	5.9	14.8
4	2300**	340	7.6	160	6.6	12.5
5		360	7.5	157	6.4	11.7
6		380	7.7	164	6.5	16.3

*13 October 1984
**8 October 1984

temperatures in late summer. During an erosional episode between March and November 1984, the stream was very turbid and milky-colored for at least 5 km below the deposit of eroding silt. Conductivity values up to 3000 μmhos per cm in the silted region indicated relatively high levels of dissolved solids. Conductivity values in the unsilted region and after siltation episodes did not exceed 380 μmhos per cm, values comparable to most nearby streams in northeastern Ohio under normal conditions. Freshly deposited sediments from the silted area consisted of 73% silt, 24.5% clay, and 2.5% sand.

Benthic insect communities downstream from the eroding silt were affected substantially by suspensions or deposits of silt. The number of species and individuals per species were greatly reduced within the area of siltation compared to nearby unsilted areas. A qualitative survey of Silver Creek, approximately 4 km below the source of eroding silt, revealed only 4 taxa of benthic insects on 8 October 1984: the trichopteran, *Neophylax,* the ephemeropterans, *Isonychia* and *Stenonema,* and the dipteran, *Atherix variegata.* Few individuals of each species were present. Except for *A. variegata,* these insects do not have obvious adaptations to silted habitats, suggesting that the few specimens collected probably were remnants of populations existing before the siltation episode. These changes in benthic community composition were similar to changes caused by inorganic sedimentation resulting from human activities such as improper logging, highway construction, surface mining, and agricultural practices (e.g. Cordone and Kelley 1961, Tebo 1955, Gammon 1970, Lemly 1982).

Above the source of eroding silt an estimated 40 to 50 taxa, including mostly chironomids, mayflies, stoneflies, and caddisflies, were present. This assemblage of insects was typical of most relatively undisturbed headwater streams in Ohio (Olive and Smith 1975, Robertson 1984). Siltation abated during the winter of 1984-1985. Turbidity declined and conductivity decreased to approximately 200-400 μmhos per cm in all areas of Silver Creek (Table 1). By 20 March 1985, the benthic insect community 4 km below the source of eroding silt (Station B) was recovering, with 23 taxa of benthic insects present (Table 2). Just upstream from the eroding silt deposit (Station A), 44 taxa were collected. Similarity in species composition between the two communities, as expected, was relatively low as indicated by Sorensen's coefficient of community (Cs) value of 0.51 (SØrensen 1948). A Cs value of 1.0 is obtained for communities with identical species composition. Because of the complexity of natural communities, a comparison of two samples from the same community seldom yields a value greater than 0.85 (Cox 1985).

Twenty-seven taxa collected on 20 March at Station A were absent from Station B (Table 2). The most abundant of these taxa were the coleopteran, *Dubiraphia,* the chironomids, *Eukiefferiella* (3 species), *Nanocladius spiniplenus, Parametriocnemus, Dicrotendipes neomodestus,* and *Paratanytarsus,* the ephemeropteran, *Habrophlebiodes,* and the trichopteran, *Cernotina.* Except for the predator, *Cernotina,* these organisms are mostly collector-gatherers of filterers and scrapers (Merritt and Cummins 1984). Most prefer lotic-erosional habitats, clinging to cobbles or living in submerged mosses and filamentous algae. *Eukiefferiella discoloripes* probably feeds on *Cladophora* (Simpson and Bode 1980). *Dubiraphia* usually is associated with submerged macrophytes (White et al. 1984). *Parametriocnemus lundbeckii* generally is regarded as saprophobic and unable to tolerate high turbidities or low levels of dissolved oxygen (Beck 1977). According to Simpson and Bode (1980), *Parametriocnemus* is restricted to clean-water streams in New York state. *Eukiefferiella* and Nanocladius *spiniplenus* are found only in clean-water or moderately polluted areas. *Dicrotendipes neomodestus* is widespread in New York streams, abundant, and thrives in organically enriched waters.

These taxa either never were present below the source of eroding silt or they were forced out of the area during the siltation episode. Because of similarities in physical characteristics and water quality between Stations A and B, most taxa found above the silt deposit probably also could exist downstream in the absence of siltation.

On 20 March 1985, 9 taxa, including *Larsia, Orthocladius, Microtendipes, Stictochironomus,* Simulidae, Tabanidae, *Antocha, Hydropsyche,* and *Neophylax,* were abundant in the recently silted area (Table 2). These taxa, except for *Neophylax,* were not present during the siltation episode. All taxa except *Stictochironomus* were abundant in the unsilted area. These "pioneer" species

TABLE 2

Benthic insects collected at Stations A and B in Silver Creek, Portage County, Ohio, on 20 March 1985 and 30-31 May 1985
Values expressed as number of individuals in four samples of 0.05 m^2 each on 20 March 1985 and six samples on 30-31 May 1985.

Taxa	20 March 1985		30-31 May 1985	
	Sta. A	Sta. B	Sta. A	Sta. B
	Never silted	Recovery	Never silted	Recovery
Elmidae				
Dubiraphia	15		11	1
Stenelmis	11	4	7	28
Haliplidae				
Peltodytes			3	
Hydrophilidae				1
Diptera				
Chironomidae				
Tanypodinae				
Clinotanypus	1			
Larsia	3	5	9	4
Paramerina	2		1	
Pentaneura	1			
Procladius sublettei	3			
Thienemannimyia grp.	4	3	9	26
Orthocladinae				
Brillia	1			1
Cardiocladius obscurus		1		
Cricotopus bicinctus	2	1	2	
Diplocladius	3			
Eukiefferiella	12		3	1
Heterotrissocladius marcidus grp.	2			
Nanocladius spiniplenus	7			
Orthocladius	194	44	74	97
Parametriocnemus	24		64	40
Rheocricotopus				3
Symposiocladius	1			
Thienemanniella				1
Chironominae:				
Chironomini				
Chironomus riparius			56	8
Cryptochironomus fulvus	3		7	
Dicrotendipes neomodestus	11			
Dicrotendipes nervosus	1			
Glyptotendipes		1		
Harnischia			4	1
Microtendipes	17	26	18	12
Paratendipes				10
Polypedilum illinoense		1	2	23
Stictochironomus		7	41	28
Chironominae:				
Tanytarsini				
Cladotanytarsus	4		66	4
Paratanytarsus	14		3	5
Rheotanytarsus	7			
Stempellinella	2		2	
Tanytarsus	4		121	4
Prodiamesinae			2	
Athericidae				
Atherix variegata	2		2	5

TABLE 2 (continued)

Taxa	20 March 1985		30-31 May 1985	
	Sta. A	Sta. B	Sta. A	Sta. B
	Never silted	Recovery	Never silted	Recovery
Ceratopogonidae	3	1	6	3
Empididae	5	1	1	4
Simulidae	23	5	9	18
Tabanidae	20	6	16	
Tipulidae				
Antocha	70	77		1
Dicranota				2
Hexatoma	2		9	1
Limnophilia			1	
Pilaria				1
Ephemeroptera				
Baetidae				
Baetis	3		5	60
Caenidae				
Caenis	1	1	1	5
Ephemerellidae		1		
Heptageniidae				
Stenonema	1	1		4
Leptophlebiidae				
Habrophlebiodes	7			
Oligoneuriidae				
Isonychia				1
Megaloptera				
Nigronia				2
Sialis			1	
Plecoptera				
Chloroperlidae	1			
Capniidae				
Allocapnia				35
Paracapnia		1		
Nemouridae				
Amphinemura	1		10	11
Perlidae				
Attaneuria ruralis			3	19
Odonata				
Boyeria				1
Trichoptera				
Hydropsychidae				
Cheumatopsyche	64	4	24	16
Hydropsyche	182	71	33	11
Hydroptilidae				
Ochrotrichia			12	18
Leptoceridae				
Oecetis			2	
Limnephilidae				
Glyphopsyche			1	
Neophylax	35	10	3	
Pycnopsyche	2	2	6	3
Polycentropodidae				
Cernotina	18			
Brachycentridae				1

represented a variety of feeding groups. *Larsia* and Tabanidae are predators; most species of *Orthocladius, Microtendipes,* Simulidae, *Antocha,* and *Hydropyche* are collector-gatherers or filterers; *Stictochironomus* is a shredder; and *Neophylax* is a scraper (Merritt and Cummins 1984). These taxa were able to find refugia within the silted area, or they were able to quickly recolonize the previously silted region from unsilted areas. When siltation stopped, additional habitats were available for colonization. Rock surfaces freed of silt became suitable for scrapers and collectors. Improved water quality benefitted all species. Leaves and other plant material suitable for shredders probably always were present in the stream, but highly turbid water prevented these forms from feeding in the silted areas. Predators undoubtedly increased in number after prey species insects became established.

By the end of May, recovery of the benthic insect communities was well advanced. More taxa (N = 42) were found in the previously silted area than in the unsilted area (N = 40) (Table 2). Species composition was quite similar between stations as indicated by Cs values of 0.68, an indication of recovery in species composition at Station B. If siltation had no effect on species composition, then the similarity between Stations A and B for March would not have differed from the similarity between stations for May. Comparison of Cs values within stations between March and May also demonstrates the impact of siltation on species composition. At Station A, a Cs value of 0.67 between March and May indicated high similarity and relatively little change in species composition, as would be expected in an undisturbed stream. At Station B, however, a Cs value of 0.49 indicated low similarity and a relatively large change in species composition.

The most notable changes in species composition at Station B between March and May were the first-time collection of the chironomids, *Parametriocnemus, Chironomus,* and *Paratendipes,* the mayfly, *Baetis,* the stoneflies, *Allocapnia, Amphinemura, Attaneuria ruralis,* and the caddisfly, *Ochrotrichia* (Table 2). Except for *Chironomus,* these organisms usually are regarded as quite sensitive to most forms of pollution including turbidity, low dissolved oxygen, and silted substrates (Hynes 1960, Hawkes 1979). Their appearance at Station B in May indicated a substantial degree of recovery from the previous episode of siltation. Assuming siltation ended in late October or early November, 1984, then approximately seven months were required for recovery of Station B from the siltation episode.

Recolonization of artificially cleared stream beds can be quite rapid. Waters (1964) found that *Baetis vagans* returned in its former abundance to cleared areas within a few days, varying only slightly with the season. Rapid recolonization was attributed to drift from upstream populations. Williams and Hynes (1976) noted that sterile substrates placed in a stream were recolonized substantially within one month. Former species diversity and population densities may not be reestablished for longer periods of time, depending upon the severity and duration of stress and the proximity of undisturbed sources of recolonizing species (Cairns et al. 1971).

Recolonization of denuded substrates can occur from downstream drift or migration, upstream migration, aerial/oviposition routes, and vertical migration from deep sediments. Williams and Hynes (1976) found that drift accounted for 41.4% of the recolonizations of denuded substrates in a small stream in Canada and aerial/oviposition routes accounted for 28.2% of the recolonization. Remaining colonizers arrived from deep sediments and upstream migration.

In Silver Creek most recolonization of formerly silted areas probably occurred via downstream drift. The reasons for this are: (1) undamaged refugia occurred less than 1 km upstream; (2) species composition of undamaged areas and of recolonized areas was quite similar; (3) recolonization occurred during winter and early spring when aerial/oviposition routes would have been minimal; (4) deposition of silt probably rendered hyporheic habitats unsuitable as refugia; and (5) upstream migration is a slow process and probably could not have accounted for the relatively rapid recolonization observed in this study.

Natural erosion/siltation episodes such as the one observed in this study probably have occurred many times in streams occupying formerly glaciated areas of northeastern Ohio. Benthic insect communities in these streams, compared to streams in unglaciated regions, probably contain a larger proportion of species capable of surviving siltation episodes in nearby tributaries or upstream refugia. When siltation subsides, these species are well adapted for quickly recolonizing the formerly silted substrates.

The results of this study provide an optimistic view for the future of sediment-polluted streams in Ohio. The deposition of eroding soils and settleable solids from domestic wastes are major sources of pollution in Ohio waterways (Olive and Smith 1975, Olive 1976). If these sources are eliminated or substantially reduced, more diverse benthic insect communities and presumably other forms of aquatic life probably would become reestablished, perhaps within a few weeks or a few months depending upon the season.

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