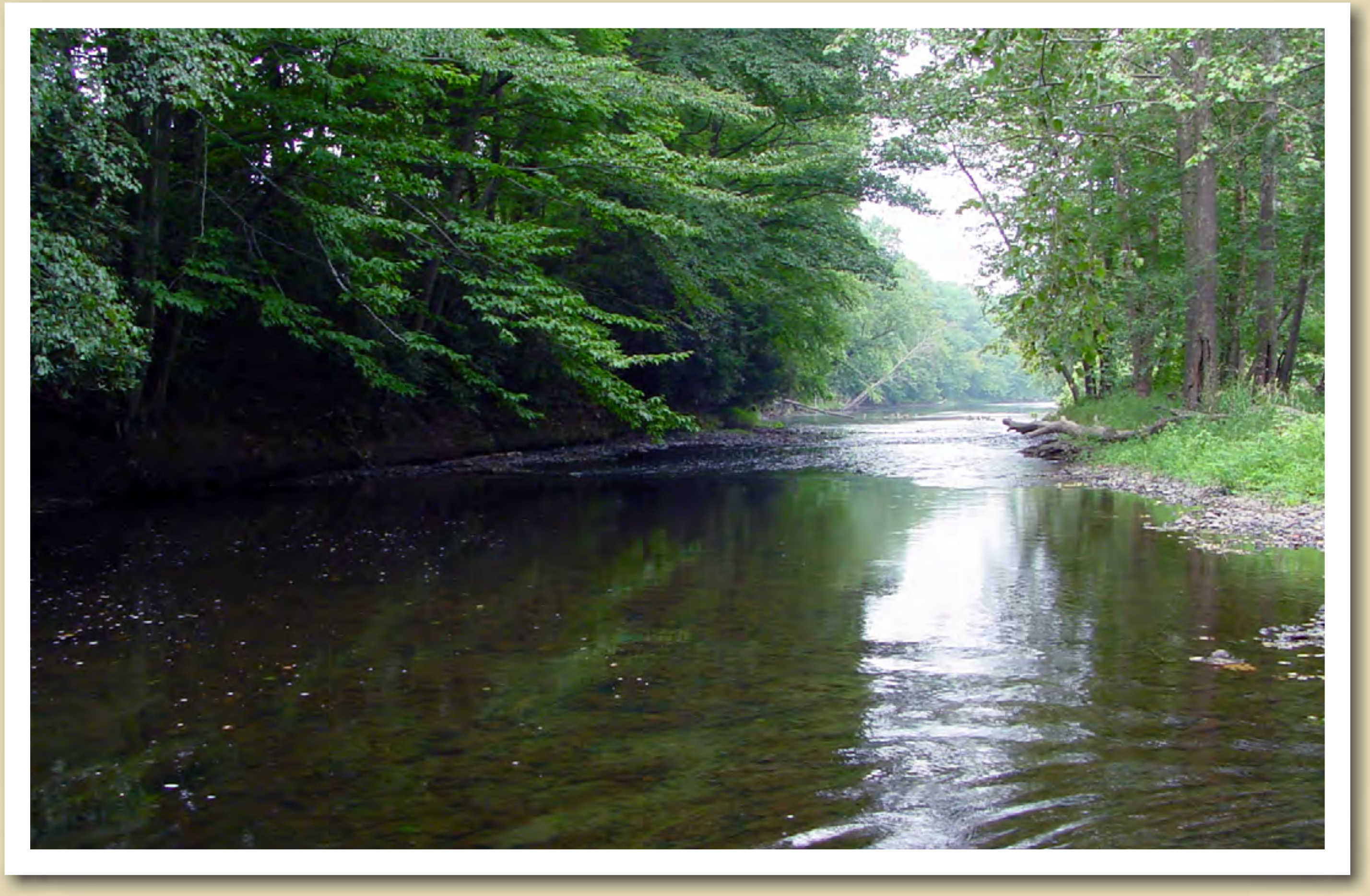
Prepared in cooperation with
The Nature Conservancy,
New York City Department of Environmental Protection,
and the Towns of Thompson and Mamakating

Effects of Habitat Characteristics and Water Quality on Macroinvertebrate Communities along the Neversink River in Southeastern New York, 1991–2001



Scientific Investigation Report 2008–5024

U.S. Department of the Interior
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Cover. Photo of Neversink River near Godeffroy.

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Conversion Factors, Datum, and Acronyms

Multiply	By	To obtain
	Length	
kilometer (km)	0.6214	mile (mi)
	Area	
square kilometer (km^2)	247.1	acre
square kilometer (km^2)	0.3861	square mile (mi^2)
	Volume	
liter (L)	0.2642	gallon (gal)
cubic meter (m^3)	264.2	gallon (gal)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F = (1.8 \times °C) + 32$$

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$°C = (°F - 32)/1.8$$

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

ACRONYMS USED IN REPORT

ANC	Acid-neutralizing capacity
DOC	Dissolved organic carbon
EPT	Ephemeroptera, Plecoptera, Trichoptera
HBI	Hilsenhoff's biotic index
TNC	The Nature Conservancy
USGS	U.S. Geological Survey

Effects of Habitat Characteristics and Water Quality on Macroinvertebrate Communities along the Neversink River in Southeastern New York, 1991–2001

By Anne G. Ernst, Barry P. Baldigo, George E. Schuler[1], Colin D. Apse[2], James L. Carter, and Gary T. Lester[3]

Abstract

The Neversink River, in the Catskill Mountains of southeastern New York State, feeds the Neversink Reservoir, which diverts 85 percent of the river's flow to New York City. Acidification of several headwater reaches has affected macroinvertebrate assemblages throughout the river system above the reservoir, and the alteration of flow conditions below the reservoir dam has affected macroinvertebrate assemblages for at least 10 kilometers downstream from the reservoir. In 1999, the U.S. Geological Survey, in cooperation with The Nature Conservancy, compiled data from 30 stream reaches to quantify the effects of acidification and of the reservoir on the structure and function of macroinvertebrate assemblages throughout the Neversink River.

Acidic headwater reaches supported greater numbers of acid-tolerant chironomid taxa and fewer numbers of acid-sensitive Ephemeroptera and Trichoptera than neutral reaches, and fewer scraper individuals and more shredder individuals. The 14 reaches below the reservoir, with sharply decreased flows and altered flow patterns compared to reaches above the reservoir, supported more Chironomidae and fewer Ephemeroptera and Trichoptera than the upper reaches; they also had greater numbers of shredder individuals and fewer scraper and filterer individuals than reaches above the reservoir. Water-quality variables such as pH and aluminum concentration appear to have affected macroinvertebrate assemblages more strongly in the headwaters than below the reservoir, whereas physical-habitat variables such as mean channel width and water temperature have affected these assemblages more strongly downstream from the reservoir than in the headwaters. The water-quality changes due to acidification, combined with the decreased flows and lowered water temperatures below the reservoir, have disrupted the downstream continuum of macroinvertebrate communities that would normally be observed from the headwaters to the mouth. The information presented herein provides a basis for further evaluation of the Neversink and similar river systems, and for assessment of the effectiveness of future conservation efforts.

Introduction

The Neversink River, in the Catskill Mountains of southeastern New York State (fig. 1), is impounded midway through its course by the Neversink Reservoir, which diverts about 85 percent of the river's flow to New York City and provides some of the purest water in the city's supply network. Changes in the physical and chemical conditions in some parts of the river since the construction of the reservoir in 1953, however, and the acidification of several streams in the upper parts of the basin through acidic deposition ("acid rain"), have altered ecosystem functions and some stream biota. The Neversink Reservoir (fig. 1) alters water quality and diminishes sediment transport for more than 8 km below the dam, affecting fish and **macroinvertebrate** populations, and the acidification of several headwater reaches has adversely affected macroinvertebrate and fish communities, including brook trout, locally within the upper basin (Baldigo and Murdoch, 1997; Baldigo and Lawrence, 2001).

The structure and function of macroinvertebrate communities in streams with forested headwater reaches such as those of the Neversink River generally follow a predictable progression, from the small, cold headwaters to the large, warm, more productive reaches near the mouth, called the River Continuum Concept (Vannote and others, 1980). Small, shady headwater reaches tend to support invertebrates that consume fallen-leaf material (termed **shredders** and **gatherers**), whereas the larger downstream reaches, which receive more sunlight and less fallen-leaf material, support invertebrates that consume algae (known as **scrapers**) or that consume decomposed leaf matter transported from upstream (known as **filterers**). The acidification of some headwater

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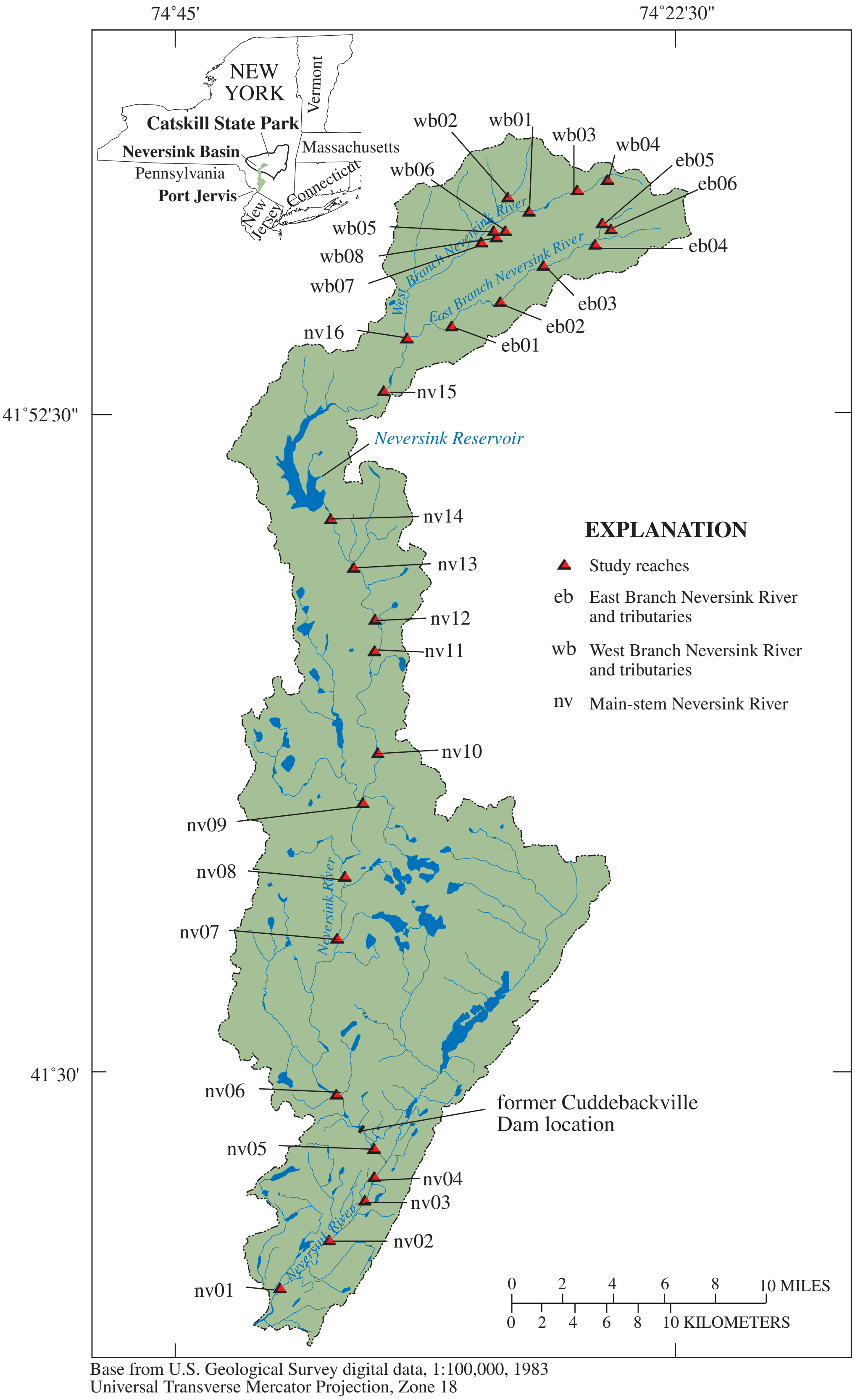

Base from U.S. Geological Survey digital data, 1:100,000, 1983
Universal Transverse Mercator Projection, Zone 18

Figure 1. Locations of the 30 reaches investigated in the Neversink River basin in southeastern New York, 1991–2001.

reaches of the Neversink River, and the presence of the reservoir since 1953, appear to have disturbed the normal headwater-to-mouth progression of macroinvertebrate-community composition, but these disturbances have not been thoroughly documented.

Since the 1980s, the U.S. Geological Survey (USGS), in cooperation with the New York City Department of Environmental Protection, The Nature Conservancy (TNC), and the towns of Thompson and Mamakating, has collected data on habitat, fish communities, flow patterns, channel geomorphology, basin physiography, and soil and water chemistry from many reaches throughout the 1,126 km^2 Neversink River basin. Multidisciplinary studies have inventoried macroinvertebrate communities at 30 of these reaches (fig. 1) to identify the effects of stream acidification and of various logging practices on macroinvertebrate assemblages (Baldigo and others, 2003; Murdoch and others, 2007), and to define the spatial relations among environmental conditions, macroinvertebrate assemblages, and several rare mussel species (Baldigo and others, 2002; Baldigo and others, 2004). In 2002, the USGS, in cooperation with TNC, began a 2-year study to compile macroinvertebrate data from the above studies to identify the effects that stream acidification and the reservoir have had on macroinvertebrate assemblages throughout the Neversink River and its tributaries.

Purpose and Scope

The main objectives of this study were to document the following:

- the composition of macroinvertebrate communities at each of the 30 study reaches,
- alterations in the expected downstream progression of macroinvertebrate-community structure, and
- the habitat and water-quality factors that have affected species distribution and macroinvertebrate-community structure.

This report summarizes the macroinvertebrate data from four prior investigations (Baldigo and others, 2002; Baldigo and others, 2003; Baldigo and others, 2004; Murdoch and others, 2007). It (1) describes the study area, (2) discusses the habitat characteristics and water-quality changes that have affected macroinvertebrate communities, (3) describes and depicts through graphs the effects that these changes have had on macroinvertebrate communities and **functional feeding groups** throughout the river system, and (4) describes the utility of these results as a basis for assessment of future conservation efforts in the Neversink and similar river systems. A glossary of technical terms that may be unfamiliar to the reader is included at the back of the report.

Study Area

The Neversink River arises in the Catskill Mountains and flows to the Delaware River at Port Jervis, PA (fig. 1). The 1,126-km^2 Neversink River basin is largely forested and consists of three physiographically distinct subbasins (fig. 1). The 238-km^2 upper basin is mountainous and terminates at the Neversink Reservoir Dam, which was built in 1953 to supplement New York City's water supply. Stream channels in the upper basin are generally carved in bedrock. The 606-km^2 middle basin lies between the reservoir dam and the decommissioned Cuddebackville Dam (fig. 1). Here the river begins along a broad flood plain, then passes through a narrow gorge for most of its length. The river in the 282-km^2 lower basin is broad, with a relatively narrow flood plain.

Water of the main-stem Neversink is generally clear and fairly soft, with calcium concentrations of less than 200 µmol/L. Many of the headwaters of the East and West Branches (in the upper basin, fig. 1) are chronically or episodically acidified (Lawrence and others, 1999; Baldigo and Lawrence, 2001). This acidification has been shown to have had detrimental effects on the survival rates and community composition of several fish species, including brook trout (Baker and others, 1996; Van Sickle and others, 1996; Baldigo and Murdoch, 1997; Baldigo and Lawrence, 2000).

The predominant physical feature of the Neversink River basin is the Neversink Reservoir (fig. 1), which has a surface area of 6.1-km^2 and impounds 132,500,000 m^3 of water at maximum capacity. The impoundment itself, and the diversion of 85 percent of the river's flow to New York City (Butch and others, 1998; Krejmas and others, 1998), have decreased the river's potential for flooding in the middle and lower parts of the basin but also have decreased the river's total annual discharge, lowered the duration of high-flow pulses, and increased the duration of low flows. The reservoir also acts as a settling basin that decreases the release of sediment downstream, which can interrupt the food supply for some macroinvertebrates. In addition, the dam is a bottom-release type that releases cold water.

Methods

Data on habitat characteristics, stream-water quality, and macroinvertebrate assemblages were collected from as many as 30 reaches during 1991–2001 for use in three USGS studies of freshwater mussels (Baldigo and others, 2002) and forest harvest effects on macroinvertebrates (Baldigo and others, 2003; Murdoch and others, 2007). The data were compiled and standardized for use in the data analyses for this report. The methods of sampling and measurement for each category are as follows:

Habitat characteristics: More than 40 habitat conditions were characterized at 29 of the 30 reaches from 1991 through 2001. Among the factors that were quantified at every reach were the following: drainage area, elevation, gradient, pool-to-riffle ratio, amount of open canopy, bank stability, channel width and depth, substrate particle-size classes, and water temperature.

Stream-water quality: From 2 to 155 water samples were collected at each of the 30 reaches during 1991–2001 and analyzed for pH and concentrations of 17 constituents, including acid-neutralizing capacity (ANC), calcium, dissolved organic carbon (DOC), total dissolved aluminum (Al), inorganic monomeric Al, orthophosphate, and nitrate.

Macroinvertebrates: Macroinvertebrates were collected from riffles and runs through a variety of collection methods from all 30 reaches during 1991–97. Macroinvertebrate data from the post-logging period of the forest harvest studies were omitted to avoid the effects of tree removal on stream-water quality. Sampling methods differed from year to year, as summarized below:

- In 1991 and 1992, total counts (all specimens) were collected from three replicate Surber samples (0.093 m^2) at each of 12 reaches surveyed in the East and West Branches and upper section of the main stem.
- In 1995 and 1996, subsamples of 200 invertebrates were taken from three replicate Surber samples (0.093 m^2) collected in both years from four of the eight headwater reaches in the West Branch Neversink.
- In 1997, subsamples of 200 invertebrates were sorted from single traveling-kick samples applied for 5 minutes over a 5-m stretch of stream (Bode and others, 1996) from 14 main-stem reaches.
- Standardization of **metrics** among reaches entailed pooling data from all samples collected from each reach and each year (when sampled in more than 1 year). Macroinvertebrate-community metric values were estimated from the average of 100 random computer-generated 200-count subsamples of the pooled data. The metrics used for each reach are defined as follows:
  1. Total macroinvertebrate taxa **richness**—a measure of the number of taxa found at each reach.
  2. **EPT** richness—a measure of the number of mayfly (**E**phemeroptera), stonefly (**P**lecoptera), and caddisfly (**T**richoptera) taxa found at each reach. These taxa are frequently used because they are common and tend to be sensitive to water quality.
  3. **Hilsenhoff's Biotic Index (HBI)**—an indicator of average tolerance to organic contamination. Sensitive taxa have low tolerance values, and tolerant taxa have high tolerance values.
  4. Feeding group percentage—the number of individuals in selected functional feeding groups, expressed as a percentage of the total macroinvertebrate count.

A reach in good condition will have high total richness and EPT richness, but a low HBI score.

Standardized macroinvertebrate-community metrics were evaluated through regression, correlation, and graphical analyses to assess the effects of the reservoir, and of water-quality and physical-habitat characteristics, on macroinvertebrate communities. Variables that were log-transformed to normalize their distributions included drainage area; pool-to-riffle ratio; mean particle size; temperature; concentrations of acid-neutralizing capacity (ANC), calcium, total dissolved aluminum, organic monomeric aluminum, orthophosphate, and nitrate; percent Plecoptera and Trichoptera individuals; and percent shredder, gatherer, filterer, and predator individuals.

Effects of Habitat Characteristics and Water Quality on Macroinvertebrate Communities

Most of the habitat characteristics that were analyzed reflected the typical differences between high-elevation reaches (small drainage area, steep slope, and low water temperatures) and low-elevation reaches (large drainage area, low slope, and high water temperatures). The stream-water pH data indicated acidification at several headwater reaches, mainly in the East Branch of the Neversink River (fig. 2A). Concentrations of other constituents generally followed expected patterns from headwaters to downstream reaches; for example, a reach-to-reach decrease in pH (increase in acidity) was accompanied by increased concentrations of inorganic monomeric aluminum (Al) and decreased concentrations of ANC, DOC, and calcium (fig. 2A, 2B). Inorganic monomeric Al concentration and pH reached acutely toxic levels in four acidified headwater reaches (sites wb04, eb03, eb04, and eb05, fig. 2A), three of which are along the East Branch, which is chronically acidified throughout most of its length (Baldigo and Murdoch, 1997). As expected, concentrations of ANC, DOC, and calcium generally increased from the headwaters downstream, whereas both total and inorganic monomeric aluminum concentrations decreased (fig. 2B). Water quality in nearly all reaches downstream from the reservoir (sites nv14–nv01) was generally not “impaired” as defined by the New York State Department of Environmental Conservation (Bode and others, 2002).

Macroinvertebrate Communities

The effects of stream acidification and the reservoir on macroinvertebrate communities were evaluated through two perspectives—predominance of given taxa, and predominance of given functional feeding groups—at each reach in downstream order. Results of both evaluations were then compared with the downstream progression that would be expected in an undisturbed system to reveal anomalies that

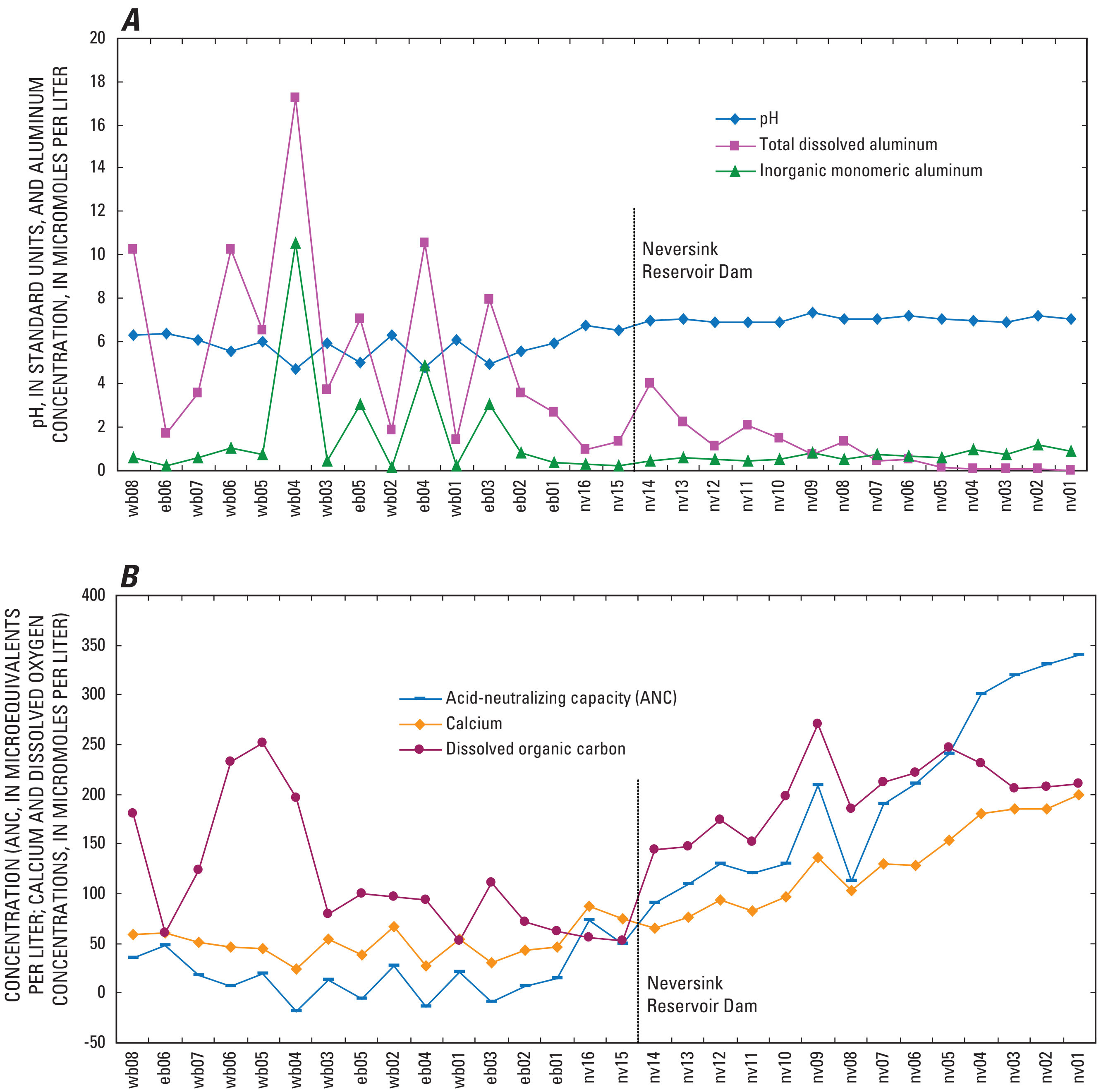

Figure 2. Mean concentrations of selected constituents at 30 reaches in the Neversink River basin in southeastern New York, 1991–2001: *(A)* pH, total dissolved aluminum, and inorganic monomeric aluminum, and *(B)* Acid-neutralizing capacity, calcium, and dissolved organic carbon. (Locations of reaches are shown in fig. 1.)

may be attributed to acidification and habitat changes due to the impoundment and diversion of flow at the reservoir.

Macroinvertebrate Taxa

Macroinvertebrate samples at all 30 reaches consisted predominantly of seven main invertebrate taxa-**Chironomidae**, other Diptera, Trichoptera, Plecoptera, Ephemeroptera, Oligochaeta, and Coleoptera. Sixteen other broad taxa (generally class or order) made up less than 5 percent of the samples at any reach.

Comparison of values obtained for three metrics (total community richness, EPT richness, and HBI scores) with impairment thresholds defined by the New York State Department of Environmental Conservation (Bode and others, 1996; Bode and others, 2002) indicated potential impairment at several reaches (fig. 3). All three of these metrics indicate that macroinvertebrate communities were impaired in three of the four strongly acidified reaches in the upper basin (eb03, eb04, and eb05), in two slightly acidified reaches in the upper basin (eb02 and eb06), and in the two reaches immediately downstream from the Neversink Reservoir (nv13, nv14). Two of the three metrics indicate impairment in three of the acidified reaches (eb01, wb03, and wb04) and in a circumneutral reach just above the reservoir (nv15). Most of the 14 headwater reaches with circumneutral pH generally had high total and EPT richness and low HBI values (for example, wb02, wb05, and wb07). This uneven geographic distribution of acidified reaches is attributed to the distribution of calcium-rich bedrock or soils in the Catskill region.

Most acidified reaches had fewer EPT taxa and fewer EPT individuals than the other reaches. The acid-tolerant midge larvae (Chironomidae) dominated most tributaries and main-stem reaches in the upper basin (fig. 4) and constituted at least 50 percent of the macroinvertebrate communities in all reaches along the acidified East Branch of the Neversink

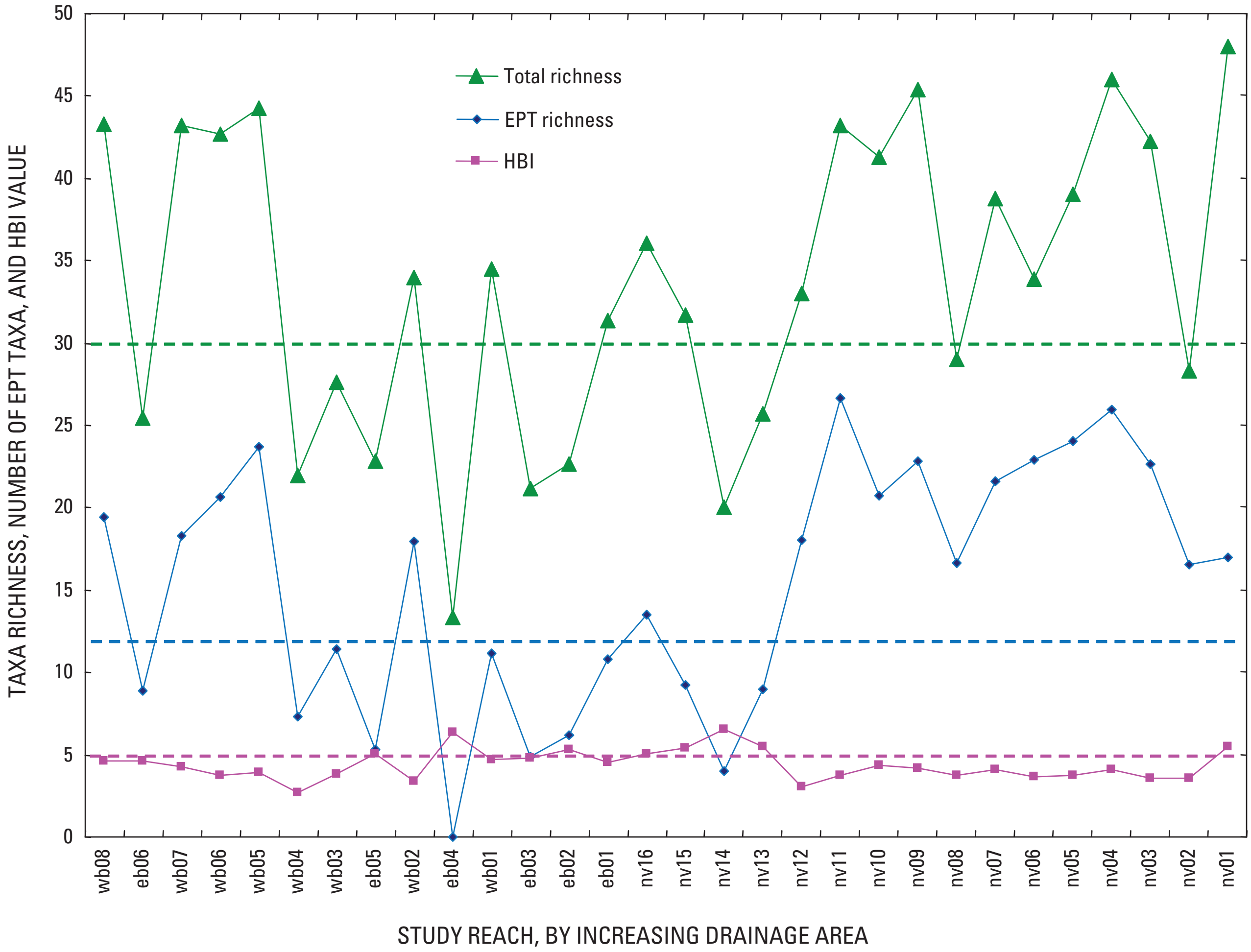

Figure 3. Total macroinvertebrate-taxa richness, EPT (Ephemeroptera-Plecoptera-Trichoptera) richness, and HBI (Hilsenhoff’s Biotic Index) values for 30 reaches in the Neversink River basin, New York, 1991–97, with New York State thresholds for “slight impairment” shown with dashed lines. (Locations of reaches are shown in fig. 1.)

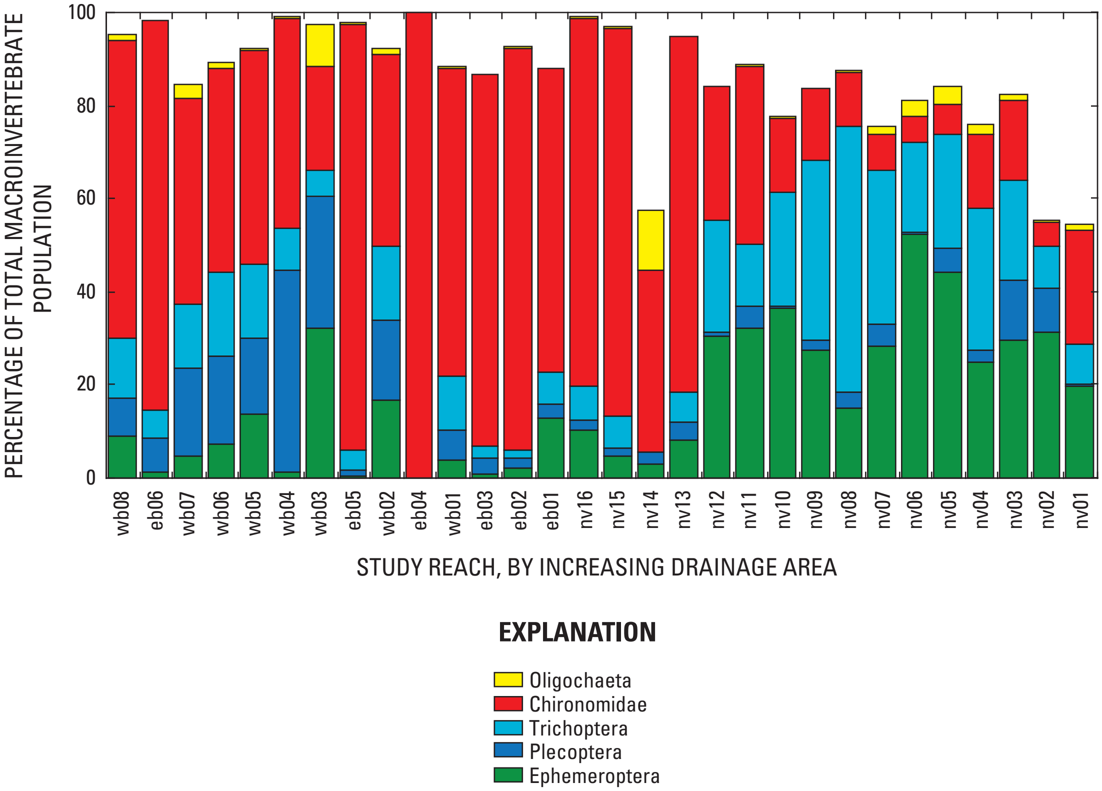

Figure 4. Ephemeroptera, Plecoptera, Trichoptera, Chironomidae, and Oligochaeta, as a percentage of total macroinvertebrate community, at 30 reaches in the Neversink River basin, New York, 1991–97. (Locations of reaches are shown in fig. 1.)

River. Less tolerant EPT taxa dominated the macroinvertebrate communities in most reaches of the West Branch and in most main-stem reaches in the middle and lower basin. In general, the percentage of the macroinvertebrate community represented by EPT increased downstream, although Plecoptera typically decreased in relation to Ephemeroptera and Trichoptera. The two reaches immediately downstream from the reservoir showed relatively few EPT taxa, and increased numbers of chironomids and oligochaetes.

Functional Feeding Groups

Macroinvertebrates can be grouped into functional feeding groups according to their feeding mechanisms and behavior (Vannote and others, 1980; Merritt and Cummins, 1996), which tend to vary with river size and productivity from headwaters to the mouth in most river systems. The distribution of functional feeding groups in the Neversink River basin generally followed expected patterns outlined by the River Continuum Concept (Vannote and others, 1980); that is, the percentages of total macroinvertebrate community that were represented by shredders and gatherers decreased downstream as fallen-leaf material decreased, whereas the percentages represented by scrapers and filterers increased downstream (fig. 5) with increased algae production and increased decomposed material from upstream. This pattern in biological communities is known as a continuum and is typical of undisturbed stream systems with forested headwaters (Vannote and others, 1980; Ward and Stanford, 1983). Exceptions were found in several severely acidified headwater reaches; wb04 and eb04 contained more shredders and fewer gatherers than less acidified reaches nearby, and eb03 and eb04 had few or no scrapers. Other exceptions were found at the two reaches just below the Neversink Reservoir Dam (nv14 and nv13), which had fewer scrapers and filterers than nearby reaches, and more shredders (fig. 5). **Generalist** feeders were uncommon at most reaches and represented less than 10 percent of the invertebrate population at all but four reaches (nv01, nv07, nv08, and nv09, all below the reservoir), where they represented 12–47 percent (fig. 5).

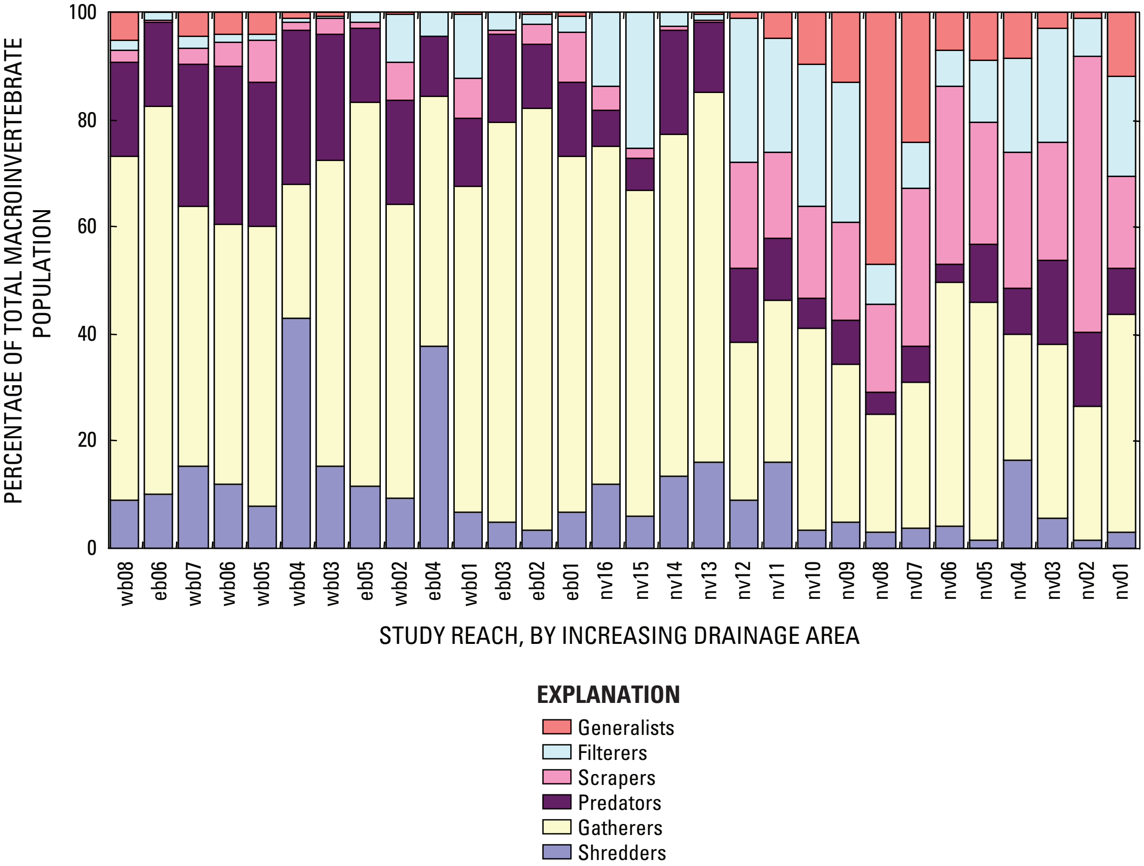

Figure 5. Percentage of total macroinvertebrate population represented by selected functional feeding groups at 30 reaches in the Neversink River basin, New York, 1991–97.

Statistical Correlations between Macroinvertebrate Communities and Stream Habitat and Water Quality

The statistical relations between the macroinvertebrate metrics and the physical-habitat and water-quality factors (table 1) indicate that water-quality factors generally explained more of the variation in total richness and distribution of Ephemeroptera, Trichoptera, and Chironomidae individuals than the physical-habitat factors. Most of the water-quality factors that were positively correlated with Ephemeroptera, Trichoptera, and total richness were negatively correlated with Chironomidae (table 1). Physical-habitat factors generally explained more variation in the distribution of Plecoptera and filterers than did water-quality factors. A combination of physical-habitat and water-quality factors equally explained the other macroinvertebrate metrics and the percentages for functional feeding groups other than filterers.

Macroinvertebrate Discontinuum

Unusual water-quality and physical-habitat conditions can cause a discontinuum in the transition of macroinvertebrate communities from small headwater reaches to large downstream reaches. For example, the predominance of certain taxa and functional feeding groups, and the values of several metrics, indicated impairment of water quality in several acidified headwater reaches and of habitat in the two reaches immediately downstream from the Neversink Reservoir. This is consistent with the documented adverse effects of acidification (for example, Simpson and others, 1985; Kimmel and others, 1996; Dangles and Guerold, 2000), and of reservoirs (for example, Ward and Stanford, 1983; Pringle and others, 2000) on macroinvertebrate assemblages in other streams. The following sections briefly describe the disruptions in the macroinvertebrate continuum found in this study.

Table 1. Significant correlations (p<0.05) for physical-habitat and water-quality factors with taxa and functional feeding groups.

[All values based on percentage of total macroinvertebrate population represented by **taxon** or feeding group]

Factor	Macroinvertebrate taxa						Functional feeding groups				
	Total taxa richness	Ephemer-optera	Plecop-tera	Trichop-tera	EPT individuals	Chiro-nomidae	Shredders	Scrapers	Gatherers	Filterers	Predators
Physical habitat											
Drainage area		0.58	-0.59			-0.51	-0.50	0.66	-0.47	0.70	-0.68
Elevation	-0.39	-.69	.53	-0.48	-0.45	.66	.58	-.78	.53	-.67	.61
Gradient		-.41	.62				.44	-.45		-.64	.67
Pool-to-riffle ratio		.41		.45	.44	-.53	-.12	.50	-.64	.38	
Open canopy			-.61				-.41	.15		.43	-.59
Bank stability	.44	.41		.40				.45			
Mean channel width		.65	-.55	.44	.48	-.64	-.55	.79	-.58	.70	-.64
Mean channel depth		.37	-.39					.52	-.37	.52	-.43
Mean substrate particle size			.49							-.47	
Water temperature	.57	.56		.70	.68	-.72	-.52	.66	-.61	.47	-.36
Water quality											
pH	.52	.66	-.41	.62	.51	-.65	-.49	.64	-.43	.58	-.53
ANC		.61	-.46	.51	.45	-.62	-.38	.70	-.67	.64	-.56
Calcium	.58	.72	-.40	.57	.57	-.72	-.59	.78	-.54	.66	-.55
DOC	.54	.56		.68	.69	-.75		.59	-.69		
Total dissolved Al	-.45	-.59			-.40	.59	.57	-.76	.48	-.62	.45
Al, organic monomeric	-.36	-.59	.43	-.73	-.49	.68		-.76	.57	-.60	.50
Orthophosphate	.46	.80		.70	.77	-.85	-.55	.76	-.70	.54	-.61
Nitrate		.45	-.45	.53	.45	-.42	-.47	.40		.47	-.70

Headwater Reaches

Macroinvertebrate taxa: Acidic conditions in headwaters of the East and West Branches of the Neversink River appear to have affected the structure of macroinvertebrate communities by strongly favoring certain acid-tolerant chironomid taxa over acid-sensitive Ephemeroptera and Trichoptera taxa. Acidified reaches showed much lower total richness and EPT richness than nearby, less acidified headwater reaches, which is a pattern seen in other acidic streams (Kimmel and others, 1996; Ventura and Harper, 1996). Plecoptera were common in acidified reaches, despite lower overall EPT richness; their dominance of invertebrate communities, coupled with low numbers of mayflies, has been documented in other acidified streams of the Northeast (Simpson and others, 1985; Ventura and Harper, 1996), though some species of Plecoptera are acid-sensitive (Bradley and Ormerod, 2002; Lepori and others, 2003). Several acidified headwater reaches (for example, sites eb03 and eb05) contained five times as many Plecoptera as Ephemeroptera (five times the percentage of total macroinvertebrates). This apparent anomaly was especially striking at site wb04, which had the lowest median pH (4.72) of any site; here the Plecoptera represented more than 43 percent of the total macroinvertebrates, and the Ephemeroptera only 1 percent. This finding is not surprising, however, in that Plecoptera were found to be affected more by physical-habitat factors than by water-quality factors, whereas the Ephemoptera were affected more by water-quality factors than by physical-habitat factors. Most species of Ephemeroptera are rarely found in acidified stream reaches (Simpson and others, 1985), whereas Plecoptera can thrive in headwater reaches with high acidity and elevated aluminum concentrations.

Functional feeding groups: Acidic conditions in some headwater reaches of the Neversink River have affected the function of macroinvertebrate communities as well as their structure by altering the feeding-group distributions. The low numbers of scrapers in highly acidic reaches, especially those in the East Branch, have been observed in acidic streams in Europe as well (Dangles and Guerold, 2000; Ledger and Hildrew, 2001). Stream acidification can cause a decrease in the quality or quantity of biofilms (Ledger and Hildrew, 2001), which in turn may limit the numbers of macroinvertebrate scrapers for which biofilms are a primary food source (Merritt and Cummins, 1996). Acidic streams also tend to have a higher standing stock of coarse particulate matter than neutral streams because this material decomposes more slowly under acidic conditions (Dangles and Guerold, 2000, Pretty and others, 2005). This can result in increased accumulations of leaf material that may support shredders and thereby account for the greater percentages of individual shredders in acidified reaches than elsewhere. The River Continuum Concept (Vannote and others, 1980) predicts fewer scrapers in headwater streams because of more shading, and more shredders in headwater streams because of greater inputs of leaf material. The key difference in the Neversink River headwaters, however, is that acidified reaches here had fewer scrapers and more shredders compared to less-acidified reaches, suggesting a change in community composition associated with pH. Certain streams may be unaffected by shifts in feeding groups; for example, a study of stoneflies in an acidic stream in England found that generalist feeders can graze in streams where specialist scrapers are absent, such that stream function may remain unchanged despite a shift in the functional feeding groups (Ledger and Hildrew, 2000). Generalists are uncommon in the Neversink River and its tributaries, however, especially in the East and West Branches; therefore, the altered conditions there may alter the downstream distribution of feeding groups.

Main-Stem Reaches Below the Reservoir

Macroinvertebrate taxa: Physical-habitat conditions below the Neversink Reservoir appeared to affect the structure of macroinvertebrate communities by favoring taxa that tolerate the uniform flows and low water temperatures caused by the dam. Biodiversity in reaches below dams tends to be lower than in other reaches because the more stable habitat conditions below a dam favor assemblages with a few dominant taxa (Pringle and others, 2000; Vinson, 2001). This is consistent with observations below the Neversink Reservoir, where species richness at reaches immediately below the dam was far lower than at the reaches above the reservoir or farther downstream. The habitat immediately downstream from dams can be unfavorable for EPT taxa (Vinson, 2001; Bednarek and Hart, 2005; Tiemann and others, 2005), but macroinvertebrate communities generally recovered within the first 10 km below the dam, as has been reported in other impounded river systems (Bednarek and Hart, 2005).

Functional feeding groups: The structure of macroinvertebrate communities in terms of functional feeding groups below the reservoir also shifted. As in acidic reaches, shredders were more abundant just below the dam than in reaches farther downstream, and scrapers were slightly less abundant. This finding is inconsistent with that predicted by the Serial Discontinuity Concept (Ward and Stanford, 1983), which states that the decreased ratio of coarse- to fine-particulate organic matter in reaches below upper- to middle-reach dams will decrease the number of shredders. This prediction is supported by studies in Spain and Portugal, which found decreases in the relative abundance of shredders below bottom-release dams (Camargo and others, 2005; Cortes and others, 2002). It is also supported by a study of dams worldwide that found that the decreased variability of streamflow generally leads to an abundance of periphyton and plant growth, which should in turn lead to an increase in the numbers of scrapers (Stanford and Ward, 1979). The greater relative abundance of shredders found just below the Neversink Reservoir, and the lesser relative abundance of scrapers, were surprising, but may simply be a result of sampling techniques. Invertebrate samples were taken only from riffles or runs. The extensive, dense, perennial macrophyte beds that are common in channels downstream from the reservoir provide a good substrate for periphyton and, therefore, scrapers, but these macrophyte beds were not sampled.

Another effect of the dam on functional feeding groups was that fewer filterers than expected were found in reaches immediately downstream from the reservoir. Filter feeders are commonly abundant below dams that release water over a spillway (Allan, 1997), but the bottom-release Neversink Reservoir Dam probably causes a decrease in the amount of particulate organic matter downstream. This is consistent with conclusions of a study of macroinvertebrate communities below surface-release and bottom-release dams, which found that filterers were common only below the surface-release dam (Ward and Short, 1977). Dissolved oxygen levels may also be lower below the Neversink Reservoir Dam, which could lead to reduced numbers of filterers, but dissolved oxygen levels were not measured.

Recovery from the effects of the reservoir (stabilized flow, cold water, decreased sediment and nutrient content) occurred within a relatively short distance downstream, however; scrapers and filterers rebounded to high percentages of the invertebrate community within 10 km below the dam, and shredders returned to low percentages within 18 km.

Comparing Headwater Reaches to Reaches Below the Reservoir

Stream conditions both above and below the reservoir dam led to similar invertebrate communities, although the influences were different. The water-quality variables (chiefly pH and aluminum) found to shape macroinvertebrate communities in the upper basin resulted in macroinvertebrate communities with fewer EPT taxa at reaches in the chronically acidified East Branch than the neutral West Branch, even though the two branches are similar in physical-habitat characteristics. The physical-habitat characteristics (chiefly low temperatures and low flow rates) at the two reaches immediately downstream from the reservoir also resulted in communities that favored chironomids over EPT taxa (fig. 6).

The reach-to reach differences in water quality and physical-habitat conditions found in this study, and the macroinvertebrate-metric results that were obtained, indicate that several reaches have been slightly to moderately affected and the distributions of functional feeding groups have been altered. For instance, the number of shredders in two acidified headwater reaches increased in response to the large amount of leaf matter that may be due to decreased decomposition rates; this number also decreased in two reaches below the reservoir, where low, stable flows and low water temperatures similarly decreased the decomposition rates of organic matter and permitted leaf accumulation. The number of scrapers both above and below the reservoir decreased, possibly in response to decreased food availability, either because acidic water above the reservoir affected the quality or quantity of biofilms, or because the variable physical and chemical conditions below the reservoir restricted periphyton growth. In summary, macroinvertebrate communities at two of the reaches downstream from the reservoir were similar to those in acidified reaches far upstream from the reservoir—an indication that impaired stream conditions, related either to physical habitat or water quality, can disrupt the normal downstream progression of stream-invertebrate communities.

Potential Applications of this Study

The data and findings from this study serve as indicators of the degree to which two significant environmental stresses—stream acidification and flow alteration by the dam—affected the macroinvertebrate community in the Neversink River Basin. These data and findings can be used to evaluate changes to the macroinvertebrate communities in other streams that are acidified or that have large impoundments. Such information also is useful in studies of the relative importance of given environmental stresses, a critical step toward the protection and conservation of aquatic systems from threats such as point- and nonpoint-source pollution, dams, acidic atmospheric deposition, and invasive species.

The findings of this study, some of which are in contrast to the accepted theory of linear progression of stream macroinvertebrate communities (the Serial Discontinuity Concept, Ward and Stanford, 1983), may serve to stimulate further studies in similar river systems with acidified streams and large impoundments. Such studies could be designed for use in evaluating the effectiveness of conservation actions and could lead to improved resource management in this and similar river systems in the future.

Summary and Conclusions

The Neversink River provides New York City with some of the purest water in its supply network and minimizes downstream flooding, but physical and chemical conditions in parts of the basin threaten some stream biota. Data were collected during 1991–2001 from 30 reaches of the Neversink River and its tributaries above and below the Neversink Reservoir Dam to identify the effects of stream acidification, selected habitat characteristics, and the reservoir on the health and composition of macroinvertebrate assemblages. Macroinvertebrate assemblages generally showed a predictable pattern of change from upstream headwaters to downstream reaches, with some exceptions. Water-quality data indicated that several headwater reaches, mainly in the East Branch of the Neversink River, had low pH, low acid-neutralizing capacity, low concentrations of dissolved organic carbon and calcium, and toxic concentrations of inorganic monomeric aluminum and, thus, that the structure and function of macroinvertebrate communities in these reaches were

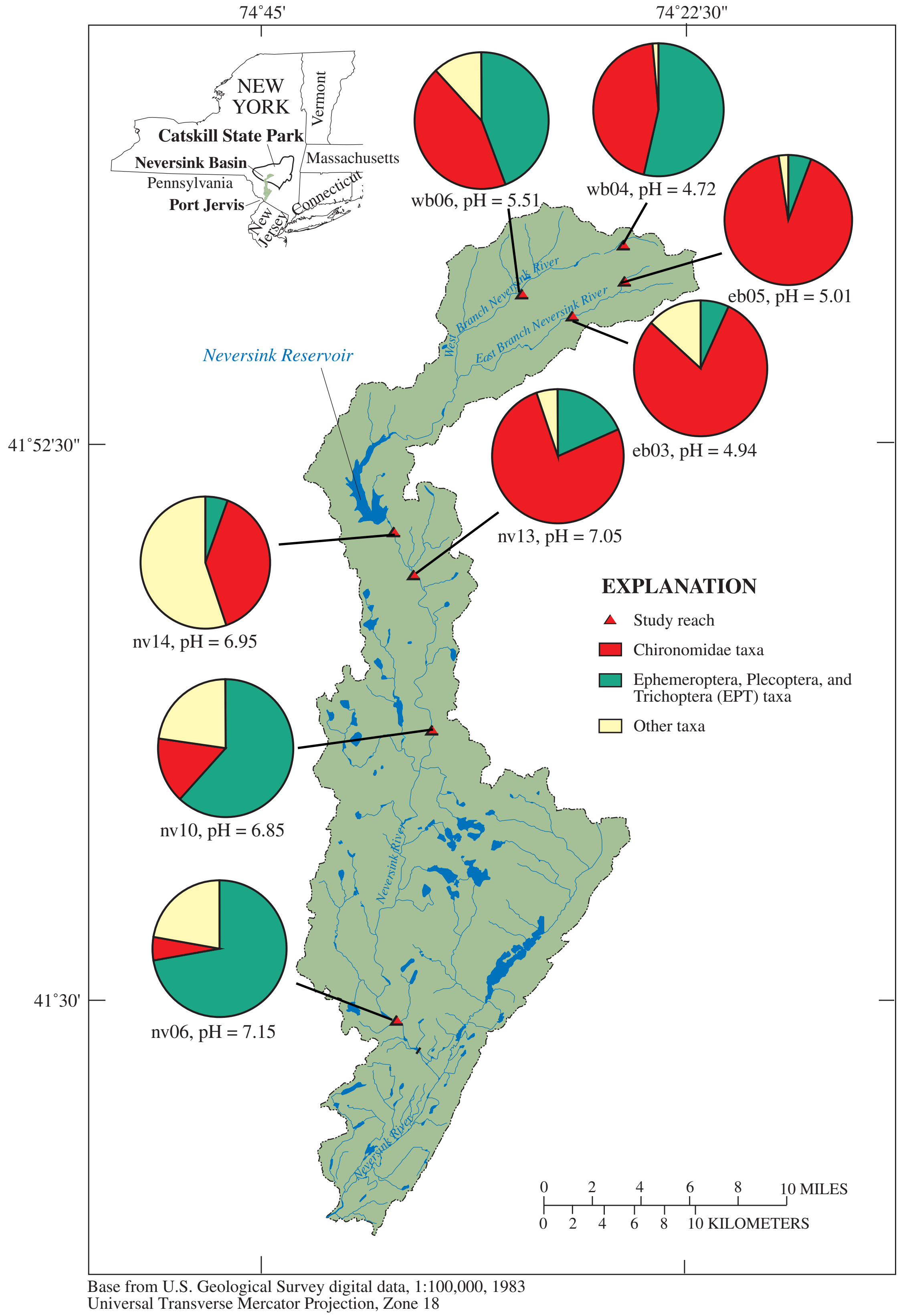

Figure 6. Stream-water pH and composition of macroinvertebrate communities at eight reaches from the headwaters of the Neversink River to the lower basin, selected to show the range in macroinvertebrate-community composition with varying pH.

impaired. The physical-habitat data indicated that the low water temperature and low flows at two reaches downstream from the Neversink Reservoir created conditions that interrupted the expected progression of stream-invertebrate communities below the reservoir. The macroinvertebrate communities in acidified reaches and in two reaches below the reservoir supported fewer Ephemeroptera and Trichoptera, and fewer scraper and filterer macroinvertebrates, than reaches unaffected by acidification or the reservoir, and more Chironomidae and shredders. Acidification and flow alteration have disrupted the expected continuum of macroinvertebrate communities from headwaters to downstream reaches. The information provided in this report may serve to stimulate further studies in similar river systems with acidified streams and large impoundments.

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Glossary

C

Chironomidae Midge larvae, a group of macroinvertebrates that tends to be tolerant of organic pollution.

E

EPT Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies), the invertebrate taxa that tend to be most sensitive to water quality. Streams with good water quality tend to have many EPT taxa, whereas streams with poor water quality tend to have fewer.

F

Filterer A macroinvertebrate that consumes particulate matter in transport. Filterers form a functional feeding group.

Functional feeding group A group of macroinvertebrates classified by their means of acquiring and consuming food, such as “scraper” or “filterer”.

G

Gatherer A macroinvertebrate that consumes the accumulated particles of leaves and algae from the surfaces of rocks or other hard substrata. Gatherers form a functional feeding group.

Generalist A macroinvertebrate that acquires and consumes a variety of food, and, therefore, is not able to be assigned to a single functional feeding group.

H

HBI Hilsenhoff’s Biotic Index, a measure of the average tolerance of an assemblage to contamination by organic compounds. Sensitive taxa within the assemblage have low tolerance values, whereas tolerant taxa have high values.

M

Macroinvertebrate An invertebrate that is visible to the naked eye, such as an insect larva.

Metric A measure of a characteristic that summarizes data and facilitates comparisons among sites, such as richness or HBI value.

R

Richness The number of taxa present in an area.

S

Scraper A macroinvertebrate that consumes algae, generally by scraping it off of rocks and other surfaces where it grows. Scrapers form a functional feeding group.

Shredder A macroinvertebrate that consumes fallen-leaf material. Shredders form a functional feeding group.

T

Taxon A group of similar organisms, such as a genus or species. (Taxa, plural)

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