UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
THE ADMINISTRATOR

TECH TRANSFER

July 25, 1988

MEMORANDUM

SUBJECT: Report on Nonpoint Source Impacts on Aquatic Life

FROM: Steven A. Dressing SAD
Nonpoint Sources Branch (WH-585)

TO: All Regional Nonpoint Source Coordinators

The Monitoring and Data Support Divison contracted with Research Triangle Institute to report on the extent of current information on the effects of NPS pollution on aquatic biota. The attached final report is intended to provide an overview which is representative of the existing literature and provide some guidance to those involved in NPS monitoring programs.

attachment

cc: Carl Myers
Mattie Ruffin

SUBJECT: NPS Impacts on Aquatic Life

RESEARCH TRIANGLE INSTITUTE

July 1988

NONPOINT SOURCE IMPACTS ON AQUATIC LIFE—LITERATURE REVIEW

by

Dr. Patricia A. Cunningham
Center for Environmental Systems
Research Triangle Institute
Research Triangle Park, NC 27709

Work Assignment No. 18
Contract No. 68-03-3423

Work Assignment Manager: Mattie M. Ruffin
Project Officer: Mattie M. Ruffin

MONITORING AND DATA SUPPORT DIVISION
OFFICE OF WATER REGULATIONS AND STANDARDS
401 M STREET, SW
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SECTION 1

INTRODUCTION

Congress has enacted the Water Quality Act of 1987, including Section 319, which encourages States to strengthen their nonpoint source (NPS) water pollution management programs. Over 4 years from the date of enactment, $400 million is authorized to help States implement their NPS pollution control responsibilities. Currently, in some States NPS runoff is the largest remaining uncontrolled source of pollution and is the principal cause of remaining water quality problems.

This report was prepared to examine the extent of current information on the effects of NPS pollution on aquatic biota by EPA Region, State, and type of nonpoint source. It is not intended to be an exhaustive review of all available literature; rather, it is hoped that the report provides an overview of primary sources representative of NPS pollution impact studies on aquatic biota. In addition, the report should offer some guidance from the scientific literature to EPA Regional and State personnel who are responsible for reviewing and implementing appropriate State monitoring programs to evaluate site-specific NPS pollution problems.

After the initial acquisition process in which more than 300 references were identified, 68 primary sources (e.g., research papers and reports) were selected for review and inclusion in this document. Secondary sources (e.g., books or literature review articles) identified in the acquisition process were used exclusively to locate primary sources. Although the data reviewed are insufficient to establish definitive trends in National or Regional NPS pollution problems, this collection of primary sources does provide an overview of where NPS pollution effects on aquatic life have been investigated over the past 20 years, including the specific waterbodies studied, site-specific nonpoint sources of pollution, monitoring and assessment techniques used to evaluate the biological community, and resulting impacts on the aquatic biota. In response to the statement of work, geographic (Regional) trends in the types of NPS pollutants also are discussed (see Section 5).

SECTION 2

LITERATURE ACQUISITION

The Research Triangle Institute (RTI) conducted a two-tiered search of the available information on the effects of NPS pollution on aquatic biota. First, standard data base and open literature searches of secondary sources were conducted to identify primary sources for review. Second, appropriate EPA Regional and State personnel involved in assessing NPS pollution problems or conducting NPS research were contacted by telephone or in person as part of RTI's assistance to approximately 30 States in preparation of their 304(1) reports.

2.1 COMPUTERIZED DATA BASE SEARCH

A computerized data search was conducted of the Nonpoint Source Annotated Bibliography System at the National Water Quality Evaluation Project (NWQEP) run by North Carolina State University in Raleigh, North Carolina, to compile the bibliographic entries. At present, there are approximately 3,000 entries in the NPS library. Complete information on this NPS data base is provided in Appendix A for readers interested in accessing this system.

The computerized data base search encompassed all holdings of the NWQEP Nonpoint Source Annotated Bibliography System, with the following limitations:

- A preliminary key word search included "aquatic," "biological monitoring," "macroinvertebrate," "fish," "algae," "aquatic impacts," "bioaccumulation," "bioavailability," and "biological impacts."

- An intensive topic search included all parameters marked with an asterisk (*) on the newly published NWQEP topic outline (see Appendix A, page 15). Note: the asterisk (*) applies to all subheadings appearing below the main item starred.

- Only papers and publications printed in the English language were reviewed.

Of the more than 300 references identified, 68 were selected for inclusion in this literature review. Several criteria were used to select papers for this report:

- Only primary sources related to research studies of NPS pollution effects on aquatic biota conducted within one of the 10 EPA Regions were reviewed (Figure 1).

- Only papers presenting data on NPS pollution effects on aquatic biota derived from field monitoring activities were reviewed. Results of laboratory research derived solely from bioassay or microcosm studies were not included in this review unless the authors also validated their laboratory findings in field tests. Papers that extrapolated potential effects of chemical or physical water quality changes on aquatic populations without directly monitoring biota were not reviewed.

- Only papers published within 20 years of initiation of the data base search were reviewed. Initially the entries reviewed were limited to documents published since 1977 to keep the bibliography timely. However, because some topical areas (e.g., effects of organochlorine pesticides on aquatic life) were intensively researched from the late 1960's to mid-1970's but have not been researched as intensively since that time, the search was extended to the past 20 years with efforts concentrated on obtaining and reviewing the most recent and timely papers and reports.

All secondary sources (e.g., books and review articles) obtained directly from the computer data base search that were used to identify primary sources for review are listed in Appendix B. In addition, the June issues of the Journal of the Water Pollution Control Federation from 1977 to 1987, which contain annual reviews of NPS pollution and eutrophication papers, were reviewed to identify appropriate primary sources.

The two computerized data searches and manual review of books, symposia series, and review articles on appropriate NPS topics provided approximately 80 percent of the primary sources reviewed in this document.

2.2 TELEPHONE CONTACTS WITH EPA REGIONAL AND STATE PERSONNEL

A second method of identifying primary sources for inclusion in this literature review was to contact appropriate EPA Regional staff who supervised NPS projects or who had been involved with State personnel conducting NPS research for their respective States. Table 1 lists important NPS Program staff, including the Branch Chief and 10 Regional Coordinators. Table 2 lists

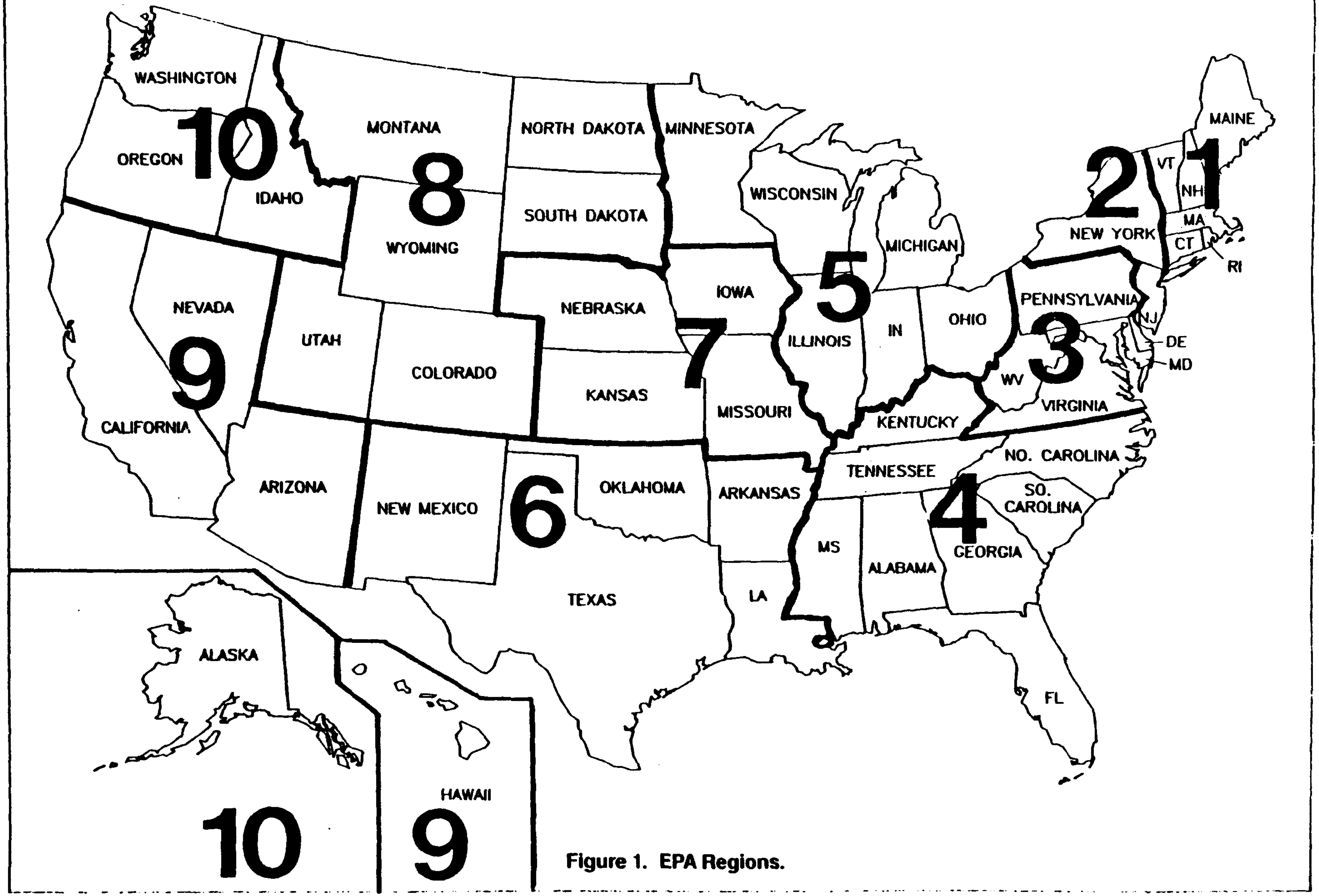

Figure 1. EPA Regions.

TABLE 1. OFFICES OF THE U.S. EPA NONPOINT SOURCES PROGRAM AND REGIONAL COORDINATORS

EPA Office	Contact (phone)	States within Region
Headquarters		
Office of Regulations and Standards Nonpoint Sources Branch (WH-585) U.S. Environmental Protection Agency 401 M. St., SW Washington, DC 20460	Carl Myers, Chief (202) 382-7100	
EPA Region 1		
Water Management Division John F. Kennedy Office Bldg. Rm. 2203 Boston, MA 02203 (617) 565-3478	Bart Hague (617) 565-3547	Connecticut Maine Massachusetts New Hampshire Rhode Island Vermont
EPA Region 2		
Water Management Division 26 Federal Plaza, Rm. 90 New York, NY 10278 (212) 264-2513	Rick Balla (212) 264-0711	New Jersey New York Puerto Rico Virgin Islands
EPA Region 3		
Water Management Division 841 Chestnut St. Philadelphia, PA 19107 (215) 597-9410	Harvey Mack (215) 597-9911	Delaware District of Columbia Maryland Pennsylvania Virginia West Virginia
U.S. EPA Cheseapeake Bay Program 410 Savern Ave. Annapolis, MD 21403	Lynn Shuyler (301) 266-6873	Delaware District of Columbia Maryland Pennsylvania Virginia West Virginia

(continued)

TABLE 1. (continued)

EPA Office	Contact (phone)	States within Region
EPA Region 4		
Water Management Division 345 Courtland St., NE Atlanta, GA 30365 (404) 347-4450	Bo Crum (404) 347-7788	Alabama Florida Georgia Kentucky Mississippi North Carolina South Carolina Tennessee
EPA Region 5		
Water Management Division 230 S. Dearborn St. Chicago, IL 60604 (312) 886-0148	Tom Davenport (312) 886-0124	Illinois Indiana Michigan Minnesota Ohio Wisconsin
EPA Region 6		
Water Management Division 1201 Elm St. Dallas, TX 75270 (214) 655-7100	Susan Alexander (214) 655-7140	Arkansas Louisiana New Mexico Oklahoma Texas
EPA Region 7		
Water Management Division 726 Minnesota Ave. Kansas City, KS 66101 (913) 236-2812	Bob Steiert (913) 236-2817	Iowa Kansas Missouri Nebraska
EPA Region 8		
Water Management Division 999 18th St., Suite 1300 Denver, CO 80202 (303) 293-1542	Roger Dean (303) 293-1571	Colorado Montana North Dakota South Dakota Utah Wyoming

(continued)

TABLE 1. (continued)

EPA Office	Contact (phone)	States within Region
EPA Region 9		
Water Management Division 215 Fremont St. San Francisco, CA 94105 (415) 974-8115	Kathryn Kuhlman (415) 974-8285	Arizona California Hawaii Nevada American Samoa Guam
EPA Region 10		
Water Division 1200 Sixth Ave. Seattle, WA 98101 (206) 442-1237	Elbert Moore (206) 442-4181	Alaska Idaho Oregon Washington

TABLE 2. EPA REGIONAL STAFF AND STATE CONTACTS

Contact	Affiliation
Peter Nolan	Region 1 Lexington, MA
Tom Fikslin	Region 2 Edison, NJ
Judith Weis	Department of Zoology and Physiology Rutgers University Newark, NJ
Jim Green	Region 3 Wheeling, WV
Leonard Nowak	Region 4 Atlanta, GA
Dave Lenat	Department of Natural Resources and Community Development Raleigh, NC
Allan Thomas	U.S. Forestry Service Asheville, NC
Andrew Smith	U.S. Soil Conservation Service Raleigh, NC
Jean Spooner Kelly Tindle	NCSU School of Agriculture and Life Sciences Water Quality Group Raleigh, NC
Geoffrey Scott	School of Public Health University of South Carolina Columbia, SC
Wayne Davis	Region 5 Chicago, IL
Michal Bastian Russ Bowen Glenda Gross	Region 6 Dallas, TX
Jim Piatt	New Mexico Environmental Improvement Division Santa Fe, NM

(continued)

TABLE 2. (continued)

Contact	Affiliation
Norman Crisp John Houlihan	Region 7 Kansas City, MO
Bill Wuerthele Del Nimmo	Region 8 Denver, CO
Loren Bahls	Department of Health and Environmental Sciences Helena, MT
Milt Tunzi	Region 9 San Francisco, CA
Evan Hornig	Region 10 Seattle, WA

other EPA Regional staff and State agency personnel who were contacted by RTI and who provided reports to RTI on NPS pollution problems.

The telephone contacts approach, although successful in identifying several reports that could be included in this literature review, provided only 20 percent of the primary sources reviewed. Several Regions indicated that reports germane to this literature review would not be available in final form until after this document was finalized.

SECTION 3

LITERATURE REVIEW

Once a primary source was identified and obtained in hard copy, the paper or report was reviewed and pertinent information was extracted and transferred to matrix data sheets (Figure 2) to highlight the most important findings of the research effort.

3.1 EPA REGION AND STATE DESIGNATION

The matrix data sheets are arranged by EPA Region in Appendix C. Within each Region, the references are alphabetized by State.

3.2 WATERBODY

The name of the waterbody studied and the county in which the waterbody occurs are given when available.

3.3 NONPOINT SOURCE

The nonpoint source and associated pollutants are identified for each entry and may fall into one or more of the following categories:

1. Agricultural activities (sediment, nutrients, pesticides, bacteria, total dissolved solids)
2. Forestry activities (sediment, nutrients, pesticides)
3. Urban runoff (sediment, nutrients, pesticides, bacteria, total dissolved solids, heavy metals)
4. Mining activities (sediment, total dissolved solids, heavy metals, acids)
5. Construction activities (sediment, nutrients, pesticides)
6. Hydromodification activities (sediment, total dissolved solids)
7. Landfill leaching (sediment, pesticides, heavy metals, other toxics)
8. Acid deposition.

EPA REGION 1

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source

Figure 2. Matrix data sheet.

3.4 IMPACTS ON AQUATIC BIOTA

This section of the matrix data sheet summarizes the effects of a specified nonpoint source activity and associated NPS pollutants (when known) on a designated biological community (e.g., aquatic plants, algae, periphyton, zooplankton, benthic macroinvertebrates, amphibians, fish, or aquatic birds). Some pertinent data from the primary reference may be tabulated for the reader to highlight a specific biological response. In cases where the primary source is extremely lengthy, only generalized summary statements are given to describe general trends noted by the author(s).

3.5 SOURCE

The literature source is the last entry on the matrix data sheet, and the reader need only refer to the annotated bibliography in Appendix D to look up the corresponding reference for that paper. The annotated bibliography is arranged alphabetically by author and is cross-referenced in the lower right corner to the corresponding matrix data sheet by EPA Region number(s) and State abbreviation(s).

SECTION 4

ANNOTATED BIBLIOGRAPHY

Appendix D contains the annotated bibliography of NPS pollution documents written by Federal, State, and private researchers that are reviewed in this document. It is not intended to be an exhaustive listing of all available primary sources; rather, it is hoped that the bibliography provides an overview of the principal research areas studied over the past 20 years that are generally representative of NPS pollution impact studies.

The bibliographic entries are arranged alphabetically by author. Besides containing information on the paper or report title, authorship, publication date, publisher, page length, and report number(s), each entry also has an abstract adapted from the primary source document. If the complete document or paper is needed, the reader can obtain it by writing to the publication source ("available from:") listed on the bibliographic sheet.

Moreover, each bibliographic entry is cross-referenced in the lower right corner to the corresponding matrix data sheet using the EPA Region number and State abbreviation(s).

SECTION 5

RESULTS

One of the original objectives of this review was to assess geographic (Regional) trends that might emerge from the literature on nonpoint sources of pollution. The primary sources collected, however, do not lend themselves to analysis of Regional trends. Due to time and funding constraints, the literature review was not exhaustive. In addition, many primary sources that dealt solely with chemical or physical changes in water quality parameters resulting from NPS pollution could not be included in this review because they failed to meet the criteria for inclusion in the literature review (i.e., they failed to provide biomonitoring data for assessing changes in aquatic biota).

This literature review is biased toward primary sources published in peer-reviewed journals or EPA reports; the review does not identify a large body of literature (primarily State water quality reports) that address current NPS pollution problems. Thus, trends that might emerge from a review of this small number of subjectively chosen primary sources cannot be assumed to be indicative of either the magnitude or distribution of NPS pollution problems in the United States. Finally, despite efforts to identify research projects conducted in each Region, the EPA Regions are not equally represented by the reviewed literature. Distribution of the primary sources by Region is as follows:

Region	No. of sources
1	8
2	6
3	9
4	14
5	11
6	3
7	3
8	4
9	5
10	5

This difference in Regional representation precludes any discussion of Regional NPS pollution trends of the reviewed literature.

A far less biased approach to assessing current trends is available by using responses of all States to a set of NPS issues such as can be gleaned from America's Clean Water: The States' Nonpoint Source Assessment (1985), prepared by the Association of State and Interstate Water Pollution Control Administrators (ASIWPCA), or from the more recent report, National Water Quality Inventory 1986 Report to Congress (U.S. EPA, 1987). Several national trends are also noted in the latter based on information supplied by each State in their respective 1986 305(b) reports.

5.1 NATIONAL NPS TRENDS

Nationwide, NPS pollution is a significant problem that is responsible for 76 percent, 65 percent and 45 percent, respectively, of the impairment of lakes, rivers and streams, and estuaries reported by States in their 1986 305(b) reports (Figure 3).

Among the 31 States that provided statewide data on lakes not fully supporting uses, nonpoint sources were the principal sources affecting 76 percent of assessed lakes. Point sources affected 9 percent of impaired lakes (8 percent municipal, 1 percent industrial), while 12 percent impairment was related to natural and 3 percent to unknown sources.

Among the 37 States providing data on river miles not fully supporting uses, nonpoint sources were again the principal source, affecting 65 percent of assessed river miles where designated uses were impaired. Point sources affected 27 percent of impaired rivers and streams (17 percent municipal, 9 percent industrial, and 1 percent combined sewer overflows), while natural and unknown sources accounted for 6 percent and 2 percent, respectively, of use impairment.

Among the 16 States reporting on sources of pollution in estuarine waters that do not support designated uses, nonpoint sources were the principal cause of impairment (45 percent), while point sources affected 34 percent (22 percent municipal, 8 percent industrial, and 4 percent combined sewer overflows), and unknown and natural sources accounted for 18 percent and 3 percent, respectively, of use impairment.

The magnitude of NPS pollution is becoming increasingly evident as the States improve their ability to assess the causes of use impairments. Sixteen States identified nonpoint sources as an issue of special concern in their

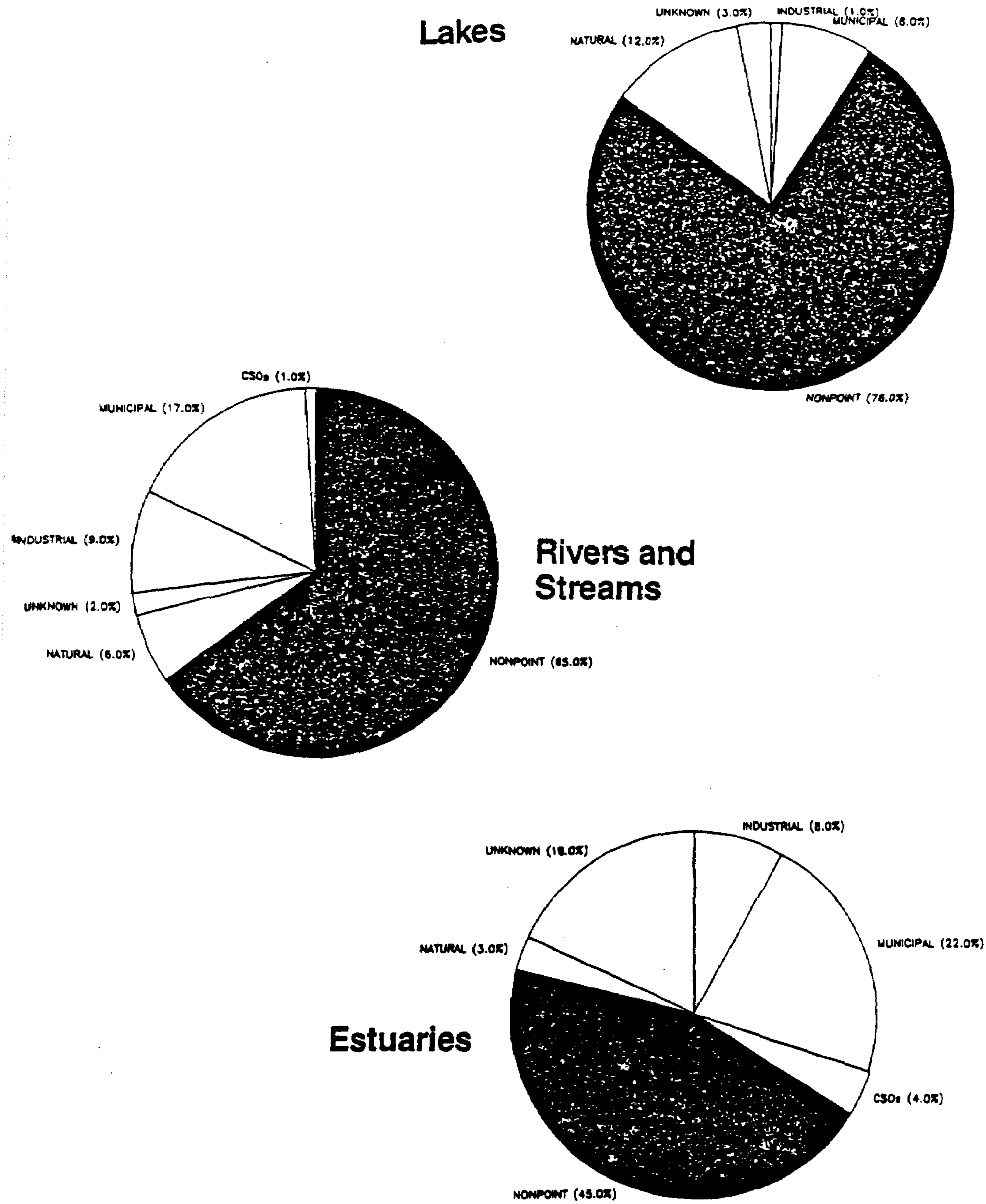

Figure 3. Relative causes of nonsupport in various aquatic ecosystems (adapted from U.S. EPA, 1987).

1986 305(b) reports (Figure 4). Of 52 States and territories that ranked the impact of nonpoint sources, 33 found nonpoint sources to be a major problem, 14 found them to be a moderate problem, 1 reported only minor impacts, and 4 reported that nonpoint sources were a problem of unknown magnitude (U.S. EPA, 1987).

The nonpoint sources reported as major causes of use impairment of State waterbodies are shown in Figure 5. Agricultural activities and urban runoff were reported by more than half the States as the major causes of waterbody impairment, followed by construction runoff, mining activities, landfill leaching, hydromodification, and forestry activities. The most widely reported NPS pollutant of concern was fecal coliform bacteria, followed closely by nutrients, turbidity (sediment), and biochemical oxygen demand (BOD)/dissolved oxygen (DO) (Figure 6). Other pollutants included heavy metals, pesticides/organics, and pH/acidity (U.S. EPA, 1987).

5.2 REGIONAL NPS TRENDS

Regional trends in nonpoint sources can be constructed from several sources of information collected by States, by EPA, or by other Federal agencies. Information on geographic trends is presented on maps where practical. Not all information sources are as current as others, and some trends are based on specific assumptions made from the available data. Readers should consult the original papers cited for specific information on sampling procedures and specific criteria used in data analysis. With these limitations noted, some geographic trends in NPS pollution are presented in the following discussion.

5.2.1 Agricultural Activities

Agricultural activities include crop production and animal production operations. NPS pollutants from agriculture fall into five basic categories: sediment, nutrients, pesticides/herbicides, bacteria, and total dissolved salts (U.S. EPA, 1983). Figure 7 shows the extent of water-caused erosion (tons of soil lost/acre) from the estimated average annual erosion on all U.S. cropland in 1982 (U.S. Department of Agriculture, 1987). The reader should note that water-caused erosion includes sheet and rill erosion, but excludes loss of soil from wind erosion that can be significant, particularly in the arid western States.

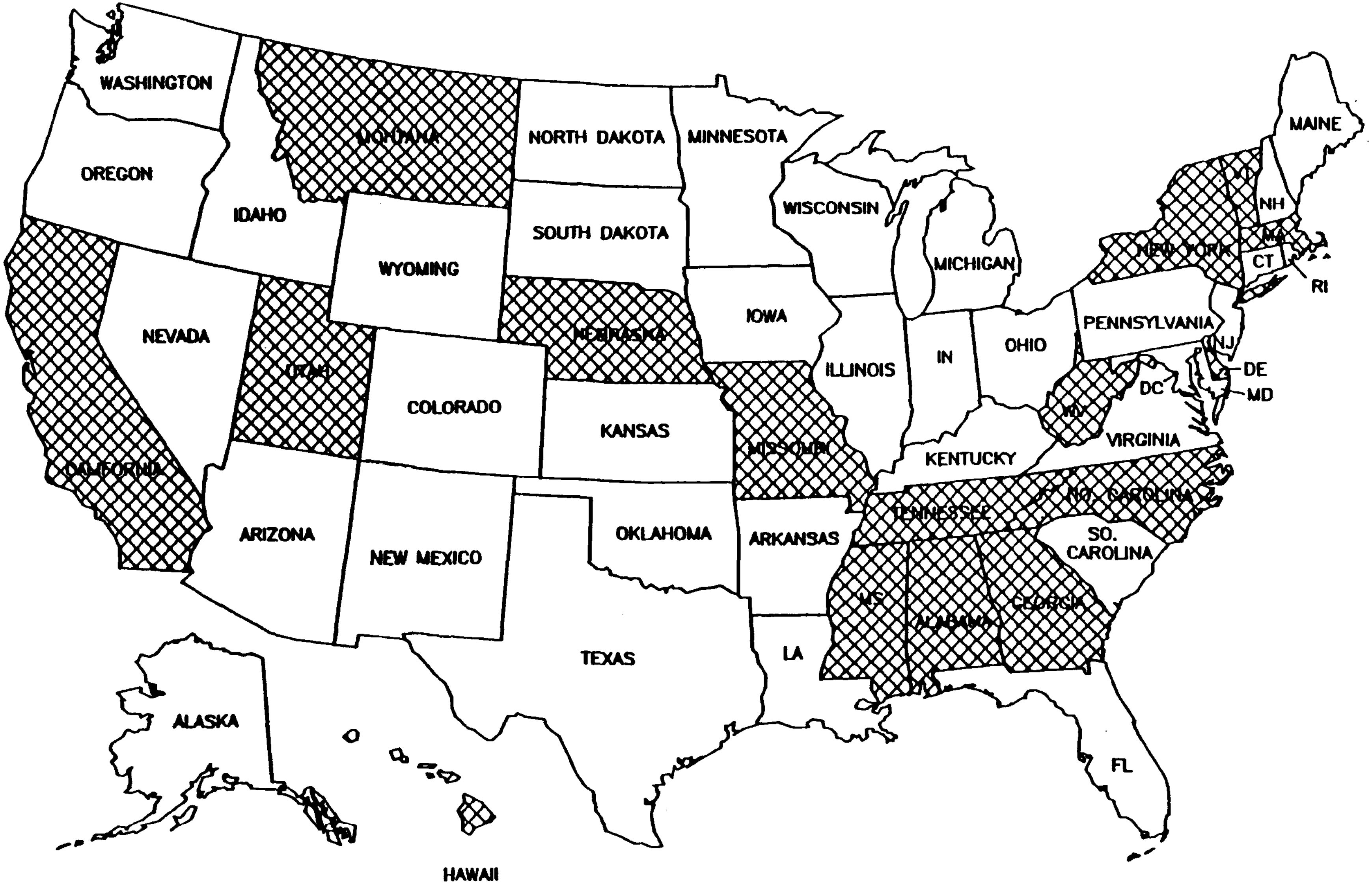

Figure 4. States reporting nonpoint sources as a special concern in their 1986 305(b) reports (from U.S. EPA, 1987).

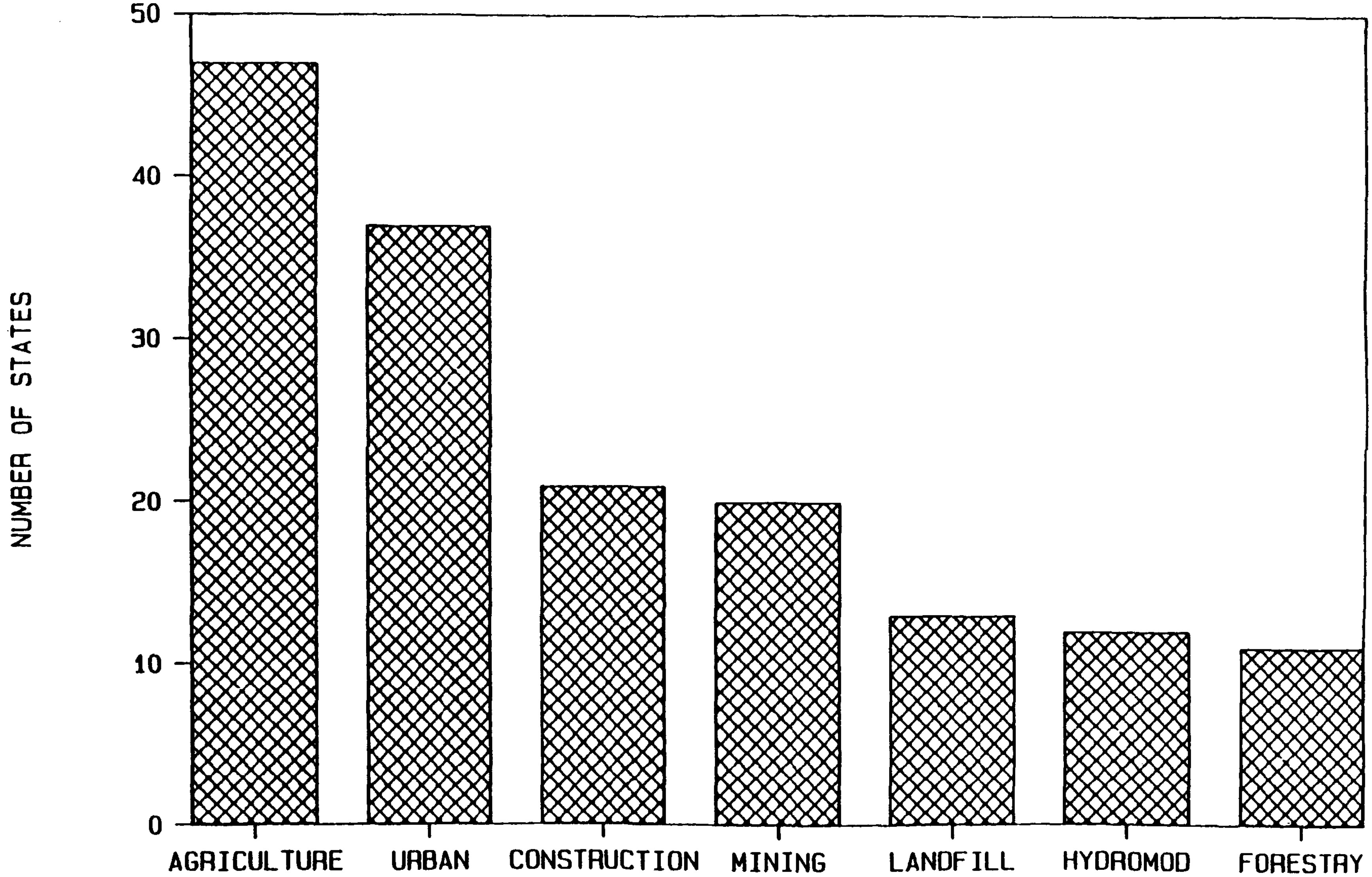

Figure 5. Nonpoint sources reported as major causes of use impairments in State waterbodies (adapted from U.S. EPA, 1987–National Water Quality Inventory).

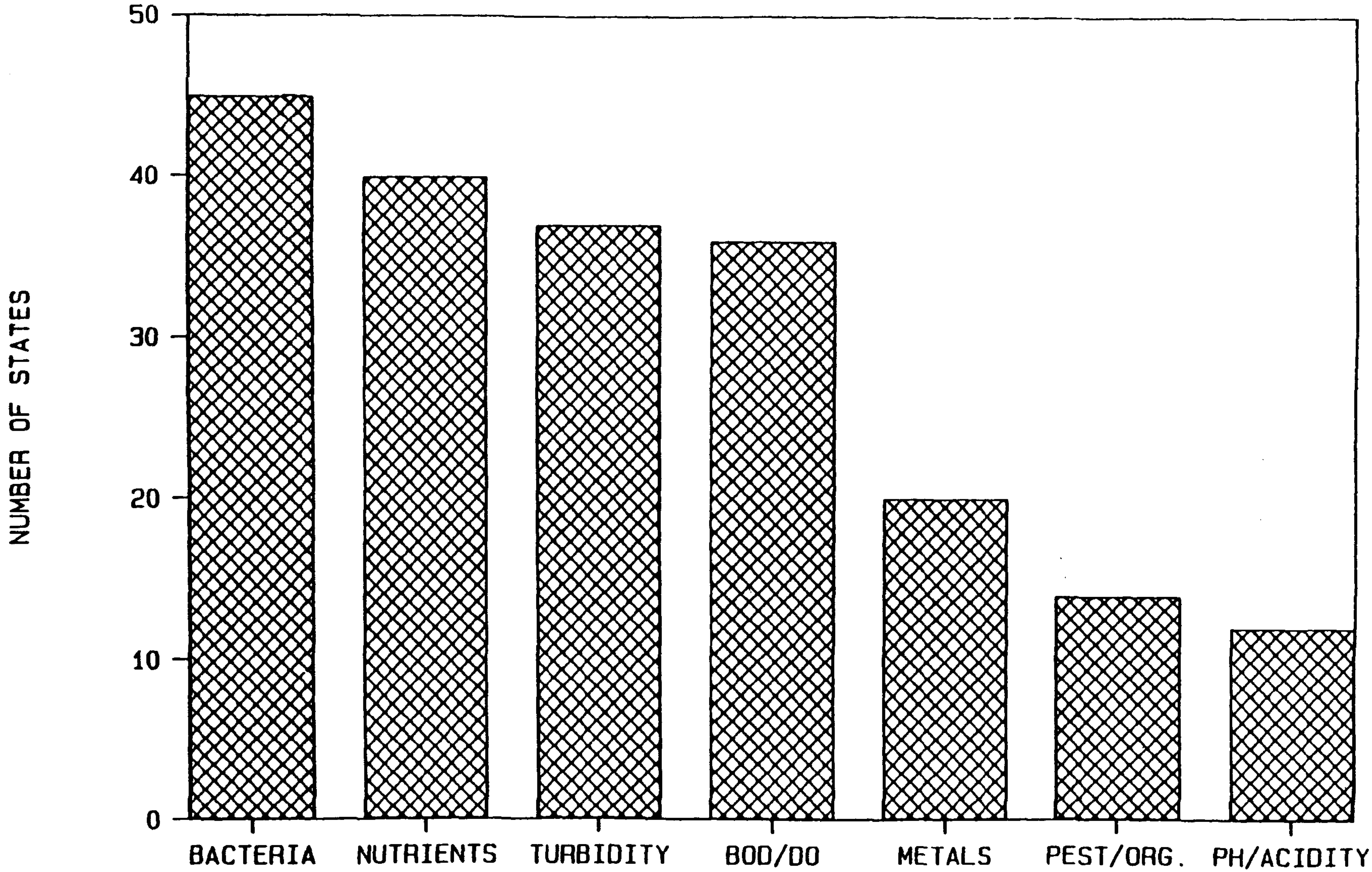

Figure 6. NPS pollution parameters most widely reported by States (from U.S. EPA, 1987–National Water Quality Inventory).

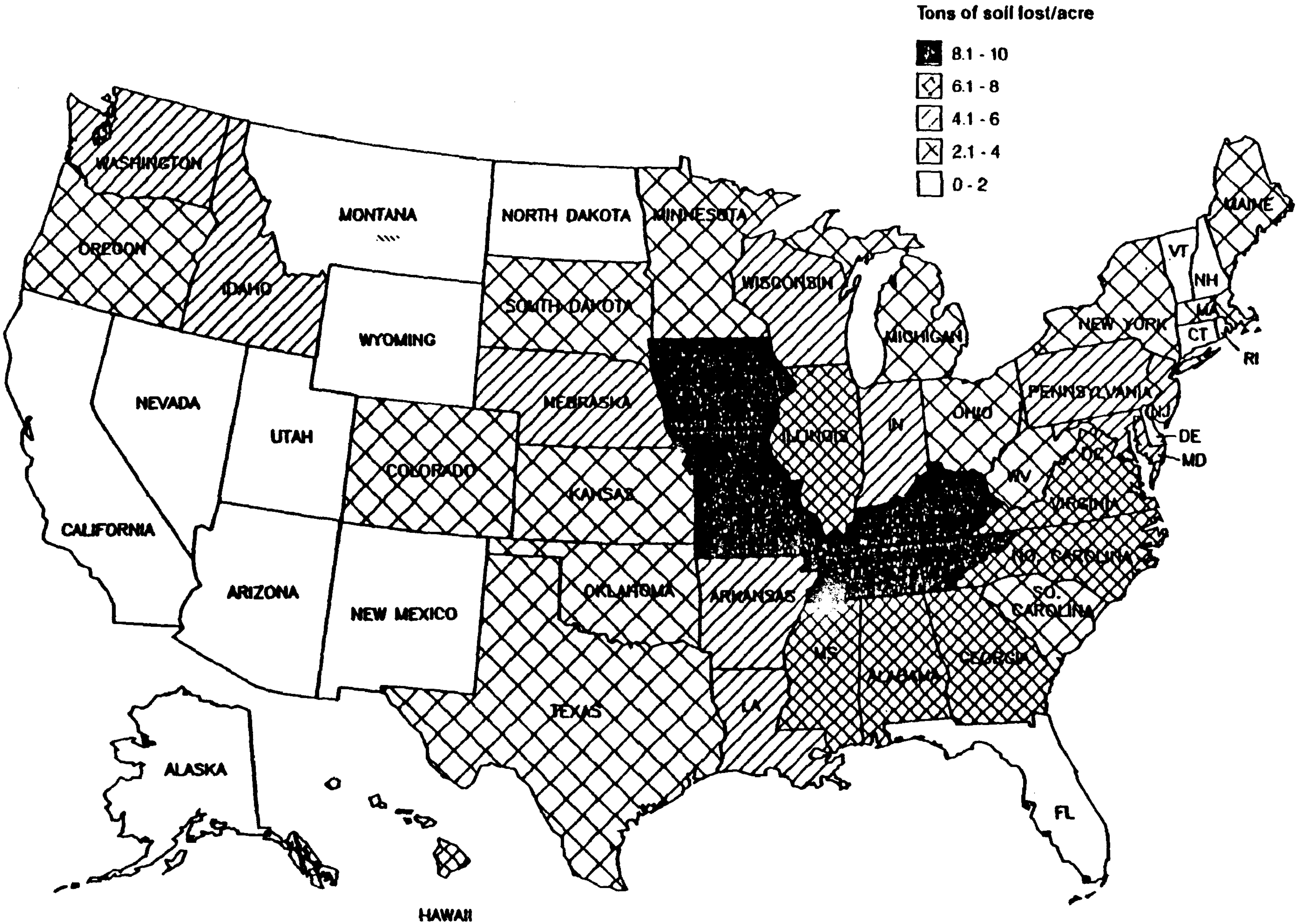

Figure 7. Annual average water-caused soil erosion on all cropland in 1982 (adapted from U.S. Department of Agriculture, 1987).

The magnitude of soil erosion on cropland is assumed to be directly proportional to the intensity of agricultural practices in a given State. As seen in Figure 7, water-caused erosion from agricultural cropland is most severe in Region 7 (IA, MO) and Region 4 (KY, TN, AL, GA, MS, NC), followed by Region 5 (IL), Region 3 (VA), and Region 9 (HI). The Caribbean territories in Region 2 (U.S. Virgin Islands and Puerto Rico) are not shown on the map, but have the highest overall erosion rate (11.05 tons of soil lost/acre). Waterbodies in the geographic areas exhibiting high water-caused erosion rates are likely to have the highest potential for NPS pollution impacts from sediment, nutrients, total dissolved solids, pesticides/herbicides, and bacteria.

5.2.2 Urban Runoff

Urban runoff results from precipitation that flows over urban areas and gathers airborne particles and chemicals; it also results from the subsequent runoff water that collects sediment, bacteria, nutrients, pesticides/herbicides, and other toxic chemicals as it flows across paved and unpaved urban surfaces. The resulting polluted runoff is often discharged into receiving waterbodies via storm sewers.

Figure 8 shows the location of U.S. cities with populations of more than 200,000 inhabitants as of 1980 (U.S. Department of Commerce, 1983). It has been assumed for this discussion that the extent of urban runoff is related to the number and sizes of cities in a given area. The 1980 U.S. population for cities with a population of more than 200,000 inhabitants is given in Table 3. The total number of cities with a population of more than 200,000 is summarized by Region below:

Region	Number of cities >200,000 inhabitants
1	1
2	5
3	7
4	13
5	12
6	13
7	4
8	2
9	13
10	2

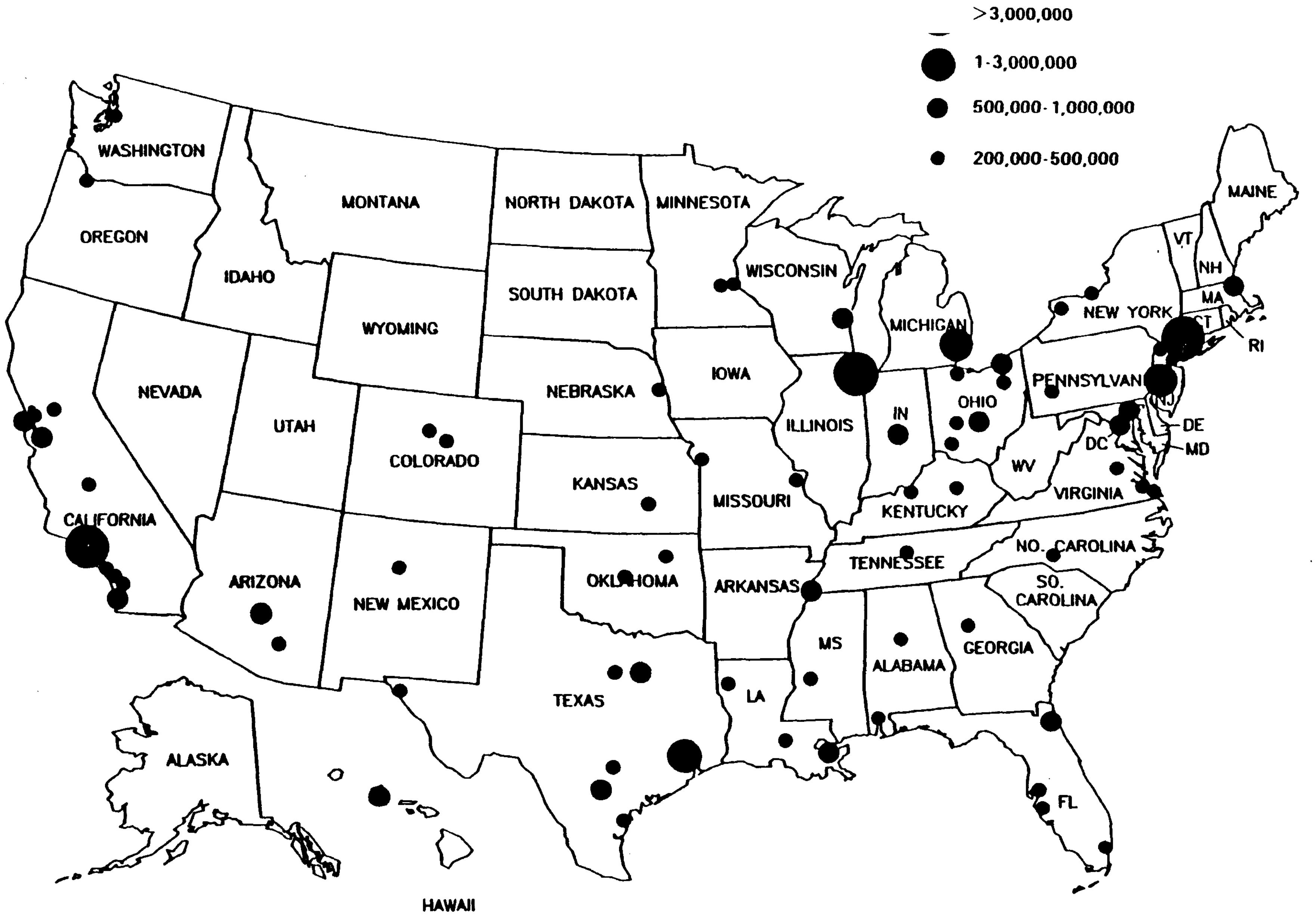

Figure 8. Location of U.S. cities with populations of more than 200,000 inhabitants (adapted from U.S. Department of Commerce, 1983).

TABLE 3. U.S. CITIES WITH 1980 POPULATION GREATER THAN 200,000 INHABITANTS[a]

City	Population	City	Population
EPA Region 1			
Boston, MA	562,994		
EPA Region 2			
New York, NY	7,071,639	Rochester, NY	241,741
Buffalo, NY	357,870	Jersey City, NY	223,532
Newark, NJ	329,248		
EPA Region 3			
Philadelphia, PA	1,688,210	Virginia Beach, VA	262,199
Baltimore, MD	786,775	Norfolk, VA	266,979
Washington, DC	638,333	Richmond, VA	219,214
Pittsburgh, PA	423,938		
EPA Region 4			
Memphis, TN	646,356	Louisville, KY	298,451
Jacksonville, FL	540,920	Birmingham, AL	284,413
Nashville-Davidson, TN	455,651	Tampa, FL	271,523
Atlanta, GA	425,022	St. Petersburg, FL	238,647
Miami, FL	346,865	Lexington-Fayette, KY	204,165
Charlotte, NC	314,447	Jackson, MS	202,895
		Mobile, AL	200,452
EPA Region 5			
Chicago, IL	3,005,072	Cincinnati, OH	385,457
Detroit, MI	1,203,339	Minneapolis, MN	370,951
Indianapolis, IN	700,807	Toledo, OH	354,635
Milwaukee, WI	636,212	St. Paul, MN	270,230
Columbus, OH	564,871	Akron, OH	237,177
Cleveland, OH	573,822	Dayton, OH	203,371
EPA Region 6			
Houston, TX	1,595,138	Austin, TX	345,496
Dallas, TX	904,078	Tulsa, OK	360,919
San Antonio, TX	785,880	Baton Rouge, LA	346,029
New Orleans, LA	557,515	Albuquerque, NM	331,767
El Paso, TX	425,259	Corpus Christi, TX	231,999
Oklahoma City, OK	403,213	Shreveport, LA	205,820
Fort Worth, Tx	385,164		

(continued)

TABLE 3. (continued)

City	Population	City	Population
EPA Region 7			
Kansas City, MO	448,159	Omaha, NE	314,255
St. Louis, MO	453,085	Wichita, KS	279,272
EPA Region 8			
Denver, CO	492,365		
Colorado Springs, CO	215,150		
EPA Region 9			
Los Angeles, CA	2,966,850	Tucson, AZ	330,537
San Diego, CA	875,538	Oakland, CA	339,337
Phoenix, AZ	789,704	Sacramento, CA	275,741
Honolulu, HI	762,874	Fresno, CA	218,202
San Francisco, CA	678,974	Anaheim, CA	219,311
San Jose, CA	629,442	Santa Ana, CA	203,713
Long Beach, CA	361,334		
EPA Region 10			
Seattle, WA	493,846		
Portland, OR	366,383		

[a]Data from U.S. Department of Commerce, 1983.

Regions 4, 5, 6, and 9 have the largest number of cities in this category (>200,000 inhabitants). However, the six most densely populated cities are in Regions 2 (New York), 3 (Philadelphia and Baltimore), 5 (Chicago and Detroit), 6 (Houston), and 9 (Los Angeles). Within Regions 1, 2, and 3, the megalopolis extending from Boston, New York, Philadelphia, and Baltimore to Washington, DC contains a densely populated interstate urban corridor. A similar interstate urban area exists in the Midwest (Region 5) encompassing Detroit, Toledo, and Cleveland. Within Region 6 in Texas, the cities of Fort Worth, Dallas, Austin, San Antonio, and Houston form a large but more dispersed urban cluster. In Region 9 in California, two highly urbanized clusters are formed by San Francisco, Oakland, San Jose, and Sacramento and also by the Los Angeles, Long Beach, Santa Ana, Anaheim, and San Diego corridor and in Hawaii, by Honolulu on the island of Oahu.

5.2.3 Construction Runoff

Although construction activities are temporary events, they are responsible for a large amount of localized environmental damage to nearby waterbodies associated with erosion of disturbed surface soils. By volume, sediment is the major pollutant resulting from construction projects (e.g., highway, residential, or industrial building). An acre undergoing construction may produce sediment losses of 40,000 times that of an adjacent acre of undeveloped woodland (U.S. EPA, 1983).

A study conducted by the U.S. Soil Conservation Service (1978-1979) to assess construction site erosion found it accounted for only 1.4 percent of all erosion (U.S. EPA, 1983); however, construction sites in 10 States accounted for more than 60 percent of all construction erosion nationwide (see Table 4). Of these 10 States, those in Region 4 (AL, NC, GA, TN, KY) accounted for 38 percent; Region 6 (LA, OK, TX) accounted for 16 percent; Region 3 (PA) accounted for 3.9 percent; and Region 5 (OH) accounted for 3.8 percent. Total annual erosion from construction activities for Alabama was twice that of the next highest State monitored. The remaining 40 States together accounted for less than 39 percent. Population shifts to the sunbelt States are likely responsible for increasing highway, residential, and industrial construction, particularly in Region 4, which contributes to the trend toward increased construction runoff.

TABLE 4. SOIL EROSION FROM CONSTRUCTION SITES
(adapted from U.S. EPA, 1983)

Region	State	Tons of erosion (in thousands)	Percent of national total
3	Pennsylvania	3,126	3.9
4	Alabama	13,653	17.1
4	Georgia	3,817	4.8
4	Kentucky	2,970	3.7
4	North Carolina	6,674	8.3
4	Tennessee	3,280	4.1
5	Ohio	3,004	3.8
6	Louisiana	5,071	6.3
6	Oklahoma	4,231	5.3
	Total of 10 States	49,354	61.7
	Total of other 40 States	30,586	38.3
	Total erosion	79,940	100%

5.2.4 Mining Activities

NPS impacts to rivers and lakes are produced from a variety of mining-related activities. Acid mine drainage occurs when sulfur-bearing minerals are exposed during mining operations, resulting in the formation of sulfuric acid in the presence of water and air. The resulting acidic waters may dissolve heavy metals from geologic formations. Major NPS pollutants of concern associated with mining activities include pH/acidity, heavy metals, and sediment.

Figure 9 shows the nine States that cited mine drainage as a special concern in their States' 1986 305(b) reports. By Region, the States include: Region 1 (ME), Region 3 (PA, MD, WV), Region 4 (KY, AL), Region 7 (MO), Region 8 (MT), and Region 9 (CA). Region 3 contains the largest number of States reporting mining activities as a NPS concern.

5.2.5 Forestry Activities

Silviculture activities encompass the cultivation and harvest of timber for commercial uses. NPS impacts can result from site preparation, tree harvesting activities, fertilization, pesticide/herbicide use, reforestation activities, fire suppression activities, and road building (U.S. EPA, 1983). NPS pollutants from silviculture activities include sediment, nutrients, and pesticides/herbicides.

The percentage of land area in each State in commercial forest production is shown in Figure 10.* NPS pollution impacts from forestry activities appear to be most likely in Region 1 (ME, VT, NH, MA, CT, RI), Region 3 (WV, PA, VA) Region 4 (AL, GA, NC, SC, MS), and Region 10 (OR, WA) based on the percentage of commercial forest land. According to U.S. Forest Service estimates, timber production will continue to be concentrated primarily in the Pacific Northwest States and the South (U.S. EPA, 1983). Although it can be a severe local problem, silviculture-related pollution does not appear to be a problem of widespread national significance (U.S. EPA, 1983).

5.2.6 Acid Deposition

Acid deposition occurs in the United States due largely to sulfur dioxide and nitrogen dioxide emissions from industrial processes, combustion, and

*Approximately 67 percent (500 million acres) of forest land is classified as commercial forest--land capable of producing 20 cubic feet of woody fiber per acre per year (U.S. EPA, 1983).

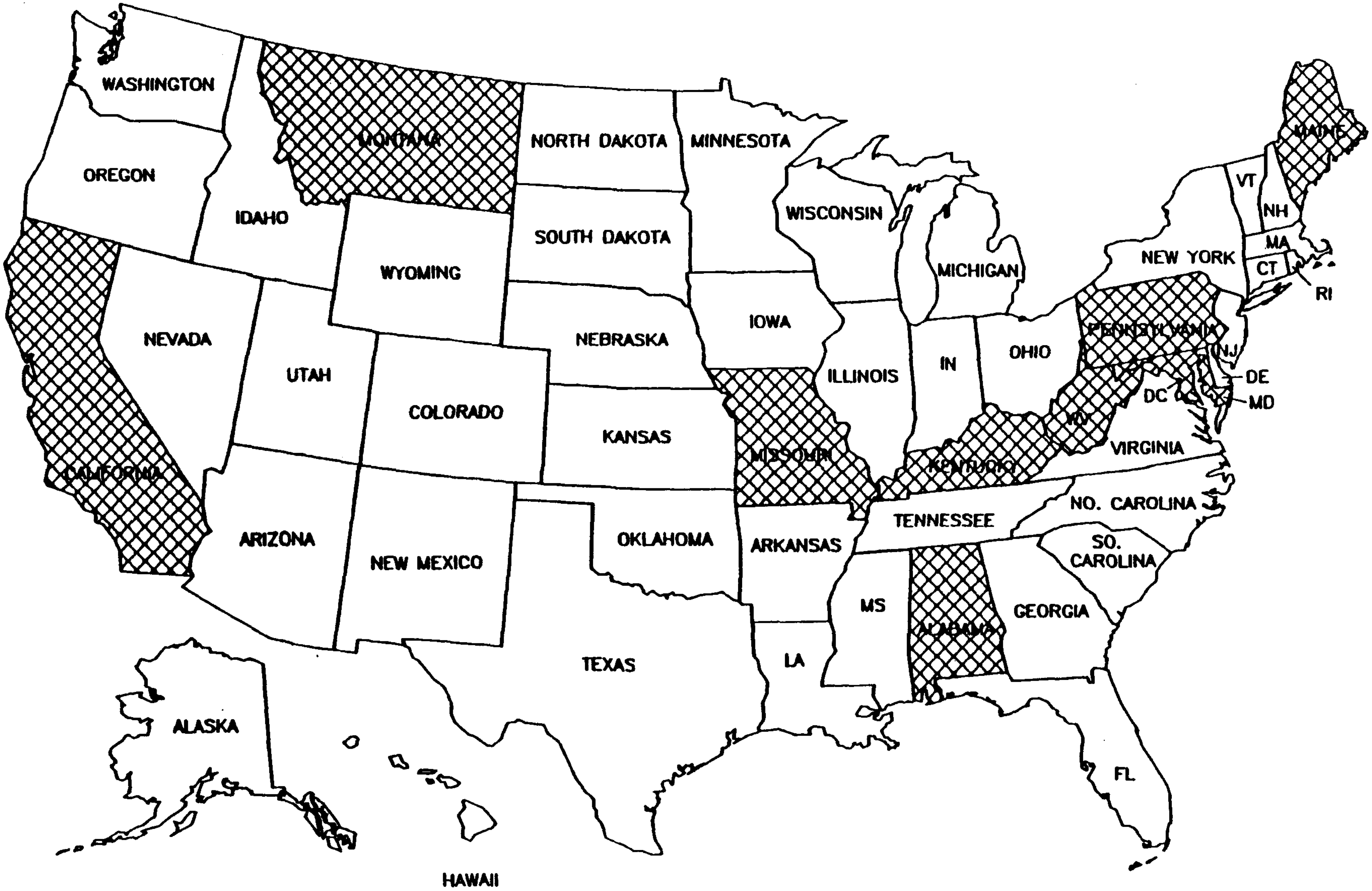

Figure 9. States reporting mining-related problems as a special concern in their 1986 305(b) reports (from U.S. EPA, 1987).

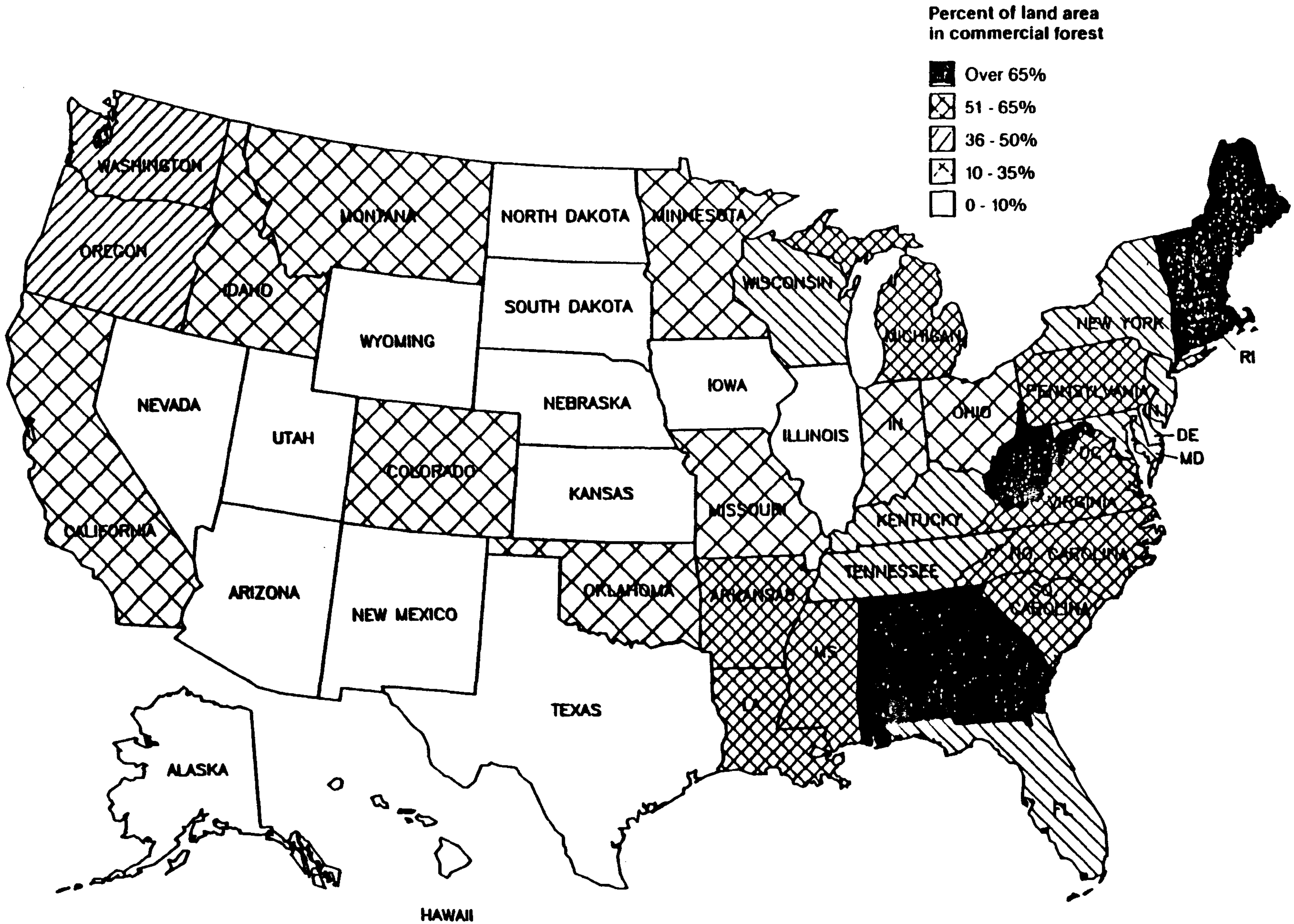

Figure 10. Percentage of commercial forest land in each State (adapted from U.S. Department of Agriculture, 1980).

mobile sources; however, oxidants such as ozone, hydrogen peroxide, and organic free radicals are also associated with and required for the production of sulfuric and nitric acid, which cause acidic rain (National Acid Precipitation Assessment Program, 1987).

Acid deposition was cited in the 1986 305(b) reports of 13 States as an NPS problem of concern. These States are shown in Figure 11 and include Region 1 (ME, NH, MA, CT), Region 2 (NY, NJ), Region 3 (PA, MD), Region 4 (FL, TN), Region 6 (LA), and Region 8 (MT, WY). Most of these 13 States cited lowering of rainwater pH as evidence of potential problems (U.S. EPA, 1987). Based on rainwater pH, the New England States (Region 1) and Mid-Atlantic States (Regions 2 and 3) appear to be most severely affected by the acid deposition problem (U.S. EPA, 1987).

A slightly more extensive area affected by acid deposition has been reported in several other recent studies. Figure 12 shows a map of pH in rainfall over the United States based on 1985 annual precipitation-weighted pH values from the National Acid Precipitation Assessment Program (NAPAP). The most acidic rain encompassed by the 4.2 pH contour includes western Pennsylvania, eastern Ohio, and northern sections of West Virginia and Maryland. Rainfall with a pH of 4.4 or less encompassed Region 1 (southern ME, VT, NH, MA, CT, RI), Region 2 (NY, NJ), Region 3 (PA, DE, MD, WV, VA), Region 4 (western NC, TN, KY), and Region 5 (OH, IN, MI, eastern IL). An almost identical spatial distribution pattern is reported for median pH of rainfall from a study by Semonin et al. (1987) using National Acid Deposition Program (NADP) network data. Knapp et al. (1988) reported that the 10 NADP sites where the most acidic rain was collected from January 1979 to December 1984 were located in Region 2 (NY), Region 3 (PA and WV), and Region 5 (OH). In their study, sites with a median pH ≥ 5 were all located west of a line extending from northwestern Wisconsin to the Gulf Coast of Texas. Because precipitation is greater in the East than in the western United States, both the intensity and amount of acidic inputs to both terrestrial and aquatic ecosystems are greater in the East (Knapp et al., 1988). Acid deposition appears to be a more severe NPS pollution problem in the eastern United States than in the western United States.

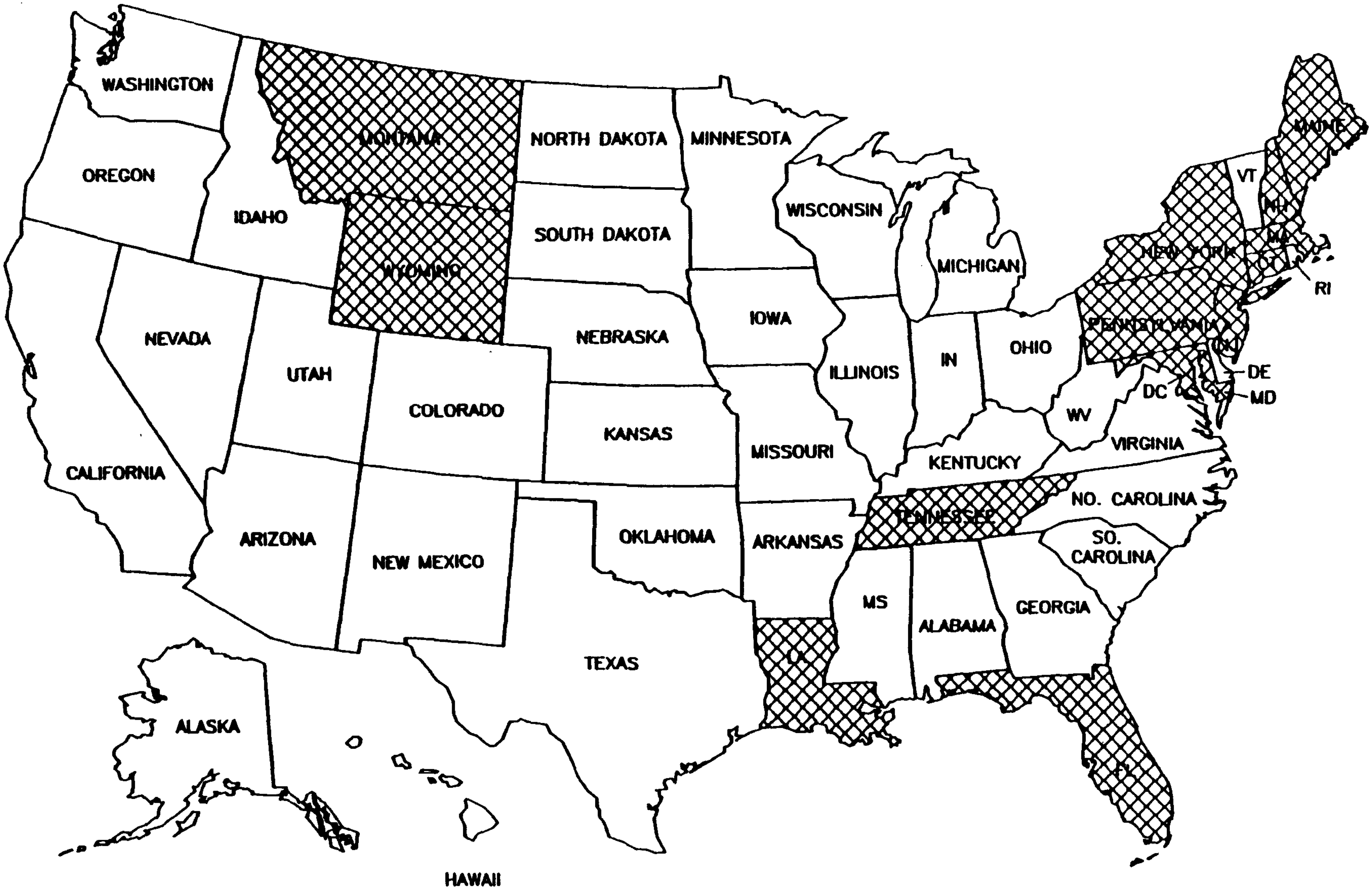

Figure 11. States reporting acid deposition as a special concern in their 1986 305(b) reports (from U.S. EPA, 1987).

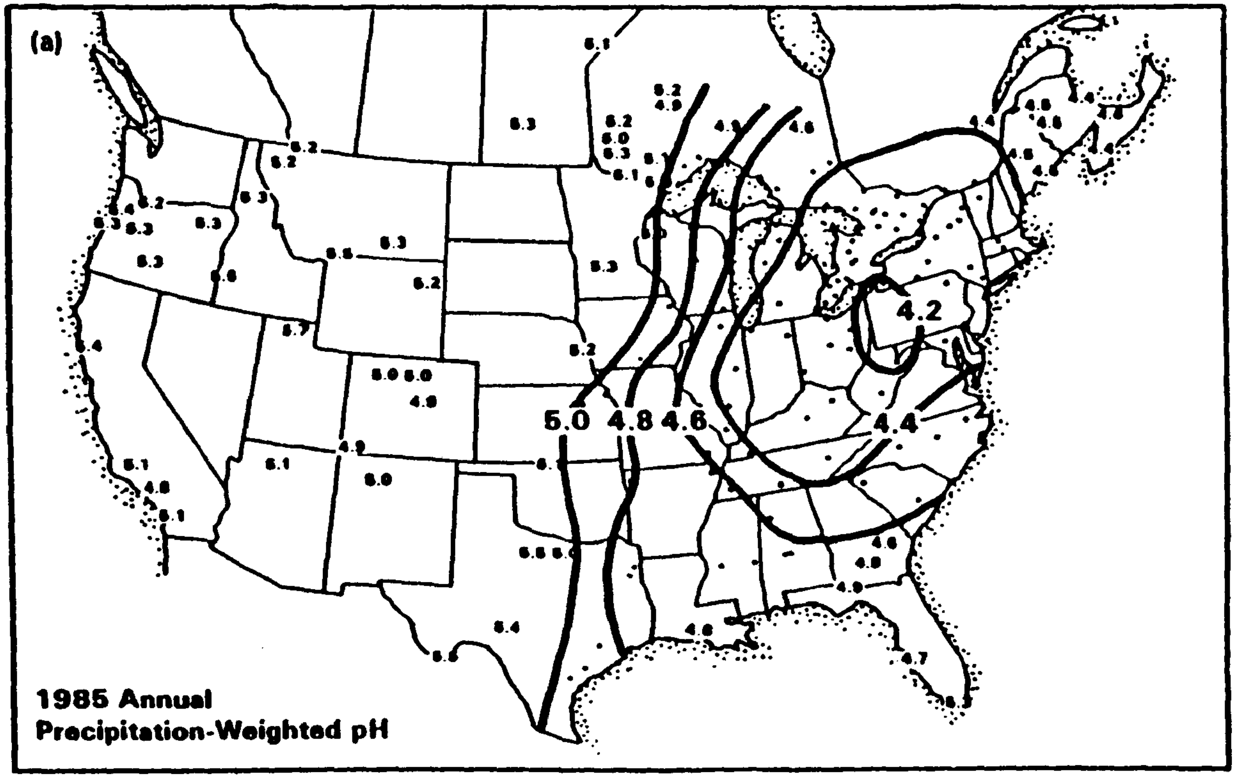

Figure 12. 1985 Contour and selected station map of pH in rain over the United States (from National Acid Precipitation Assessment Program, 1987).

5.3 BIOMONITORING TRENDS

Even though the nature of this literature review precludes any discussion of Regional NPS pollution trends on aquatic life, some trends emerge with respect to the type of nonpoint sources studied using biomonitoring techniques and the nature of the aquatic community chosen to monitor NPS impacts. With respect to the nonpoint sources studied, 69 percent of the reviewed primary sources reported effects on aquatic biota from agricultural activities, forestry activities, or urban runoff. Agricultural activities (including 7 percent land use studies), forestry activities, and urban runoff represented 38, 16, and 15 percent, respectively, of the nonpoint sources of pollution in the literature review. The remaining 31 percent reported impacts to aquatic biota from mining activities (13 percent), construction activities (12 percent), acid deposition (3 percent), hydromodification activities (1.5 percent), and landfill leaching (1.5 percent) (see Figure 13).

With respect to the effects of NPS pollution on aquatic biota, 65 percent of the papers reviewed reported changes to only one group of biota, 25 percent reported changes to two groups, and 10 percent reported changes to three or more different groups of biota at various trophic levels in the aquatic community. Of those authors using only one group of biota to monitor NPS pollution effects, 68 percent selected macroinvertebrates, 21 percent selected fish, and 11 percent selected other groups (i.e., amphibians, algae/periphyton, aquatic plants, or zooplankton). Of those authors using two groups of biota to monitor NPS pollution effects, 60 percent used both macroinvertebrates and fish, while 40 percent used various combinations of macroinvertebrates or fish with another group. Of those using three or more groups, all monitored effects on both macroinvertebrates and fish in addition to a variety of other groups of aquatic biota.

Macroinvertebrates and fish were the predominant groups of choice as bioindicators of NPS pollution for the literature reviewed. Overall, 47 percent of the primary sources reviewed monitored changes in the macroinvertebrate community, 25 percent in the fish community, 17 percent in the algal or periphyton community, 5 percent in aquatic plants (macrophytes), 3 percent in zooplankton, 2 percent in amphibians, and 1 percent in aquatic birds (Figure 14). The statistical analysis of biological monitoring data was most extensive and rigorous for the macroinvertebrate and fish communities

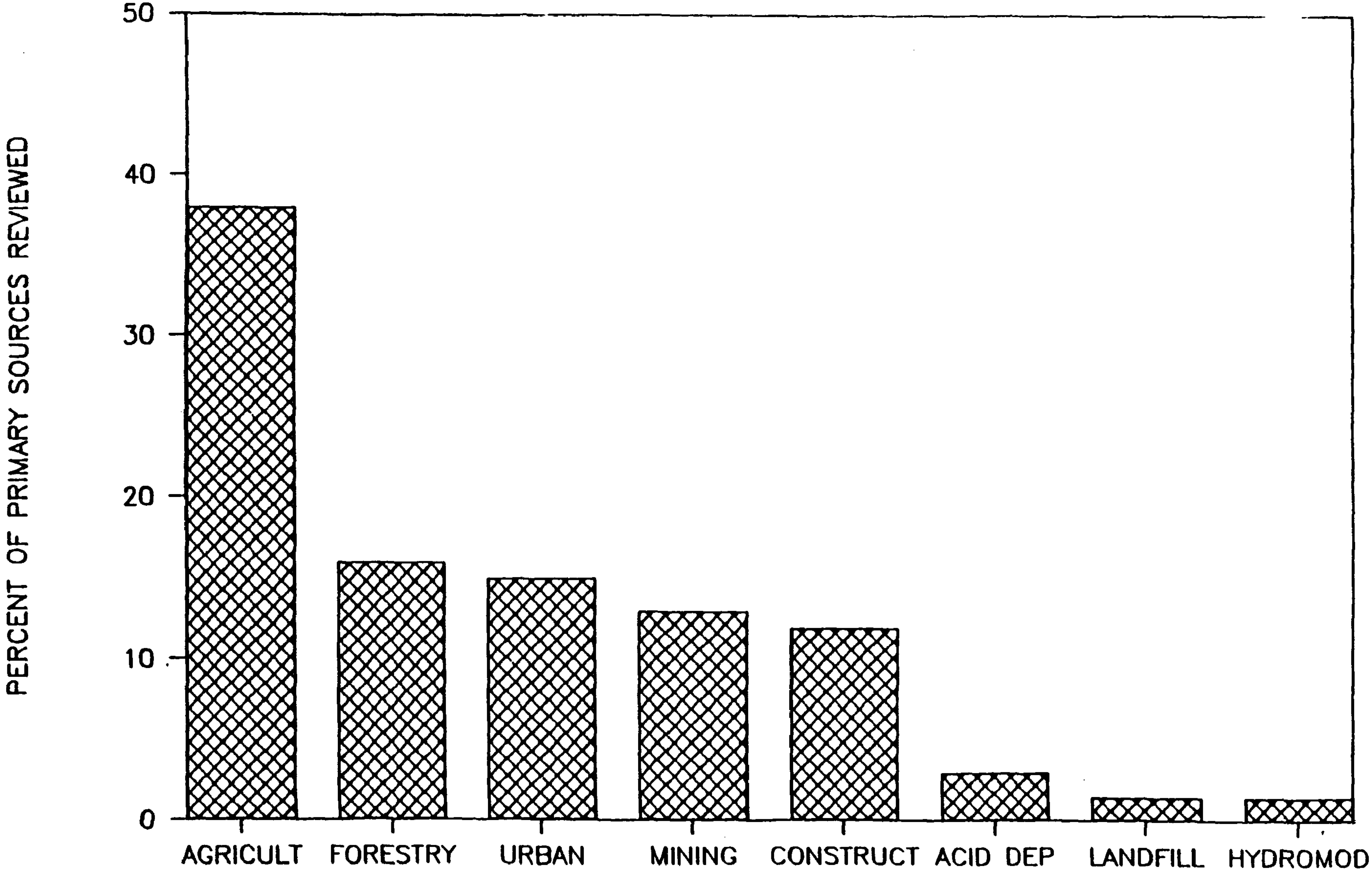

Figure 13. Nonpoint sources represented in this literature review.

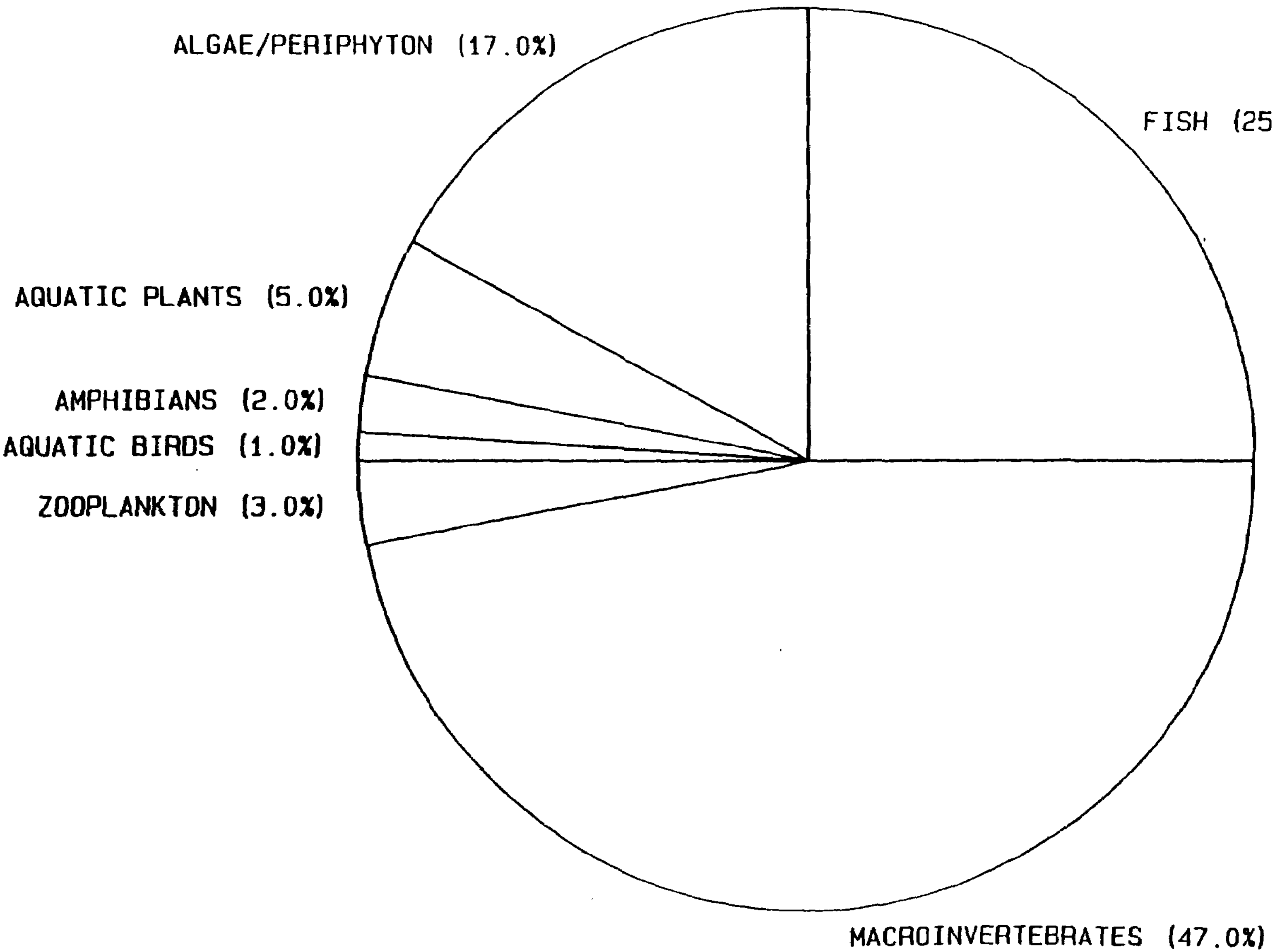

Figure 14. Representative groups of biota used to monitor effects of NPS pollution on aquatic communities.

studied and included (1) the use of a variety of species versity indexes and biotic condition indexes, as well as (2) the analysis of taxa richness, eveness, density, biomass, and the presence or absence of recognized pollution-intolerant or pollution-tolerant species for assessing the effects of NPS pollutants.

SECTION 6

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Appendix A

NCSU-WQ Inventory Package

ANNOTATED NPS BIBLIOGRAPHY

Version 87.1

August, 1987

NCSU Water Quality Group

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The NWQEP ANNOTATED NPS LIBRARY

INTRODUCTION

The NCSU Water Quality Group has about 3,000 holdings in its computerized Non-Point Source (NPS) Library at present. Each holding is assigned a holding number which identifies it in our library. The protocol for these assignments is to number them chronologically as they are received. The holdings consist of articles from refereed journals, reports from state and federal agencies, chapters from books and conference proceedings, NPS project reports, and non-refereed research reports presented at meetings. The NWQEP library has hard copies of most of the holdings, which may be made available for loan.

A topic number outline (see TOPIC OUTLINE section) is available which includes such main categories as Agricultural Pollution and Management Practices , Water Quality, Data Treatment, Crops, Legislation, and Agencies. Sub-level topics for each of these categories give more detail to each topic number. Further delineation to sublevel topic is designated by successive digits in the topic number. Each holding has been reviewed and assigned a topic number from the topic number outline. Four additional topic numbers (referred to as subtopcis) can be assigned to an article.

A short annotation of up to 20 typed lines (72 characters per line), is written to summarize those aspects of the article which pertain to agricultural or urban water quality issues, control practices, or effects. If the annotation is the author's abstract, the annotation begins with 'ABS.' Otherwise, it was written by one of the NWQEP staff. Annotations too long to fit in the allotted space on the computer system are shortened.

The computerized library may be accessed through the card file or by an interactive retrieval program which runs SAS jobs to search the data base either by keywords on titles and/or annotations, author, or by topic number. Using the interactive program, articles can be retrieved by author even if the author requested is not the primary author, but appears as one of the secondary authors. A search by a general topic number will yield all subtopics nested within that number. A more specific topic number request will retrieve only those subtopics nested below in the outline, along with the requested subtopic. The user is given the choice of requesting both the citations with annotations or just the citations in any given search.

The attached bibliography is a listing of the current computerized library arranged in major topic number order within each topic number, articles are arranged by year of publication and article number.

SYSTEM OBJECTIVES

The Nonpoint Source Control Water Quality Evaluation and Technical Assistance Library System (LS) was created to meet five objectives:

(1) To document the availability of publications related to various aspects of nonpoint source control.

(2) To identify publications on a topic-specific basis so that the user may efficiently search the literature.

(3) To enable easy access from one point in the system to any other point in the system.

(4) To provide a continuous update of information for the preparation of reports on BMP effectiveness.

(5) To provide enough flexibility to allow for expansion of the system beyond Objective 1.

SYSTEM DESCRIPTION

The LS consists of six components which are integrated in such a way that the user may find information at several levels (Figure 1). The user has access from one point in the system to any other point in the system as shown in Figure 1.

Outline. The outline is arranged by topic with each major level and sublevel assigned a decimal number. Major topic levels (e.g. legislation, agencies, agricultural management practices) are assigned integral numbers (1,2,3,etc.) and topic sublevels (e.g. Federal, statewide, fertilizer) are given decimal fraction numbers (1.1, 1.11, 1.111, etc.). In the event that more than nine topic sublevels exist at any level in the outline, the upper case letters (A,B,C, etc.) are used (e.g. 1.8, 1.9, 1.A, 1.B, etc.). Changes and additions to the outline are facilitated by the fact that the outline is open-ended.

Each article is assigned a primary topic. It may have up to 4 additional topics, referred to as subtopics.

A complete description of the outline is included at the end of this section.

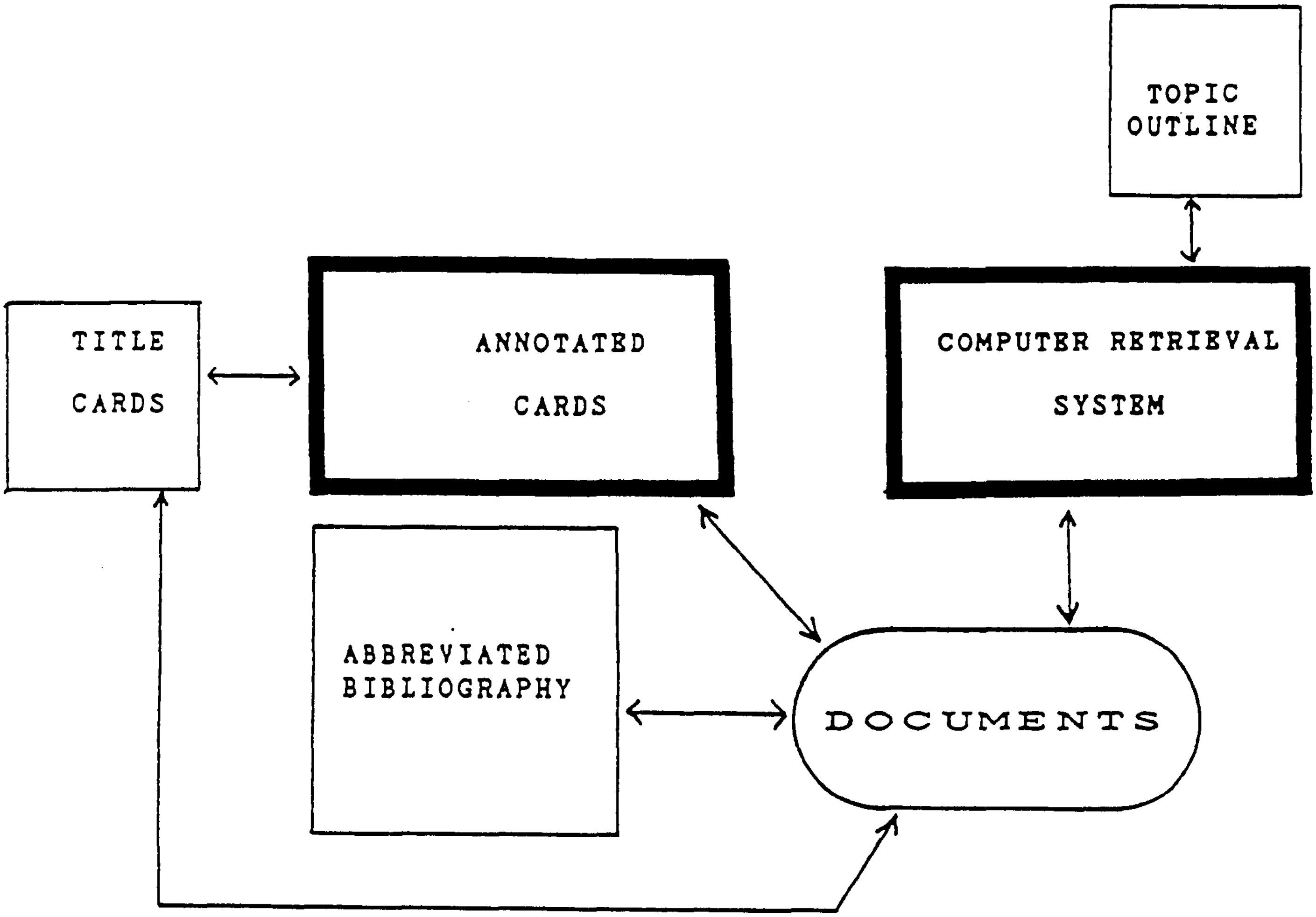

Figure 1. Flow Diagram of Library System Components

Title Cards. Each publication has a corresponding title card located in the NCSU Water Quality group title card file. Title cards list the title, authors, topic number, subtopic numbers, source number, citation, and the location of the hard copy in the NWQEP's library (C=filing cabinet, B=bookshelf, F=microfiche, P=project files). No complete bibliography is provided. Below is the format of a title card:

Topic number (subtopics)	Source No. Location Code
Title	
Authors	
Citation	

Title cards are utilized most often by the librarian, while updating the library, or by users who know the title of a work of interest.

Annotation Card. The annotated bibliography is arranged alphabetically by author on cards. On each card is a complete bibliography, short annotation, source number, topic number, subtopic numbers, additional keywords, cross reference article numbers, and hard copy location:

Topic number (subtopics)	Source No. Location Code
Authors "Title" Source citation Year of publication	
Annotation KEYWORDS: XREF:	

Abbreviated Bibliography. The abbreviated bibliography a printed document arranged numerically by source number (aka 'the Black Book'). Each entry has a source number, the first author, the first 60 characters in the title, primary and subtopic numbers, and location of the hardcopy. This is not included in this publication, but is maintained by the NCSU Water Quality Group librarian.

Computerized System. The attached listing is a printout of the current computerized annotated bibliography. It is sorted by primary topic number, year of publication, and article number in this printout.

The computer retrieval system consists of a data file, complete with citations, annotations, and article and topic numbers (it is essentially a copy of the annotated card file). There is also a record of the entry date into the computer, the year of publication, and the code for the hard copy location in the library holdings.

This file can be searched by a program which will retrieve articles by keywords on the title and/or annotation, by authors, or topic number. Output will include all citations for a given search, accompanied by annotations if desired.

Keyword, Topic, and Author Searches. We have the capability to do keyword searches on the titles and/or annotations in our NPS library. We can also perform searches for author names and for topic numbers.

Searches for topic numbers will be on both primary and subtopic numbers for the articles.

The topic outline is hierarchical in design. If you ask for a search on topic 3. you will get **ALL** articles under 3, including 3.1, 3.2, ..., 3.6, 3.62, etc. Therefore, you need to be as specific as possible or your search will be larger than you might suspect. A list of each topic number and how many articles would be found in a topic number search is shown in Table 1.

The current keyword search, by default, looks to see if **ANY** of the requested words are found. Optionally, you may request that the article be retrieved only if **ALL** of the keywords are found.

The retrieval request form must be completed and sent to NCSU Water Quality Group, ATTN: NPS librarian. Form is shown in Figure 2. A separate form is required for each type of search. However, multiple searches for a field are accepted. For example, several authors, etc.

The output of a search is in the same format as the printed library. It is sorted by major topic number and publication date and contains the complete citation and annotation.

The price of the search is a function of the number of pages requested. A processing charge of $5.00 plus $0.06 per page will be assessed. Any special services will have a $20.00/hr. charge. First class postage fees usually range between $1.00 to $3.00 and will be charged to the requester.

Documents. Library holdings consist of articles from refereed journals, reports from state and federal agencies, chapters from books and conference proceedings, Nonpoint Source project reports, and non-refereed research reports presented at meetings. The NCSU Water Quality Group Library has hard copies of most of the citations in the annotated file.

Table 1. Tabulation of frequency of articles with a given topic or subtopic number. Due to counting of subtopics, the number is greater than the number of articles. Version 87.1. August, 1987.

Topic	Freq.	Topic	Freq.	Topic	Freq.	Topic	Freq.	Topic	Freq.
1.0	2	3.42	71	4.4	3	5.61	33	6.52	1
1.1	14	3.43	43	4.5	24	5.62	12	7.0	16
1.11	4	3.44	52	4.6	1	5.63	6	7.1	16
1.2	15	3.5	35	4.8	15	5.64	2	7.11	1
1.3	3	3.5A	21	4.9	7	5.65	1	7.111	1
1.4	1	3.51	5	5.A	64	5.651	1	7.12	1
2.1	4	3.52	26	5.A1	45	5.652	1	7.122	1
2.11	7	3.521	2	5.A2	16	5.7	16	7.13	3
2.12	20	3.522	25	5.A3	4	5.71	13	7.14	1
2.2	4	3.523	5	5.A4	13	5.72	5	7.2	19
2.21	1	3.524	3	5.B	1	5.73	1	7.21	8
2.211	2	3.525	1	5.B1	1	5.75	1	7.22	2
2.212	2	3.53	15	5.B3	1	5.8	92	7.222	4
2.218	2	3.531	12	5.C	1	5.81	50	7.3	9
2.3	1	3.532	4	5.D	3	5.82	1	7.31	5
2.31	22	3.533	5	5.E	3	5.83	6	7.32	4
2.4	17	3.534	2	5.0	69	5.84	17	7.4	7
2.5	31	3.54	1	5.1	13	5.9	6	7.5	20
3.0	27	3.55	44	5.11	29	5.94	1	8.1	2
3.1	134	3.56	31	5.12	13	6.0	24	8.131	1
3.11	15	3.563	1	5.13	1	6.1	25		
3.12	13	3.57	45	5.14	4	6.11	35		
3.13	225	3.58	33	5.15	3	6.111	16		
3.14	149	3.581	1	5.2	195	6.112	16		
3.144	1	3.59	20	5.2A	1	6.113	20		
3.15	22	3.6	85	5.21	44	6.12	9		
3.16	4	3.6A	7	5.22	17	6.121	4		
3.2	84	3.6B	12	5.23	8	6.122	7		
3.20	1	3.61	40	5.24	5	6.123	2		
3.21	12	3.62	43	5.3	170	6.13	6		
3.22	1	3.63	145	5.30	1	6.131	5		
3.223	1	3.631	40	5.31	1	6.132	4		
3.23	4	3.64	51	5.4	19	6.133	2		
3.24	34	3.65	18	5.41	1	6.2	44		
3.25	25	3.651	30	5.43	2	6.21	61		
3.26	23	3.652	16	5.5	39	6.22	23		
3.27	33	3.653	19	5.51	51	6.23	27		
3.28	8	3.654	18	5.511	38	6.24	46		
3.281	2	3.66	17	5.512	8	6.25	73		
3.282	118	3.67	18	5.513	1	6.26	17		
3.3	112	3.68	17	5.514	10	6.261	1		
3.31	8	3.69	9	5.515	1	6.3	7		
3.32	166	4.A	5	5.52	8	6.31	9		
3.321	17	4.B	3	5.521	9	6.32	161		
3.322	35	4.C	4	5.522	3	6.33	279		
3.323	162	4.0	10	5.523	1	6.34	29		
3.324	80	4.1	8	5.525	1	6.35	30		
3.4	50	4.2	6	5.551	1	6.4	3		
3.41	122	4.3	19	5.6	76	6.43	1		

Figure 2.

FORM FOR NWQEP NPS LIBRARY RETRIEVAL REQUEST

Please fill in items 1 and 2. Then complete item 3 or 4 or 5 according to the type of search you are requesting.

1. Requestor's Name: ______________________ Date Processed ____________ (Leave Blank
Request Date: ______________________
Address: ______________________
____
Phone No.: ( ) ______________

2. Type of Search: (Circle 1) Author (go to #3)
Topic (go to #4)
Keyword (go to #5)

If a keyword search is requested, circle one or both of the fields to search:

TITLE and/or ANNOTATION.

---

3. Topic Search:

List topic number from the NPS library topic outline you would like printed. Articles with primary and subtopic numbers that match request will be printed. Be as specific as possible. For example topic #3 will yield 300 pages, but 3.62 produces about 5-10 pages.

a.
b.
c.
d.

---

4. Author Search:

List authors you would like to search for articles. They do not have to be first authors.

a.
b.
c.
d.

---

5. Keyword Search:

Problem Description:

List the keywords you would want identified in the title and/or annotation field (See #2 above). Please indicate if you would like **ALL** of the words found for the article to be cited. The default is to cite the article if **ANY** one of the keywords is found. Each line below represents a separate search:

a.
b.

ABBREVIATIONS

AGENCIES AND ORGANIZATIONS

FULL NAME	ABBREVIATIONS
All State Extension Services	XX Ag. Ext. Service (XX's State Abb.)
American Society of Agricultural Engineers	ASAE
American Society of Civil Engineering	ASCE
American Water Resources Association	AWRA
Chesapeake Research Consortium	CRC
Comptroller General of the United States, General Accounting Office	Comptrol. Gen. US, GAO
Council for Agricultural Science and Technology	CAST
Financial Management Assistance Program	FMAP
Food and Drug Administration	FDA
Illinois Environmental Protection Agency--Water Pollution Control	ILEPA-WPC
International Hydrological Decade, World Health Organization	IHD-WHO
International Joint Commission	IJC
--Pollution from Land Use Activities Reference Group	--PLUARG
Iowa Department of Water, Air and Waste Management	IA Dept. WA Air Wst Mg.
National Association of Conservation Districts	NACD
National Council of the Paper Industry for Air and Stream Improvement, Inc.	NCASI
National Research Council of the United States	Nat. Res. Council, US
National Technical Information Service	NTIS
National Water Quality Evaluation Project	NWQEP
North Carolina Department of Natural Resources and Community Development	NRCD
North Carolina Department of Natural Resources and Community Development--Division of Environmental Management	NRCD-DEM
North Carolina State University Water Quality Group	NCSU Water Quality Group
Office of Technology Assessment	OTA

Royal Society of Canada	Royal Soc. of Canada
Rural Clean Water Program	RCWP
Surface Water, Section of the University of Illinois	SWS
Southwestern Illinois Metropolitan and Regional Planning Commission	SWIL-MAPC
United States Department of Agriculture	USDA
--Advances in Agricultural Technology	--AAT
--Agricultural Conservation Program	--ACP
--Agricultural Research Service	--ARS
--Agricultural Stabilization and Conservation Service	--ASCS
--Cooperative Extension Service	--CES
--Economic Research Service	--ERS
--Economics and Statistics Service	--ESS
--Science and Education	--SE
--Soil Conservation Service	--SCS
--Field Office Communication and Automation System	--FOCAS
United States Environmental Protection Agency	USEPA
--Water Planning Division	--WPD
United States Geological Survey	USGS
United States Water Resources Council	US. Water Res. Council
Utah State University Foundation	Utah St. Univ. Found.
Water Resources Research Institute	WRRI

JOURNALS

FULL NAME	ABBREVIATIONS
Agrichemical Age	Agr. Age
American Journal of Agricultural Economics	Am. J. Agr. Ec.
Bulletin of the Geological Society of America	Bull. Geol. Soc. Am.
Chemosphere	Chemosphere
Environmental Management	Environ. Manage.
Environmental Science and Technology	Environ. Sci. Tech.
Groundwater	Groundwater
Journal of Agriculture and Food Chemistry	J. Agr. Food Chem.
Journal of Environmental Engineering	J. Envir. Eng.
Journal of Environmental Health	J. Envir. Health
Journal of Environmental Science and Health	J. Envir. Sci. Health
Journal of Environmental Quality	J. Envir. Qual.
Journal of Soil and Water Conservation	JSWC
Journal Water Pollution Control Federation	JWPCF
National Association of Conservation Districts	NACD
Science	SCI
Soil, Biology, Biochemistry	S, Biol, Biochem.
Soil Conservation Society of America	SCS Am.
Soil Science Society of America Journal	Soil Sci. Soc. Am. J.
Transactions of the American Society of Agricultural Engineers	Trans. ASAE
Transactions of the American Society of Civil Engineers	Trans. ASCE
Water, Air and Soil Pollution	Water, Air Soil, Pol.
Water Quality Bulletin	Water Qual.Bull.
Water Research	Water Res.
Water Resource Bulletin	Water Res. Bull.
Water Resource Research	WRR

TOPIC OUTLINE

Explanatory Notes

These notes are to describe the library topic number system, and to aid in the process of choosing topic numbers for new acquisitions or literature searches. The text will go through each section and describe prior uses of each number assignment.

Library topic numbers are assigned for use in identifying topic areas. A main topic should be selected, and secondary topics may be added in parentheses.

1. **Legislation** - Any legislation or summaries of legislation with the exception of that dealing with water quality, belong here. So do reports on progress of programs set up by the particular legislation. At present the outline includes only state, federal, regional and local categories. Room is available for subtopics for each, but none have been assigned.

Example: If you have a copy of the federal clean air act, it would receive #1.1 State versions of similar legislation would be given number 1.2, etc. water quality concerns are under 5.1.

2. **Agencies** - Again any literature about particular agencies, programs, etc. on a federal, state or local level belong here. Several agencies are included as subtopics. State reports by the Division of Environmental Management about water quality or soils or agriculture do not get categorized here. This category is for information about the agency itself or their role in government.

3. **Agricultural Pollution and Management Practices** - This topic has led to a bit of confusion due to overlap between some of the subtopics. Interpretation of the subtopics should be done in a very general way. Consideration of other available subtopics should also be made. An attempt will be made here to give specific examples which might highlight the gray areas.

3.1 Fertilizer - This includes soil testing, liming, application of N, P, K, S. This topic area includes articles and information about fertilizers, assessing application methods, crop requirements, nonpoint sources and management.

This topic area has also been used for articles on monitoring or modeling the movement of the nutrients through soil. If you are looking for movement of nutrients through soils, search under 3.1. If you are looking at nutrient movement or concentrations in waterbodies, use topic 5.a runoff water quality series. If you are looking more generally at the fate of nutrients on fields and in water, you might want to run a search on both topics 3.1 and 5.A.

3.2 Animal wastes - These topics are for articles dealing with the storage, handling, and land application of animal waste.

3.3 Sediment/Soils - This topic has been used for subjects concerned with erosion and sedimentation such as control, causes and effects, and models which predict or describe soil erosion and deposition. This heading should also be used for articles about soils.

3.4 Water - This has been used only for water topics concerning the quantity of water and the quality of water from irrigated and/or drained lands. Salinity is used for papers addressing the effects of salinity, management of saline water and the relationships between saline water and agricultural practices.

3.5 Pesticides - This topic area has been broken down extensively and is self-explanatory. Subtopics here for surface runoff, groundwater leaching, etc. apply strictly to pesticides, not to other topics such as fertilizer, nutrients or water quality.

3.6 Best Management Practices - This topic area is for literature about development implementation, or assessment of BMP's. The subtopics are self explanatory. The subtopics here overlap with the topics listed above under Ag. Management. This area is for papers primarily concerned with BMPs, although they may also contain background information.

4. **Crops**- This topic area is for literature concerned with particular crops, rather than other topics included in the outline. Articles of a general nature on forestry have also been placed here under 4.3, Forestry. Crop headings are described in more detail on the following two pages of the outline.

5. Water Quality

5.1 Legislation - For legislation concerning water quality, as well as progress reports on programs resulting from water quality legislation.

5.2 Assessment - This topic should be interpreted in a general way. For instance, an article describing the use of algal communities to assess water quality would go here, while an article describing the method used to describe the algal community would go under 6.113. This topic area may overlap with others, in particular, 5.3, management. Articles describing the chemical, physical or biological condition of a water body should go here as well.

5.3 Management - This topic should be for articles describing water quality management, including the use of aerators, copper sulfate, weed cutting, detergent bans, and other remedial efforts which affect water quality.

5.4 Standards - This topic area is for articles or information regarding existence or development of water quality standards, including information on specific standards.

5.5-5.E These subtopics refer to water body types and are self explanatory. Four sub-subtopics have been added to several of the water quality sub-subtopics as follows: 5.61 nutrients, 5.62 sediment, 5.63 pathogens 5.64 toxic contaminants. Two additional subtopics have also been added; 5.A surface runoff quality studies, and 5.B wetlands. These would also include the sub-subtopics mentioned above, and are listed as 5.A1, 5.A2 etc.

6. Data

6.1 Collection methods - This topic area is for articles describing methods of obtaining data, especially from water, sediment, and biota.

6.2 Methods - Another method category, this is for describing analytical methods for analysis with subtopics for water, sediments, and biota. An article of results, however, would probably go under 5.2, water quality assessments. Two other subtopics have been added to 6.2-6.24 Land use, and 6.25, Economic cost-benefit analysis. Treatment (6.3) covers the use of numbers generated by 6.2; assessment follows that.

6.3 Treatment - This relates to articles about data treatment, storage, statistics, and models. Although this area would seem to overlap with 6.2, the former is for the chemical or biological analyses, while this is for treatment of the data obtained by that analysis.

7. **Urban Pollution and Management Practices** - This is a new topic and currently contains articles pertaining to pollutant type, sources, BMP's, monitoring and evaluation, economics, and impact of urban NPS pollution.

8. **Special Topics** - Description of policies, (e.g., point/nonpoint source trading policies set up by EPA), case studies, and assessment of pollution source control tradeoffs and their effects on water quality. This topic is to be used for new issues in NPS Water Quality. This is a new topic.

NWQEP ANNOTATED NPS BIBLIOGRAPHY TOPIC OUTLINE (Ver 87.1)

1. **Legislation**

1.1 Federal

1.11 Conservation Reserve and Other 1985 Farm Bill Programs (CRP)

1.2 State

1.3 Regional

1.4 Local

2. **Agencies**

2.1 Federal

2.11 U.S. Dept. of Agriculture
2.12 U.S. Environmental Protection Agency

2.2 State

2.21 Statewide

2.211 Dept. of Natural Resources & Community Development
2.212 Division of Soil and Water Conservation
2.213 Division of Forest Resources
2.214 Coastal Resources
2.215 Groundwater
2.216 Division of Land Resources
2.217 Division of Community Assistance
2.218 Cooperative Extension Service

2.22 N.C. Regional

2.221 Triangle J Council of Governments
2.222 Land-of-Sky Council of Governments

2.23 Local

2.3 Independent

2.31 NCSU Water Quality Group

2.4 Task Forces

2.41 Agricultural Task Force

2.411 Members
2.412 Activities

2.4121 Chowan River
2.4122 Union/Anson Counties

2.4123 Wayne/Lenoir Counties
2.4124 Wake County Demonstration Farm
2.4125 Land-of-Sky

2.5 International Joint Commission

3. Agricultural Pollution and Management Practices

3.1 Fertilizer

3.11 Soil Testing
3.12 Liming
3.13 Nitrogen
3.14 Phosphorus
3.15 Potassium
3.16 Sulfur

3.2 Animal Waste

3.21 Broiler Litter
3.22 Turkey Litter
3.23 Caged Layer Waste
3.24 Dairy Cattle Waste
3.25 Beef Cattle Waste
3.26 Swine Waste
3.27 Treatment
3.28 Recycle

3.281 As feed
3.282 Land Application

3.3 Sediment/Soil

3.31 Types
3.32 Movement/Erosion

3.321 Types
3.322 Cause/Effect
3.323 Control Practices
3.324 Modeling

3.4 Water

3.41 Irrigation
3.42 Drainage
3.43 Salinity
3.44 Runoff Quantity

* 3.5 Pesticides

3.51 Fungicides

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*Computer-searched.

- 3.52 Herbicides
  - 3.521 Paraquat
  - 3.522 Atrazine
  - 3.523 2,4D
  - 3.524 Other Triazines
  - 3.525 Alachlor
- 3.53 Insecticides
  - 3.531 Organochlorines
  - 3.532 Carbamates
  - 3.533 Organophosphates
  - 3.534 Synthetic Pyrethroids
- 3.54 Nematocides
- 3.55 Surface Runoff Studies (sediment)
- 3.56 Groundwater - Soil Leaching
- 3.57 Persistence/Degradation
- 3.58 Toxicity/Ecosystem Effects (Aquatic)
- 3.59 Drift and Volatilization
- 3.5A Soil Adsorption/desorption

*3.6 Best Management Practices (BMPs)

- 3.61 Fertilizer
- 3.62 Animal Waste
- 3.63 Sediment
  - 3.631 Conservation Tillage
- 3.64 Water
- 3.65 Pesticides
  - 3.651 Conservation Tillage
  - 3.652 Other SWCPs (Disposal)
  - 3.653 Application Timing and Techniques
  - 3.654 Integrated Pest Management
- 3.66 Salinity
- 3.67 Targeting/Critical Areas
- 3.68 Farmer Attitudes
- 3.69 Stream Protection
- 3.6A Filter Strips
- 3.6B Conservation Tillage

4. Crops

- 4.1 Fiber (e.g. cotton, flax, sugarcane)
- 4.2 Forage Crops (e.g. alfalfa, fescue)
- 4.3 Forestry
- 4.4 Fruits (e.g. cranberries, grapes, tomatoes, blueberries, strawberries, watermelon, pineapples)
- 4.5 Grain Crops (e.g. corn)

4.6 Lawn and Turf
4.7 Nursery/Ornamentals (e.g. shrubs)
4.8 Oil Crops (e.g. peanuts, soybeans, sunflower)
4.9 Small Grain Crops (e.g. barley, oats, rice, sorghum, wheat)
4.A Tobacco
4.B Tree Fruits (e.g. apples, cherries, grapefruit, lemons, olives, oranges, peaches, pears, plums, prunes, tangelos, tangerines)
4.C Vegetables (e.g. artichokes, asparagus, green beans, snap beans, beets, broccoli, brussels sprouts, cabbage cantaloupes, carrots, cauliflower, celery, sweet corn, cucumbers, eggplant, escarole, garlic, lettuce, honeydew melons, mint, onions, peas, green peppers, spinach, potatoes, sweet potatoes)

5. Water Quality

5.1 Legislation

5.11 Federal
5.12 State
5.13 Regional
5.14 Local
5.15 International

*5.2 Assessment (description of the existing water quality conditions)

5.21 Nutrients
5.22 Sediment
5.23 Pathogens
5.24 Toxic Contaminants

5.3 Management

5.4 Standards

5.41 Standards
5.42 Sediment
5.43 Pathogens
5.44 Toxic Contaminants

*5.5 Lakes

5.51 Natural

5.511 Nutrients
5.512 Sediment
5.513 Pathogens
5.514 Toxic Contaminants (e.g. Pesticides, PCB's, heavy metals, etc.)
5.515 Chlorophyll

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*Computer-searched.

5.52 Impoundments

- 5.521 Nutrients
- 5.522 Sediment
- 5.523 Pathogens
- 5.524 Toxic Contaminants (e.g., pesticides, PCB's, heavy metals, etc.)
- 5.525 Chlorophyll

*5.6 Rivers, Streams, Creeks

- 5.61 Nutrients
- 5.62 Sediment
- 5.63 Pathogens
- 5.64 Toxic Contaminants (e.g., pesticides, PCB's, heavy metals, etc.)

*5.7 Estuaries and Bays

- 5.71 Nutrients
- 5.72 Sediment
- 5.73 Pathogens
- 5.74 Toxic Contaminants (e.g., pesticides, PCB's, heavy metals)
- 5.75 Wetlands

5.8 Groundwater

- 5.81 Nutrients
- 5.82 Sediment
- 5.83 Pathogens
- 5.84 Toxic Contaminants (e.g. pesticides, PCB's, heavy metals)

5.9 Farm Ponds

- 5.91 Nutrients
- 5.92 Sediments
- 5.93 Pathogens

5.A Surface Runoff Quality (edge of field)

- 5.A1 Nutrients
- 5.A2 Sediment
- 5.A3 Pathogens
- 5.A4 Toxic contaminants (e.g. Pesticides, PCB's, heavy metals)

*5.B Wetlands

- 5.B1 Nutrients
- 5.B2 Sediment
- 5.B3 Pathogens
- 5.B4 Toxic Contaminants (e.g., pesticides, PCB's, heavy metals)

*5.C Acid Deposition

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*Computer-searched.

5.D Recreation

5.E Health

6. Data

6.1 Collection Methods

6.11 Water

6.111 Chemical Parameters
6.112 Physical Parameters
* 6.113 Biological Parameters

6.12 Sediment/Soils

6.121 Chemical Parameters
6.122 Physical Parameters
*6.123 Biological Parameters

*6.13 Biota

6.131 Benthic Macroinvertebrates
6.132 Fish Surveys
6.133 Fish Tissue

6.2 Analysis Methods

6.21 Water
6.22 Sediment/Soils
6.23 Biota
6.24 Land Use
6.25 Economic or Benefit/Cost analysis
6.26 Algal Bioassay

6.3 Treatment

6.31 Storage
6.32 Statistics
6.33 Models
6.34 Indices
6.35 Monitoring Design

6.4 Soils

7.0 Urban NPS Pollution and Management Practices

7.1 Sources (Description and Evaluation)

7.11 Sediment

*Computer-searched.

7.12 Nutrients

7.121 Nitrogen
7.122 Phosphorus

7.13 Toxic Contaminants (e.g., pesticides, PCB's, heavy metals)
7.14 Pathogens

*7.2 BMP's

7.21 Sediment
7.22 Nutrients

7.221 Nitrogen
7.222 Phosphorus

7.23 Toxic Contaminants (e.g., pesticides, PCB's, heavy metals)
7.24 Pathogens

7.3 Monitoring and Evaluation

7.31 Hydrology
7.32 Water Quality Parameters

7.4 Economics

*7.5 Impact of Urban NPS

8.0 Special Topics

8.1 Pollution Reduction Trading

8.11 Policy
8.12 Case Studies
8.13 Assessment
8.131 Economics
8.132 Loading

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*Computer-searched.

Appendix B

Secondary Sources Used to Locate Primary Sources

APPENDIX B

SECONDARY SOURCES USED TO LOCATE PRIMARY SOURCES

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Appendix C

Matrix Data Sheets

EPA REGION 1

State	Waterbody	NPS pollutant	Impacts on aquatic biota	Source
ME	Fish River drainage in northern Maine	Forestry activities (spraying of carbaryl [Sevin-4-oil] for spruce budworm control)	9 streams studied: 3 control streams never exposed to the chemical, 3 streams treated at a rate of 840 g A.I./ha (1-year streams), and 3 streams treated at rates of 840 g A.I./ha and 1,120 g A.I./ha the previous year (2-year streams). Drift sample collections Control - drift numbers and diversity remained stable throughout study period. Most organisms were alive at collection. 1-year streams - drift increased in numbers up to 170 times 2 days posttreatment and all organisms were dead. Plecoptera, Ephemeroptera, and Diptera were common. Most abundant taxa included the Plecoptera, *Leuctra tenella*, *L. ferruginea*, *L. tenuis*, *Amphinemura wui*; the Ephemeroptera *Paraleptophlebia* sp., *Epeorus* sp. and *Lithobrancha recurvata*; and the Diptera *Simulium* spp. and Chironomidae. Two of the three streams had increased numbers of taxa posttreatment. 2-year streams - drift increased in only 2 of the 3 streams. Dipterans - *Simulium venustum*, *S. tuberosum*, *S. latipes*, or *Pseudolimnophila* or *Pseudolimnophila* sp. constituted over 95% of organisms. The number of taxa did not increase. Benthic sample collection 1-year streams - immediately after treatment many Ephemeroptera and Plecoptera were found dead. Some Trichoptera were distressed and leaving their cases. Thirty to 60 days posttreatment, Plecoptera numbers were reduced to zero in all samples. Ephemeroptera numbers were significantly reduced. Trichoptera were reduced in 2 of the 3 streams. Diptera and Oligochaeta were not significantly reduced. 2-year streams - these streams were less affected than 1-year streams. Plecoptera populations were at or near zero prior to treatment and were reduced or zero 30 and 60 days posttreatment. Ephemeroptera similar in species composition and density to 1-year and control streams. Trichoptera numbers were not significantly reduced except in 1 of the 3 2-year streams. Diptera and Oligochaeta were not significantly reduced. Summary Carbaryl was toxic to all Plecoptera, most Ephemeroptera, and some Trichoptera and Diptera. Total numbers of organisms in treated streams were not reduced but were replaced by other groups. Long-term effects on Plecoptera populations were observed for species that were suppressed for more than 1 year. Ephemeroptera and Trichoptera repopulated quickly except for *Lithobrancha recurvata*.	Courtemanch and Gibbs, 1980

(continued)

State	Waterbody	NPS pollutant	Impacts on aquatic biota	Source
ME (con.)	Little Russell Stream (treated stream) Logan Brook (control stream) (Study area in Seboomook, Somerset, and Piscataquis Counties)	Forestry activities (spraying carbaryl[Sevin-4-oil] for spruce budworm control)	Two streams were studied. Little Russell Stream was treated with carbaryl at 0.5 lbs A.I./acre on June 7 and June 14. Brook trout (*Salvelinus fontinalis*) were collected by electrofishing in both streams 2 weeks and 1 and 3 days prior to the first carbaryl application and several hours, 1, 3, and 5 days postapplication for the first spraying, and several hours, 1 and 3 days, and 4 weeks postapplication for the second spraying. Mean fish brain AChE activity was significantly lower (15-34%) in fish from the treated stream, but the depression disappeared 24-48 hours later. The short duration of inhibition of AChE suggests adverse effects unlikely. Food weight as percent of body weight was significantly higher in the treated fish on June 8, 14, and 15. Only Coleoptera, Diptera, Ephemeroptera, Trichoptera, and terrestrial insects occurred regularly in the diet. The number of Diptera, Ephemeroptera, and Trichoptera increased in the stomach contents of fish from the treated stream on and following the date of spray application. In situ toxicity tests indicated no mortality of the young-of-the-year brook trout as a result of spraying.	Haines, 1981

(continued)

State	Waterbody	NPS pollutant	Impacts on aquatic biota	Source
ME (con.)	Mattawamkeag River	Forestry activities (spraying carbaryl [Sevin-4-oil] for spruce budworm control)	Electrofishing techniques were used to collect fish. Enzyme study Brain AChE levels were depressed in brook trout and salmon after spraying. The magnitude and duration of the depressions, up to 48 hours postspray, appeared to be related to concentrations of Sevin in the water. AChE activity levels returned to prespray values in most salmonids by 192 hours postspray. Feeding study Greatly increased feeding was evident in the 24-h post-spray salmonid stomach samples, and larval Diptera, Ephemeroptera, and Plecoptera were the major organisms consumed. After 96 h postspray, immature insects were not the major component of the trout stomach contents, and total stomach content volume returned to prespray levels. Postspray salmon stomachs contained larval Ephemeroptera, Trichoptera, Diptera, and Plecoptera. The largest numbers and volume of these organisms was present in the 24- and 48-h postspray collections. Macroinvertebrates were sampled using drift nets. A large number of invertebrates drifted shortly after Sevin was sprayed and was predominantly the Diptera *Simulium* and many Ephemeroptera and Trichoptera.	Hulbert, 1977

(continued)

State	Waterbody	NPS pollutant	Impacts on aquatic biota	Source
ME (con.)	Crawford, ME and Waite, ME sites	Forestry activities (effects of clearcutting)	<u>Aquatic plants</u> (glass slide samples) Clearcut streams tended to produce higher densities of algae (3 to 8 times higher) than reference streams. Heavy growths of algae were also visible on the bottom of clearcut streams but never in reference streams. Green algae (Chlorophyta) dominated in clearcut streams (30-95%), whereas diatoms (Bacciliariophyceae) dominated algal collections in reference streams (50-90%). Fifty percent of stream bottom in clearcut streams was covered by flowering plants; reference stream coverage was 10% or less.	Martin, Noel, and Federer, 1981
	Crawford, ME (one reference stream and one clearcut stream) Waite, ME sites (one reference stream and one clearcut stream)	Forestry activities (effects of clearcutting)	<u>Macroinvertebrates</u> (box sampler) Clearcut streams in Maine had higher densities (40,000/m)^{2}as compared to those in Vermont or New Hampshire. Logging caused a significant increase in numbers of macroinvertebrates. Macroinvertebrate densities were 3 times higher at clearcut sites than at reference streams. At Waite clearcut site, 34 taxa were collected as compared to 24 taxa at the reference site, while at Crawford clearcut site, 37 taxa were collected as compared to 43 at the reference site. This difference was not significant. Mayflies (Ephemeroptera) had significantly higher densities in clearcut streams. No effect of clearcutting on Diptera densities could be concluded, although Ephemeroptera and Diptera were primarily responsible for increases in insect density at clearcut sites.	

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
MA	Green River at Greenfield, MA	Urban runoff	<u>Macroinvertebrates</u>	Medeiros, LeBlanc, and Coler, 1983
			Macroinvertebrates were collected using Hester-Dendy multiplate samplers over 30-45 days.	
	Station 1 - upstream control		Losses of macroinvertebrates at stations 2 and 3 were higher than those at Station 1 (control).	
	Station 2 - received runoff (25% surface; 75% subsurface)		Stations 2 and 3 were 7 and 2 times more limiting than Station 1.	
	Station 3 - received cumulative runoff from Greenfield, MA		Macroinvertebrate totals for the 3 insect orders (Ephemeroptera, Plecoptera, and Trichoptera) were 100, 14, and 49, respectively, for Stations 1, 2, and 3.	
			Survival at Station 1 was 68% (Ephemeroptera), 52% (Plecoptera), and 82% (Trichoptera).	
			Survival at Station 2 was 4% (Ephemeroptera), 0% (Plecoptera), and 22% (Trichoptera).	
			Survival at Station 3 was 8% (Ephemeroptera), 30% (Plecoptera), and 47% (Trichoptera).	
			Diversity at the control was 1.5 (dry periods), 1.7 (rain), and 2.0 (snow).	
			Diversity at Station 2 was 1.5 (dry periods), 1.1 (rain), and 1.4 (snow). This indicates that runoff is responsible for channel toxicity during storms.	
			Diversity at Station 3 was 0.8 (dry periods), 1.0 (rain), and 1.0 (snow).	
			Heavy metal content (cadmium, copper, lead, and zinc) of Station 2 specimens was highest for rain or snow periods. The control values were similar for wet or dry periods.	
			At Station 2 Trichoptera (Hydropsyche) increased body concentrations of heavy metals by a factor of 10 in wet periods vs. dry periods. Plecoptera and Ephemeroptera seldom tripled their body concentrations.	
			At Station 3 the same insect orders had the same ranges in heavy metals, but the dry period values were higher than wet period values, suggesting different avenues of uptake.	
			At Station 2, metal increases were associated directly with runoff, while at Station 3 toxicity may have originated from the fine particle fraction of runoff.	

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
MA (con.)	Green River	Urban runoff (6 stations; 1 control and 5 downstream urban sites evaluated for 1 year)	Macrobenthic invertebrates sampling using rock-filled artificial substrate baskets showed that significant differences existed between the control and urban stormwater runoff-impacted stations.	Pratt, Coler, and Godfrey, 1981
		Control	Species diversity from nonurban site was consistently high throughout 1-year study period. This site had a large and stable species count ($\bar{x}$ = 61±3) coupled with high evenness value ($\bar{x}$ = 0.82±0.01). Diptera, Ephemeroptera, and Trichoptera predominated. Over 89% of the 206 species identified belonged to these three insect orders. Plecoptera were variable in number and Gastropoda and Oligochaeta were either absent or very rare.	
		Urban runoff (Stations 2-6)	Several trends in the downstream runoff stations were noted with respect to the macroinvertebrate community.	
			Number of total species decreased from 206 (control) to 108-110 for runoff stations.	
			Average count per collection generally decreased with the exception of Station 2 (63) from 61 (control) to 56-31 for runoff stations.	
			Average collection size generally decreased with the exception of Station 2 (410±40) from 300±40 (control) to 310±54 to 190±32 for runoff stations.	
			Species diversity decreased from 4.40 (control) to 4.29-3.01 for runoff stations.	
			Evenness decreased from 0.82 (control) to 0.82-0.67 for runoff stations.	
			A taxonomic shift in macrofauna dominance also occurred; Dipteran abundance increased at runoff stations (56-76%) as compared to 47% (control and runoff Station 2).	
			Taxonomic groups indicative of clean water were significantly less abundant.	
			Ephemeroptera decreased to 1-13% from 20-30% at the upstream control and runoff Station 2.	
			Plecoptera decreased to 0.6-3% from 8-10% at the upstream control and runoff Station 2.	

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
MA (con.)	Green River	Urban runoff (Stations 2-6)	Trichoptera decreased to 2.7-5.4% from 11.9-12.5% at the upstream control and runoff Station 2. Gastropods increased to 24% from 0% at the upstream control and runoff Station 2. Oligochaeta increased to 16% from 0.25-0.7% at the upstream control and runoff Station 2. Intermittent shock-loading of the system as well as low flow periods that might create a persistent stress on benthic organisms may be responsible for results. Authors attribute progressive decline in diversity in the 5.5-km stretch of the Green River studied to extenuating factors of pollution from urban runoff.	Pratt, Coler, and Godfrey, 1981

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
MA (con.)	Weweantic River estuary	Agricultural activities (pesticides)	Two groups of winter flounder (Pseudopleuronectes americanus)--migratory adults (ages 3 years and older) and resident juveniles--were monitored for DDT, DDE, heptachlor, heptachlor epoxide, and dieldrin in their tissues. Resident juveniles Resident juveniles were used to assess seasonal pesticide residue changes in the estuary. Maximum exposure of juveniles to DDT occurred in late spring and was likely to be associated with increased spring runoff from agricultural lands. Maximum DDE concentration in tissues occurred in winter months, suggesting a cyclic pattern of DDT exposure in spring with subsequent breakdown to DDE over the next 6 months. The pattern of heptachlor and heptachlor epoxide uptake by juveniles differed from the DDT-DDE cycle, with maximum heptachlor residues present in the winter months and the breakdown occurring less than 2 months later. Maximum exposure to heptachlor coincided with a midwinter thaw, during which surface runoff was substantial. Dieldrin was present in small quantities throughout the year, but exhibited no discernible pattern. Migratory adults Adults had reduced exposure to DDT by being absent from the estuary in late spring and summer, but had equal exposure to heptachlor while present in the estuary in fall and winter. Adults showed significantly lower DDE residues, but demonstrated heptachlor residues similar to those of juveniles. The authors hypothesized that ovarian concentrations of chlorinated hydrocarbon pesticides, while only 1.27 ppm, may have caused the high larval mortality at final yolk sac absorption.	Smith and Cole, 1970

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
NH	Norris Brook (Hubbard Brook Watershed)	Acid deposition (experimental acidification to pH 4)	Macroinvertebrates were collected with a cylindrical box sampler and dip nets. Emergence of aquatic insects was measured using covered traps. Emergence phenology of _Ephemerella funeralis_ was not altered by acidification. Numbers of _E. funeralis_ emerging did not differ significantly from those at the control site or from pre-acidification baseline values. All other Ephemeroptera were eliminated or severely reduced in the acidified zone. Larvae of _E. funeralis_ were significantly smaller (approximately 29%) in total body length than counterparts in the reference stream after 3 months exposure. Recruitment of the new cohort into the acidified zone was severely reduced. Populations of _E. funeralis_ in permanently acidified streams would most likely be eliminated through recruitment failure.	Fiance, 1978

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EPA REGION 1 (continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
NH (con.)	Warren, NH site (2 reference streams and 1 clearcut stream)	Forestry activities (effects of clearcutting)	Aquatic plants (glass slide sampler) Clearcut streams tended to produce densities of algae 1-10 times higher than those produced by reference streams. Heavy growth of algae was visible on the bottom of clearcut streams but never on the bottom of reference streams. Green algae (Chlorophyta) dominated in clearcut streams (30-95%), whereas diatoms (Baccilariophyceae) dominated algal collections in reference streams (50-95%). No flowering plants were observed at New Hampshire sites. Macroinvertebrates (box sampler) Clearcut streams in New Hampshire had a significant increase in the number of macroinvertebrates. Macroinvertebrate densities were 2-10 times higher at clearcut site than at reference streams. At the Warren clearcut site, 34 taxa were collected as compared to 21-28 taxa at the reference sites. The cutover stream had significantly more taxa than the reference streams. The Diptera were found in higher densities in clearcut streams than at reference sites; however, no effect of clearcutting on Diptera was concluded. Of the increased Diptera, 95% were Chironomidae. Some Ephemeroptera of the family Leptophlebiidae and the genus *Ephemerella* also added to the increase in numbers of macroinvertebrates at clearcut sites.	Martin, Noel, and Federer, 1981

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
VT	Jones Brook site (2 reference streams and 1 clearcut stream)	Forestry activities (effects of clearcutting)	Aquatic plants (glass slide sampler) Clearcut streams tended to produce densities of algae 3 to 10 times higher than those at reference streams. Heavy growth of algae was visible on the bottom of the clearcut stream but never on the bottom of the reference streams. Green algae (Chlorophyta) dominated in clearcut streams (30-96%), whereas diatoms (Baccilariophyceae) dominated algal collections in reference streams (50-96%). No flowering plants were observed at Vermont sites. Macroinvertebrates (box sampler) Clearcut streams in Vermont had a significant increase in macro-invertebrates. Macroinvertebrate densities were 1-3 times higher at the clearcut site than at the reference streams. At the Jones Brook clearcut site, 40 taxa were collected as compared to 23-40 at the reference sites. This difference was not significant. The increase in total numbers of macroinvertebrates at the clearcut streams was due primarily to the Ephemeroptera (Baetis).	Martin, Noel, and Federer, 1981

EPA REGION 2

EPA REGION 2

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
NJ	Shabakunk Creek (Mercer County)	Urban runoff (2 control sites and 4 runoff sites compared)	Sample collection for this study was conducted for 1 year from August 1979 to June 1980.	Garie and McIntosh, 1986
		Control, Main branch (2 sites)	Benthic macroinvertebrates Using natural substrate collection, significantly higher taxa richness (11 - 21 taxa collected) and significantly higher population density were found at control sites than at polluted sites. Trichoptera, Coleoptera, Ephemeroptera, and Diptera predominated. Periphyton communities Using artificial substrate collection, *Gammarus sp.* (amphipod) composed 55% of taxa collected.	
		Urban runoff, West branch (4 sites)	Benthic macroinvertebrates Using natural substrate collection, trend at 4 urban runoff sites was toward: (1) decrease in taxa richness, (2) decrease in population density, and (3) a shift in community composition toward more pollution-tolerant species. Immature Ephemeroptera, Trichoptera, Coleoptera predominated at upstream urban sites with some pollution-tolerant and some facultative species identified. Periphyton communities Using artificial substrate collection, population density trends indicated increased densities and decreased diversity below urban areas, contrary to results of natural substrate collection (Surber sampler). Chironomid larvae and Oligochaetes predominated.	

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State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
NJ (con.)	Hamilton Marsh (1 control area) Hamilton Marsh (1 storm drain) Woodbury Creek Marsh (2 storm drains)	Urban runoff (storm drain)	The effects of various nitrogen compounds, phosphorous, and 5 heavy metals (cadmium, copper, nickel, lead, and zinc) from storm drain runoff on 3 tidal marshes were evaluated. Nitrogen concentrations in vegetation were highest in June for all areas, but peak standing stocks were recorded in July or September, indicating continued demand for nitrogen well into the summer. Phosphorous concentrations in vegetation were highest in June for Woodbury Creek Marsh and Hamilton Marsh control area; Hamilton Marsh experimental area peaked in June and September. Demand for phosphorous continued well into growing season. Hamilton Marsh control area that received no NPS pollution showed little monthly variation in macrophyte heavy metal concentrations. Mean peak standing stocks of metals occurred simultaneously with peak standing crop values. Although Hamilton Marsh control received no metals from NPS discharges, peak standing stocks of all metals were as high or higher than the two sites receiving storm drain runoff. No clear metal concentration pattern emerged for the Woodbury Creek Marsh except for cadmium, which was always exported. Hamilton Marsh experimental area had significantly higher concentrations of all metals in September macrophyte samples (3 to 5 times higher than June to July values). Soil lead concentrations near discharges at the Hamilton Experimental site and Woodbury Creek Marsh site were significantly higher than lead levels at sites farther from storm drains. Retention of nutrients (nitrogen compounds and phosphorus compounds) and heavy metals during the summer and fall clearly benefits the upper Delaware River estuary by reducing nutrients and metal availability, precisely when the estuary is most stressed.	Simpson et al., 1983

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
NY	Central Long Island Sound	Landfill leaching (disposal of harbor dredge spoils off-shore)	This study assessed the scope for growth (SFG) index as a measure of sublethal effects of dredged material on the blue mussel (Mytilus edulis). The SFG measures of physiological response of mussels was studied in the laboratory. Later, the SFG index was compared for mussels exposed in the laboratory and those found in a field site. Laboratory study Mussels were exposed for 28 days to 0 (reference sediment), 10, and 30% of BRH (Black Rock Harbor, Bridgeport, CT) dredge material. SFG and shell growth were measured during exposure. The SFG index decreased with increasing concentration of BRH dredge material and with duration of exposure. Mussels from the BRH-contaminated tanks also showed little shell growth. Good correlation was seen between shell growth and SFG index. Field study Mussels from a clean reference population in lower Narragansett Bay (CT) were collected, sorted, bagged, and moored 1 m off the bottom at 4 locations at a Central Long Island Sound dredge spoil dumpsite. CNTR - Center of the site 400E - 400 m east of the site on the fringe on the disposal mound 1000E - 1000 m east of the site away from the disposal mound REFS - approximately 3 km south of the CNTR out of the area of influence of mound. SFG index measurements were made at monthly intervals for 3 months, then quarterly, for 1 year. SFG measurements on mussels from the dredge site stations showed little difference among stations after 1 month. Mussels deployed at the 400E station during dumping were lost (these would have received the largest dose). The first collection that included mussels from all 4 field stations was 2 months postdisposal. A small reduction in clearance rate was observed in mussels from the CNTR station compared to those from the 1000E and REFS stations. The SFG index was also lower at the CNTR station than at the other 3 stations. Mussels collected 3 and 4 months postdisposal showed no differences in SFG index or individual physiological parameters measured. The field data indicate no clear relationship between SFG and tissue residues. The estimated maximum field exposure (0.8 mg/L) was approximately half that of the lowest laboratory BRH exposure (1.5 mg/L) producing an adverse effect.	Nelson, 1987

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EPA REGION 2 (continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
NY (con.)	Temporary freshwater ponds on Connecticut Hill (Tompkins County)	Acid deposition	High embryonic mortality of spotted salamander (*Ambystoma maculatum*) eggs occurred in all ponds below pH 6. Mortality was 0.66% (pH 7), 0.91% (pH 6), 43.7% (pH 5.5), and >65% (pH 5 and 4.5). Mortality was low in all pH ranges during early embryonic development through late gastrulation. Mortality increased at neurulation, at late stages of gill development, and at hatching. Developmental abnormalities included stunted gills, swelling near heart, failure of yolk plug retraction, and tight coiling of embryos. Data suggest that pH is the most critical environmental variable. Temporary ponds are important breeding sites for a number of species of frogs, toads, and salamanders, and these amphibians may be the most immediately and directly affected by acid rain.	Pough, 1976

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
NY (con.)	Bullhead Bay estuary (Suffolk County)	Agricultural activities (golf course runoff)	Adult killifish (Fundulus heteroclitus) were collected by seine and traps at two sites near Southampton, NY. Gravid females were stripped of their eggs, and the eggs were fertilized by milt from stripped males. Each clutch was divided into untreated controls and experimental eggs dosed with 0.05 ppm meHg. This concentration was an effective teratogenic dose in previous work with killifish. Dorsal fin rays were counted because this parameter was found to be related to embryonic tolerance. Embryos were scored by the use of a craniofacial index (CFI), cardiovascular index (CVI), and a skeletal index (SKI). In 1982, an unusually heavy rainfall occurred in June (11 in. in one weekend) just prior to initiation of the study. Killifish embryos from site A (near a golf course) exhibited a skewed distribution toward the tolerant end of the scale. Although the CFI did not differ significantly between 1981 and 1982, it did differ significantly between 1980 and 1982, as did the SKI and CVI distributions. Embryos from the site B population (control) exhibited CFI, CVI, and SKI distributions comparable with those of embryos from the 1981 population at site A, but significantly different from the 1982 site A population's. The tolerance of population A greatly increased in 1982, while the tolerance of population B in 1982 was similar to that of population A in 1981. Surviving larvae and embryos of population A were significantly more meHg-tolerant than those of population B. Analysis of organochlorine pesticide residues and metals in both fish and sediment show substantial increases in site A when compared to the unimpacted control site. Site A (impacted site) adjacent to a golf course received numerous pesticides to maintain fairways and greens, and the 11-in. rain event in June was the probable cause of chemicals being washed into the water at site A. The unusual rain event was associated with a fish kill in a nearby town.	Weis and Weis, 1984

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State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
NY *(con.)*	Carmans River Marsh adjacent to Great South Bay (Suffolk County)	Agricultural activities (pesticide use, DDT)	This study evaluated many trophic levels of organisms in a saltmarsh ecosystem, including plankton, macroinvertebrates, fish, and carnivorous seabirds. Sediment residue concentrations of DDT ranged from 3-32 lb/acre, with the highest residues in the upper 4 cm of soil. DDT concentrations decreased with soil depth, while DDE concentrations increased. DDT residues showed a progression according to both size and trophic level; larger organisms and higher carnivores had greater concentrations than smaller organisms at lower trophic levels. Total DDT residues ranged over 10^3 from 0.04 ppm for plankton to 75 ppm for carnivorous seabirds. Carnivorous birds have concentrations of DDT approximately 1 million times greater than that of seawater. The shift in relative proportions of DDT, DDE, and DDD with progression in trophic level is also conspicuous. Organisms containing high concentrations of DDT are common at lower trophic levels; at higher trophic levels, most residues are DDE. Reductions during the past decade have occurred in local marsh populations of shrimp, amphipods, summer flounder (Paralichthys dentatus), blue crabs (Callinectes sapidus), spring peepers (Hyla crucifer), Fowler's toad (Bufo woodhousei fowleri), and woodcock (Philohela minor). Analyses of water have little meaning when evaluating the effects of persistent pesticides on animal populations.	Woodwell, Wurster, and Isaacson, 1967

EPA REGION 3

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
MD	Upper Chesapeake Bay	Agricultural activities (runoff including herbicides, sediments, and nutrient enrichment)	This paper evaluated through laboratory and field data the possible causes for the decline in submerged vascular plants in Chesapeake Bay. More than 10 species have declined in abundance in the upper estuary since the mid-1960's including: Potamogeton perfoliatus, P. pectinatus, Vallisneria americana, Zannichellia palustris, Ruppia maritima, Zostera marina, and Myriophyllum spicatum (an exotic species). Herbicide effects Atrazine and linuron (herbicides) were tested for their phytotoxicity to P. perfoliatus and M. spicatum. At 5-10 ppb (the upper limit of herbicide concentrations occurring in most estuarine shallows), a 10-20% loss of photosynthesis would be expected. Photosynthetic recovery occurred within 1-2 weeks after initial exposure despite continued presence of herbicide. Suspended sediment effects Concentrations of suspended sediments (seston) often increase in Chesapeake Bay from 20-100 mg/L within 1-2 h due to moderate (5-10 m/s) summer winds. Chlorophyll a concentrations typically range from 5-15 µg/L over a tidal cycle and are not influenced by wind. These 2 common excursions in seston and chlorophyll a would result in about 50% and 8% reductions, respectively, in the PAR (phytosynthetically active radiation) at 50 cm depth. Most light attenuation was associated with inorganic particulates and other nonchlorophyllous organics. Depth distribution of SAV may have been restricted due to reduced PAR availability. Nutrient enrichment Experimental ponds were treated with 0, 30, 60, and 120 µgM inorganic nitrogen (50% NH_4^+; 50% NO_3^-) with N:P atomic ratios of 10:1. The 60-µgM dose was equivalent to runoff from typical watershed (20% agricultural, 11% residential) flowing into Chesapeake Bay. Phytoplankton biomass (as chlorophyll-a) increased with increased nutrients. Epiphytic algal biomass increased significantly at all doses over the control. SAV biomass decreased in all dosed groups and decreased significantly at 60 and 120 µgM inorganic nitrogen as compared to controls.	Kemp et al., 1983

(continued)

EPA REGION 3 (continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
MD (con.)	Upper Chesapeake Bay	Agricultural activities (*runoff including herbicides*, sediments, and nutrient enrichment)	<u>Summary</u> Field observations and historical records all suggest that nutrient enrichment and increased turbidity associated with agricultural practices probably played major roles in the decline of SAV in the upper Chesapeake Bay. Herbicide runoff may represent an ephemerally and locally important stress, but its contribution to the general dieoff of SAV has been minimal.	Kemp et al., 1983

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State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
MD (con.)	Georges Creek (Allegany County)	Mining activities (coal pile runoff)	Macroinvertebrate community was sampled with T-sampler and artificial substrate sampler.	Swift, 1982
	Station IA - control		Control	
	Station IB - receives some runoff 60 m downstream from coal piles		The control station received no coal storage or mining wastes, but did have a high organic load.	
			The macrobenthos were primarily tubificid worms and chironomid larvae.	
	Station IIA - receives runoff from adjacent coal piles		Species diversity at the control was low because of the numerical dominance of these two taxa.	
			Species richness was also relatively low (5 to 8 taxa).	
	Station IIB - receives runoff from adjacent coal piles		Coal runoff sites	
			4 to 8 taxa were present at runoff site (IB), but they were present in very low numbers. The predatory megalopteran (*Sialis*) and chironomid larvae were predominant in artificial substrate samplers.	
			Station IIA was characterized by a greater number of species but by very low densities. 2 to 10 taxa were present in most T-samples, including the only mayflies and dragonflies collected.	
			Station IIB was characterized by having very low species richness (0-8 taxa), diversity, and density initially. Even fewer macroinvertebrates were collected in the second sample, and no macroinvertebrates were present in the third sample.	

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
PA	Several major watersheds throughout the state (Monongahela, Youghinghany, Kiskiminitas, Clarion, West branch of the Susquehanna, Swatara, Mahoney, Catawissa, Nescopeck, Upper Schuylkill)	Mining activities (acid mine runoff)	I. Fish bioassay testing A rapid bioassay for acid water using changes in cover and activity of fish was studied. The bioassay was determined to be unsuitable for the establishment of water quality criteria. II. Fish - field population studies Fishes were collected using Rotenone and electrofishing techniques throughout Pennsylvania to determine the effect of different levels of acid mine drainage (pH) on the presence or absence of fish populations. Common fish species were absent where there was severe acid mine drainage. From a list of 116 fish species found in Pennsylvania, 10 species exhibited some tolerance to low pH of 5.6 to 4.6. The species and the lowest pH of water in which they were found are shown below: pH 4.6 Chain pickerel (*Esox niger*) Golden shiner (*Notemigonus crysoleucas*) White sucker (*Catostomus commersoni*) Brown bullhead (*Ictalurus nebulosus*) Pumpkinseed (*Lepomis gibbosus*) pH 4.7 Creek chubsucker (*Erimyzon oblongus*) Largemouth bass (*Micropterus salmoides*) pH 5.0 Brook trout (*Salvelinus fontinalis*) pH 5.2 Creek chub (*Semotilus atromaculatus*)	Butler et al., 1973

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
PA (con.)	Several major watersheds throughout the state (Monongahela, Youghiogheny, Kiskiminitas, Clarion, West branch of the Susquehanna, Swatara, Mahanoy, Catawissa, Nescopeck, Upper Schuylkill)	Mining activities (acid mine runoff)	<u>pH 5.5</u> Yellow perch (<u>Perca</u> <u>flavescens</u>) <u>pH 5.6</u> Bluntnose minnow (<u>Pimephales</u> <u>notatus</u>) Blacknose dace (<u>Rhinichthys</u> <u>atratulus</u>) <u>pH 5.9</u> Brown trout (<u>Salmo</u> <u>trutta</u>) Eastern mudminnow (<u>Umbra</u> <u>phygmea</u>) Longnose dace (<u>Rhinichthys</u> <u>cataractae</u>) Margined madtom (<u>Noturus</u> <u>insignis</u>) Tesselated darter (<u>Etheostoma</u> <u>olmstedi</u>) Slimy sculpin (<u>Cottus</u> <u>cognatus</u>) <u>pH 6.0</u> Ohio lamprey (<u>Ichthyomyzon</u> <u>bdellium</u>) Stoneroller (<u>Campostoma</u> <u>anomalum</u>) Silverjaw minnow (<u>Ericymba</u> <u>buccata</u>) River chub (<u>Nocomis</u> <u>micropogon</u>) Common shiner (<u>Notropis</u> <u>cornutus</u>) Silver shiner (<u>Notropis</u> <u>photogenis</u>) Rosyface shiner (<u>Notropis</u> <u>rubellus</u>) Mimic shiner (<u>Notropis</u> <u>volucellus</u>) Hog sucker (<u>Hypentelium</u> <u>nigricans</u>) Rock bass (<u>Ambloplites</u> <u>rupestris</u>) Smallmouth bass (<u>Micropterus</u> <u>dolomieui</u>) Greenside darter (<u>Etheostoma</u> <u>blennioides</u>) Fantail darter (<u>Etheostoma</u> <u>flabellare</u>) Johnny darter (<u>Etheostoma</u> <u>nigrum</u>) Banded darter (<u>Etheostoma</u> <u>zonale</u>) Blackside darter (<u>Percina</u> <u>maculata</u>) <u>pH 6.1</u> Cutlips minnow (<u>Exoglossum</u> <u>maxillingua</u>) Fallfish (<u>Semotilus</u> <u>corporalis</u>)	Butler et al., 1973

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
PA (con.)	Several major watersheds throughout the state (Monongahela, Youghinghony, Kiskiminitas, Clarion, West branch of the Susquehanna, Swatara, Mahanoy, Catawissa, Nescopeck, Upper Schuylkill)	Mining activities (acid mine runoff)	Silvery minnow (*Hydrognathus nuchalis*) Bigeye chub (*Hybopsis amblops*) Streamline chub (*Hybopsis dissimilis*) Silver chub (*Hybopsis storeriana*) Hornyhead chub (*Nocomis biguttatus*) Comely shiner (*Notropis amoenus*) Satinfin shiner (*Notropis analostanus*) Emerald shiner (*Notropis atherinoides*) Bridle shiner (*Notropis bifrenatus*) Bigmouth shiner (*Notropis dorsalis*) Swallowtail shiner (*Notropis procne*) Sand shiner (*Notropis stramineus*) Southern redbelly dace (*Phoxinus erythrogaster*) Fathead minnow (*Pimephales promelas*) Quillback (*Carpiodes cyprinus*) Longnose sucker (*Catostomus catostomus*) Silver redhorse (*Moxostoma anisurum*) Black redhorse (*Moxostoma duquesnei*) Golden redhorse (*Moxostoma erythrurum*) Shorthead redhorse (*Moxostoma macrolepidotum*) White catfish (*Ictalurus catus*) Black bullhead (*Ictalurus melas*) Yellow bullhead (*Ictalurus natalis*) Channel catfish (*Ictalurus punctatus*) Stonecat (*Noturus flavus*) Tadpole madtom (*Noturus gyrinus*) Flathead catfish (*Pilodictis olivaris*) Trout-perch (*Percopsis omiscomaycus*) Burbot (*Lota lota*) Banded killifish (*Fundulus diaphanus*) Mummichog (*Fundulus heteroclitus*) Brook silverside (*Labidesthes sicculus*) Fourspine stickleback (*Apeltes quadracus*) Brook stickleback (*Culaea inconstans*) Warmouth (*Lepomis gulosus*) Bluegill (*Lepomis macrochirus*) White crappie (*Pomoxis annularis*) Black crappie (*Pomoxis nigromaculatus*) Bluebreast darter (*Etheostoma camurum*) Spotted darter (*Etheostoma maculatum*) Tippicanoe darter (*Etheostoma tippicanoe*)	Butler et al., 1973

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
PA (con.)	Several major watersheds throughout the state (Monongahela, Youghinghany, Kiskiminitas, Clarion, West branch of the Susquehanna, Swatara, Mahanoy, Catawissa, Nescopeck, Upper Schuylkill)	Mining activities (acid mine runoff)	Logperch (<u>Percina caprodes</u>) Channel darter (<u>Percina copelandi</u>) Longhead darter (<u>Percina macrocephala</u>) Shield darter (<u>Percina peltata</u>) Walleye (<u>Stizostedion v. vitreum</u>) Freshwater drum (<u>Aplodinotus grunniens</u>) All species shown in the study were collected in fish surveys between 1967 and 1970. Mine acid drainage has severely affected fish populations in several major watersheds in Pennsylvania. Total acidity, pH, and probably heavy metals are all involved in the toxic action of mine acid drainage on fish populations. No information was obtained on concentrations of metallic ions in these discharges, but concurrent readings of pH as low as 4.5 and total acidity as low as 15 ppm are sufficient to account for the complete loss of fish populations at about 90% of the stations examined where no fishes were present. III. <u>Aquatic insects bioassay testing</u> The median tolerance limits were determined for 5 aquatic insect species to low levels of pH. Test species were chosen on the basis of their wide occurrence. Continuous-flow bioassay systems were used; however, no values were validated in field experiments.	Butler et al., 1973

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
VA		Construction activities (sediment from highway construction)	<u>General summary</u> For both macroinvertebrates and fish, a reduction in diversity (number of species) and density (number of organisms) occurred after exposure to increased siltation and sedimentation. Reductions in density were significant. Although not significant, there was a trend toward reduction of diversity downstream from construction activities. Singular comparisons of upstream and downstream communities were useful, but the value of multiple observations before, during, and after construction were more useful. <u>Macroinvertebrates</u>	Reed, 1977
	Tributary of Totier Creek (Albermarle County) Wilderness Run (Spotsylvania County) Walk Creek (Bland County) Tributary of North Anna River (Orange County)		Macroinvertebrate sampling was conducted using a D-frame dip net at an upstream control station and a downstream impacted station on 4 rivers. At all 4 sites, there were from 12-40% fewer species and from 62-86% fewer organisms, which was a significant decrease in numbers.	
	Wilderness Run (Spotsylvania County)		Macroinvertebrates were also collected on artificial samplers (rock-filled, wire-mesh baskets). Thirty days of growth were evaluated at the first sampling. The upstream control stations contained 16-18 species and 187-405 organisms. Downstream impacted stations contained only 14 species, but the numbers of organisms fluctuated dramatically from 73-669. Results from artificial substrate samplers differ from those from D-frame dip net collections. Artificial samplers are held above the substrate, thus benthos are not smothered by sediment.	

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
VA (con.)	Back Creek (Bath County)	Construction activities (sediment from highway construction)	Fish Fish were collected using electroshocking techniques coupled with block nets. The upstream control site had 21 species, 229 individuals, and a diversity index (DI) of 0.83, while the downstream impacted site had 15 species, 106 individuals, and a DI of 0.70. There were 29% fewer fish species and 46% fewer individuals at the impacted site.	Reed, 1977
	David Creek (Appomattox County)		During construction, 10 species and 141 individuals were collected at the upstream control site (DI = 0.82). Only 11 fish species and 72 individuals were collected at the downstream impacted site (DI = 0.60). There were 31% fewer species and 48% fewer individuals at the impacted site. After construction recovery, there were 15 species, 144 individuals, and a DI of 0.73 at the upstream control site. At the downstream site there were 20 species, 300 individuals, and a DI of 0.83. Species number, diversity, and populations increased postconstruction.	
	Deep Run Creek (Stafford County)		During construction the control station contained 9 species, 35 individuals, and a DI of 0.77, while the downstream impacted site contained 8 species, 23 individuals, and a DI of 0.84. There were 11% fewer species and 34% fewer individuals at the impacted site. After construction recovery, 17 species, 332 individuals, and a DI of 0.84 were found at the control site, while 16 species, 250 individuals, and a DI of 0.70 were found at the impacted site. Fewer species and fewer individuals were collected at the impacted site postconstruction.	
	Wilderness Run (Orange and Spotsylvania Counties)		After construction stopped, the control site contained 12 fish species, 13 individuals, and a DI of 0.84, while the downstream site contained only 7 species, 73 individuals, and a DI of 0.62. This represents 35% fewer species and 42% fewer organisms. After construction recovery the control site contained 8 species, 57 individuals, and a DI of 0.57, while the impacted site contained 7 species, 57 individuals, and a DI of 0.66. No significant difference occurred in the sites postconstruction.	
	Redbud Creek (Albermarle County)		After construction stopped, an upstream control site contained 13 species, 273 individuals, and a DI of 0.82, while the downstream impacted site contained 13 species, 159 individuals, and a DI of 0.78. There was no change in the number of species, but 42% fewer organisms appeared at the impacted site.	
	Foster Branch (Albemarle County)		After construction stopped, an upstream control site contained 12 species, 161 individuals, and a DI of 0.76; the downstream impacted site contained 11 species, 109 individuals, and a DI of 0.69. This represents 8% fewer species and 32% fewer organisms at the impacted site.	

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
VA (con.)	A small 17-acre recreational lake (Chesterfield County)	Construction activities (sediment runoff from residential sites)	Sampling occurred during January and February 1972 prior to construction activities and during January and February 1973 after construction activities were initiated in June 1972. Incident radiation and temperature values were comparable during both winter sampling periods, as were wind velocities. Subsurface radiation and secchi disc values were reduced by half and were lowest at the sampling site immediately offshore from the construction area. Algal standing crop (total extractable chlorophyll) and phytoplankton primary productivity ($^{14}CO_2$ uptake) were 2 to 3 times less in 1973 than in 1972. Chemical nutrients varied less than productivity values. O_2 values and pH were lower in 1973. NH_4^+-N increased twofold, possibly due to lawn runoff and sedimentation. PO_4-P, SiO_2, and hardness also increased. The increased nutrients should have stimulated the algal productivity; however, production instead decreased some 2 to 3 times during the winter period. Total number of algal genera was reduced from 24 to 18. Significant shift in relative dominance of certain algae taxa occurred. Navicula and Dinobryon disappeared and were replaced by Chrysophytes. Mougeotia (a filamentous green algae) grew well along the lakeshore prior to construction but disappeared after construction. Stigeoclonium, Rhizoclonium, and Desmidium also disappeared after construction.	Semeel, 1973

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
WV	Tygart Lake	Mining activities (acid mine drainage)	Fish surveys were conducted over a period of 1 year (August 1966 - August 1967) using gill nets, trammel nets, and Rotenone. Data from these surveys were compared to fish survey data from 1947 - 1948 and from 1966. Brown bullheads (Ictalurus nebulosus) predominated in all years. Blue gill (Lepomis macrochirus), pumpkinseed sunfish (Lepomis gibbosus), and largemouth bass (Micropterus salmoides) are represented in the current and previous surveys. The white sucker (Catostomus commersoni) was relatively abundant in early surveys, but only 1 specimen was collected in the current study. Substantial numbers of white crappies (Pomoxis annularis) were found in the 1947 - 1948 study, but severe population decline resulted in later studies. When fish population composition was compared to a control pond composition, golden shiners (Notemigonus crysoleucas) and black crappie (Pomoxis nigromaculatus) were absent or rare in Tygart Lake. Pollution by acid mine drainage appears to be responsible for poor standing crops in Tygart Lake.	Benson, 1976

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
WV (con.)		Construction activities (assessment of impacts of sediment transport and stream channel relocation associated with highway construction)	This study was conducted for a 2-year period from September 1973 to November 1975.	Chisholm and Downs, 1978
	Lick Creek (Boone County)	3 control sites	Benthic invertebrates Ephemeroptera, Trichoptera, Coleoptera, and Diptera predominated. Diversity index ranged from 2.14-3.13, generic count from 9-18, and total count from 29-177.*	
	Turtle Creek (Boone County)	4 impact sites	Benthic invertebrates Ephemeroptera, Diptera, and Trichoptera predominated. Diversity index ranged from 0.00-3.41, generic count from 1-16, and total count from 2-248. Massive sediment transport and channel relocation along Turtle Creek generated by construction activities destroyed or severely damaged the benthic invertebrate community. Greatest damage (18 months after construction began) was observed in upper stream reaches where gradient was greatest and tributary input of benthic organisms was least. Downstream reaches were less affected; certain organisms were preferentially eliminated. Repopulation and organism diversification of old and new channels of Turtle Creek occurred quickly. Within 1 year after construction was completed and vegetation had stabilized and reduced release of sediment, the population and diversification of benthic invertebrates of Turtle Creek sites were similar to those of Lick Creek (the control). Median diversity of Turtle Creek was 2.82 (Lick Creek, 2.39). Organism drift and inflow from undamaged tributaries were the major methods by which Turtle Creek was repopulated.	

*Total count = Total number of organisms per sample.
Generic count = Total number of different genera per sample.

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
WV (con.)	Cheat Lake	Mining activities (acid mine drainage)	A 2-year study of productivity in an acid lake. The lake stations were considerably more acidic in 1973 than in 1975. Backwater areas were the reverse of the lake stations. There was no spring season of algal growth in the lake. Virtually all annual primary production took place from July to October. In 1973, despite the fact that backwater stations were less acidic than the lake station, production was much higher (2 to 4 times) at the lake stations. In 1975, data are reversed. The backwater stations were much more productive than the lake stations. pH discontinuities in the backwater stations caused ecological instability that decreased the activity of the phytoplankton without drastically lowering the biomass.	DeCosta and Preston, 1980

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
WV (con.)	4 streams in the Fernow Experimental Forest near Parsons, WV	Forestry activities (assessment of the differences in benthic fauna at a control site, clearcut site with stream buffer zone, and clear-cut site with only herbaceous cover)	Benthic samples were collected using an Eckman dredge, and emerging insects were captured in floating traps. The control watershed stream contained the highest total numbers (69,400) and total biomass of invertebrates (14 g/m^2). The watershed stream with buffer shade zone was intermediate (total numbers 44,200 and 8.4 g/m^2 biomass), and the watershed with herbaceous cover was lowest (total numbers 32,400 and 5.4 g/m^2 biomass). Diptera and Pelecypoda orders accounted for 65-91% of total biomass in the weir ponds. The number of emerging aquatic insects was 3,725 for the control site, 1,834 for the buffer shade zone site, and only 78 for the herbaceous cover site. Various silvicide residual effects could explain the low numbers of aquatic fauna at the herbaceous cover site.	Lee and Samuel, 1976

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State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
FL	Saltmarshes adjacent to Alligator Harbor (Franklin and Wakulla Counties)	Agricultural activities (pesticide spray program to control dogflies)	DDT was last applied to Franklin County beach areas in 1968; however, high concentrations of pp-DDT persisted in the upper 2 cm of marsh sediment. Field observations on blue crabs (*Callinectes sapidus*) were made biweekly from October to December 1973 in both DDT-contaminated and control (unsprayed) saltmarsh sites. When mortalities occurred in DDT-contaminated saltmarsh sites, blue crabs were collected for tissue residue analysis. Control site crabs were also collected for residue analysis. Blue crab mortalities occurred in the DDT-contaminated population simultaneously with a decrease in water temperature, whereas no mortalities were observed in control populations. Although tissue residues of DDE, DDD, and DDT were highly variable among crabs from the DDT-contaminated marsh areas, they were in all cases higher than those found in crabs from control marsh areas. Moribund crabs from the DDT-contaminated marsh apparently lacked equilibrium and were either tremoring or in an extremely torpid state. Burrowing behavior may have been altered by DDT or its metabolites.	Koenig, Livingston, and Cripe, 1976

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
GA	21 watersheds in the Atlanta metropolitan area (including North Atlanta, Decatur, Lithonia, Lawrenceville, and Loganville)	Urban runoff (urban development land use)	General conclusions on macroinvertebrate community changes were based on artificial substrate samplers. Stream communities did seem to serve as an integrator of stream conditions through time, apparently due to the differential sensitivity of species to pollutants and differing species replacement times. The diversity index was of limited value in our analyses. Looking at number of total taxa provided better results. The concept of hierarchical diversity is a useful one and its use gave us some insight into the taxonomic level at which useful information can be obtained for biomonitoring programs. Family diversity was just as informative as species diversity. The watersheds selected fell into 2 categories based on the percentage of development vs. vegetated area; the biological classification largely fell into these 2 groups. Urban development should steer clear of the streams themselves and their associated riparian vegetation and an attempt should be made to retain substantive amounts of vegetation throughout the watershed. All highly urbanized streams were very degraded biologically. The cleanest urban stream was in a new (<15 yr) residential development. There is a suggestion that degradation of some urban streams may be due to leakage from old sanitary sewers.	Benke et al., 1981

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State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
GA (con.)	Sea Island Cluster Big Creek (Ware County)	Control	This study was conducted for 2 years from July 1981 to July 1983. __Periphyton__ 21 diatom genera were collected; total chlorophyll <1.0 mg/m^2. __Macroinvertebrates__ 160 species were collected (6,000 specimens); Ephemeroptera, Trichoptera, and Diptera predominated; tubificid worm density was high for a natural area. __Fish__ 14 species were collected (143 specimens); bluegill sunfish (__Lepomis macrochirus__) was 30% of total.	Cook et al., 1983
	Hackleberney Creek (Pierce County)	Agricultural activities (phosphorus levels high enough to support nuisance algae growth)	__Periphyton__ 19 diatom genera were collected; total chlorophyll 1-23 mg/m^2. __Macroinvertebrates__ 223 species were collected (40,067 specimens); Ephemeroptera and Trichoptera low density; Isopod genera (Asellus) abundant; considered facultative to organic pollution. Tubificid and naidid worms were relatively common; considered tolerant to organic pollution and sedimentation. __Fish__ 20 species were collected (221 specimens); flier (__Centrarchus macropterus__) was 20% of total.	
	Anderson Branch (Brantley County)	Forestry activities (logging)	__Periphyton__ 11 diatom genera were collected; total chlorophyll 1-2 mg/m^2. __Macroinvertebrates__ 130 species collected (700 specimens); few Ephemeroptera species; Amphipod genus (Crangonx) common, considered facultative to organic pollution. Species intolerant of organic pollution were relatively common. __Fish__ 5 species were collected (12 specimens--not fully sampled). Brown bullhead (__Ictalurus nebulosus__) was 33% of total.	

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
GA (con.)	Sea Island Cluster Bailey Branch (Ware County)	Urban runoff (phosphorus, nitrate, and nitrite levels high enough to support nuisance algae growth)	Periphyton 17 diatom genera were collected; total chlorophyll 1-60 mg/m^2. Macroinvertebrates 75 species were collected (584 specimens); no Ephemeroptera or Plecoptera were collected; toxic-pollution-stressed stream; tubificid and naidid worms predominant; sediment- and organic-pollution-tolerant species predominant. Fish 8 species were collected (384 specimens); mosquitofish (*Gambusia affinis*) was 94% of the total.	Cook et al., 1983

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State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
GA (con.)	Ridge Valley Cluster Swamp Creek (Whitfield County)	Control	<u>Periphyton</u> 23 genera of diatoms collected; total chlorophyll <3 mg/m^2. <u>Macroinvertebrates</u> 284 species were collected (7,230 specimens). Plecoptera, Ephemeroptera, and Tricoptera were the predominant fauna of cool, clean-water streams. Many pollution-sensitive (sediment and organics) species were present. <u>Fish</u> 14 species were collected (933 specimens); 2 species accounted for 63% of total--Coosa shiner (*Notropis xaenocephalus*) and stoneroller (*Campostoma anomalum*).	Cook et al., 1983
	Little Creek (Walker County)	Agricultural activities (organics, sediment, and pesticides)	<u>Periphyton</u> 27 genera of diatoms were identified; total chlorophyll 1-25 mg/m^2. <u>Macroinvertebrates</u> 346 species were collected (12,069 specimens); Plecoptera, Ephemeroptera, and Trichoptera predominated. None of the clean-water Trichoptera found at the control site were present; only pollutant-tolerant forms were collected. The site was severely impacted by pollution. The density of macroinvertebrates was 2-3 times that at the control site. Plecoptera sensitive to pesticides occurred at only 25% of the number found at the control site. <u>Fish</u> 23 species were collected (784 specimens); 2 species accounted for 35% of the total. Coosa shiner (*Notropis xaenocephalus*) and stoneroller (*Campostoma anomalum*) were the largest populations of fish as a result of high periphyton and macroinvertebrate populations.	

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
GA (con.)	Ridge Valley Cluster Kings Creek (Floyd County)	Forestry activities (sedimentation from logging and road construction)	<u>Periphyton</u> 23 genera of diatoms were collected; total chlorophyll <1 to 7.0 mg/m^2. <u>Macroinvertebrates</u> 220 species were collected (7,712 specimens). Plecoptera, Ephemeroptera, and Trichoptera were predominant. Sediment-sensitive species were reduced in number. <u>Fish</u> 10 species were collected (760 specimens); 2 species accounted for 60% of the total. Banded sculpin (<u>Cottus carolinae</u>), stoneroller (<u>Campostoma anomalum</u>), and Coosa shiner (<u>Notropis xaenocephalus</u>) decreased after logging operations increased.	Cook et al., 1983
	Horseley Creek (Floyd County)	Urban runoff (sediment, high organics, and phosphorus levels)	<u>Periphyton</u> 26 genera of diatoms were collected; polluted-water species were common in all samples; total chlorophyll 1-37 mg/m^2. <u>Macroinvertebrates</u> 224 species were collected (4,986 specimens). Plecoptera, Ephemeroptera, and Trichoptera were predominant. Only pollution-tolerant species were found. 60 fewer species were found than were found at the control site. Organic pollution-tolerant Diptera were common (27.4% of total); naidid and tubificid worms were also common. <u>Fish</u> 19 species were collected (690 specimens); 2 species, stoneroller (<u>Campostoma anomalum</u>) and rainbow shiner (<u>Notropis chrosomus</u>) accounted for 66% of the total.	

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State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
GA (con.)	Piedmont Cluster Cable Branch (Green County)	Control	This study was conducted for 2 years from August 1981 to August 1983. Periphyton Average trichromatic chlorophyll a 3.33 mg/m^2; 104 diatom species identified; 8 dominant species accounted for 87.9% of the total. Macroinvertebrates Diptera and Trichoptera were dominant with Ephemeroptera, Coleoptera, and Plecoptera present in lesser amounts. Fish 7 species (655 specimens)	CTA, Inc., 1983
	Little Sandy Creek (Walton County)	Agricultural activities (sediment and organics)	Periphyton Average trichromatic chlorophyll a 2.27 mg/m^2; 120 diatom species identified; 21 dominant species accounted for 97.6% of the total. Macroinvertebrates Diptera were dominant with lesser amounts of Trichoptera present. Fish 13 species (378 specimens).	
	Little Creek (Jasper and Putnam Counties)	Forestry activities (sediment load)	Periphyton Trichromatic chlorophyll a 0.70 mg/m^2; 105 diatom species identified; 16 dominant species accounted for 92.5% of the total. Macroinvertebrates Diptera were dominant with lesser amounts of Trichoptera, Ephemeroptera, and Plecoptera present. Aquatic moss habitat was completely eliminated by forestry activity (clear cutting). Fish 20 species (1,136 specimens); increased sediment reduced habitat and invertebrate food sources.	

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State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
GA (con.)	Piedmont Cluster Brooklyn Creek (Clarke County)	Urban runoff	<u>Periphyton</u> Average trichromatic chlorophyll a 1.40 mg/m^2; periphyton species were indicative of a stressed system. Diatom community was dominated by pollution-tolerant species. Only 93 species identified; 13 species accounted for 60% of the total. <u>Macroinvertebrates</u> Diptera were predominant in species; Oligochaete were predominant in numbers. <u>Fish</u> 6 species (111 specimens).	CTA, Inc., 1983
	Blue Ridge/Upland Cluster Amicalola Creek/ Smith Creek (Dawson County)	Control	<u>Periphyton</u> Average trichromatic chlorophyll a 0.32 mg/m^2; 93 diatom species identified; 6 dominant species accounted for 80% of the total. <u>Macroinvertebrates</u> Aquatic moss habitat contained many species. A large number of specimens were intolerant to sediment and organic loading. <u>Fish</u> 7 species (370 specimens).	
	White Creek (White County)	Agricultural activities (sediment and organics from pasture land)	<u>Periphyton</u> Average trichromatic chlorophyll a concentration 4 times the control (1.61 mg/m^2); 99 diatom species identified. 14 dominant species accounted for 70% of the total. <u>Macroinvertebrates</u> A reduction in Plecoptera occurred. Some aquatic moss habitat and associated invertebrate populations remained intact. Sediment-intolerant species were reduced. Sediment-tolerant warm-water species were dominant. <u>Fish</u> 12 species (560 specimens).	

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State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
GA (con.)	Blue Ridge/Upland Cluster			CTA, Inc., 1983
	Jakes Branch (Lumpkin County)	Forestry activities (sediment load from road construction)	<u>Periphyton</u> Average trichromatic chlorophyll a 0.60 mg/m²; 135 diatom species identified; 8 dominant species accounted for 76% of the total. <u>Macroinvertebrates</u> Total number of species were reduced (Trichoptera, Ephemeroptera, Plecoptera, and Diptera predominant). Aquatic moss habitat and associated invertebrate assemblage were greatly reduced. <u>Fish</u> 7 species (232 specimens); sediment reduced density.	
	Flat Creek (Hall County)	Urban runoff (high organic load)	<u>Periphyton</u> Trichromatic chlorophyll a 20 times control stream (0.0 mg/m²); 90 diatom species identified; 10 dominant species accounted for 60% of the total. <u>Nitzschia palea</u>, a recognized indicator species for organic pollution, was 25.4% of the total. <u>Macroinvertebrates</u> Dominant pollution-tolerant species of Oligochaeta and Diptera were present. No aquatic moss habitat or associated invertebrates were present. <u>Fish</u> 0 species (0 specimens).	
	Gulf Coastal Plains Cluster			
	Little Sturgeon Creek (Ben Hall County)	Control	<u>Periphyton</u> Average trichromatic chlorophyll a 4.42 mg/m²; 80 diatom species identified; 12 dominant species accounted for 85.8% of the total. <u>Macroinvertebrates</u> Chironomidae, Odonata, and Coleoptera were dominant with lesser amounts of Ephemeroptera and Trichoptera present. A large Amphipoda component was also present. <u>Fish</u> 20 species (188 specimens).	

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
GA (con.)	Gulf Coastal Plains Cluster			CTA, Inc., 1983
	Camp Creek (Dooly County)	Agricultural activities (sediment and organics)	Periphyton Average trichromatic chlorophyll a 2.22 mg/m²; 107 diatom species identified; 14 dominant species accounted for 85.2% of the total. Macroinvertebrates Diptera were dominant (40.5%), with Trichoptera accounting for 30.5%. Sediment- and organic-tolerant species constituted virtually all the Trichoptera collection. Fish 22 species (302 specimens); good fishery; most diverse fauna.	
	Beaver Creek (Macon County)	Agricultural activities (sediment and organics)	Periphyton Average trichromatic chlorophyll a 1.64 mg/m²; Chlorophytes (*Volvox*) and Euglenophytes were dominant; 99 diatom species identified; 10 dominant species accounted for 83.7% of the total. Macroinvertebrates Chironomidae, Trichoptera, and Ephemeroptera predominated. Fish 15 species (110 specimens); high-turbidity water.	
	Heard Creek (Tifton County)	Agricultural activities (sediment)	Periphyton Average trichromatic chlorophyll a 0.94 mg/m²; 90 diatom species identified; 11 dominant species accounted for 78.7% of the total. Macroinvertebrates Chironomidae, Oligochaeta, Isopoda, Pelecypoda, Ephemeroptera, Simuliidae, and Ptychopteridae were dominant. Low numbers of individuals were collected. Fish 11 species (101 specimens); highly stressed environment.	

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State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
GA (con.)	Gulf Coastal Plains Cluster New River (Tifton County)	Urban runoff (high organic load)	<u>Periphyton</u> Average trichromatic chlorophyll a 8.38 mg/m^2; high primary productivity; 85 diatom species identified; 11 dominant species accounted for 58% of the total. <u>Macroinvertebrates</u> Simuliidae, Chironomidae, Ephemeroptera, Oligochaeta, Pelecypoda, and Trichoptera predominated. Species found were tolerant to organic loading stress environment. <u>Fish</u> 11 species (559 specimens); residential land use predominated.	CTA, Inc., 1983

State	Waterbody	NPS pollutant	Impacts on aquatic biota	Source
NC		Urban runoff (storm water)	Comparison of upstream or rural control station to urban storm water runoff station using "Kick" method for macroinvertebrate collection	Dude, Lenat, and Penrose, 1979
	Sweeten Creek Upstream control site compared to downstream urban site (Asheville, NC)		(table below)	
			Taxa richness at control was highest for Diptera, other groups, Trichoptera, Plecoptera, and Ephemeroptera; at urban site taxa richness was highest for Diptera and Oligochaeta.	
			Density of macroinvertebrates at the control site was highest for Plecoptera, Trichoptera, and Ephemeroptera; at the urban site it was highest for Oligochaeta and Diptera (93% of sample).	
			The number of different species found in each sample was reduced 70% from that of the control site.	
			Pollution-sensitive Ephemeroptera, Plecoptera, and Trichoptera are almost completely eliminated and are replaced by pollution-tolerant Oligochaeta (*Limnodrilus hoffmeisteri*, *L. udekemianus*, *Ilyodrilus templetoni*, and *Nais communis*) and the Chironomidae (*Chironomus* spp. and *Cricotopus* spp.)	
	Control site: Fourmile Creek (Davidson County)		General comments on urban pollution of 4 Piedmont urban runoff sites as compared to a control Piedmont site	
	Urban runoff sites: Salem Creek (Winston-Salem) Tar Branch (Winston-Salem) Pigeonhouse Branch (Raleigh) Rocky Branch (Raleigh)		Urban sites contained only 8-13 taxa as compared to 35-44 taxa at the control site. This is more than a 60% reduction, which would classify all urban study streams as severely stressed.	
			A high percentage of Oligochaeta and pollution-tolerant Chironomidae were present. These 2 groups represent >90% of the total organisms collected at urban sites, and only 37% at the control site.	
			Ephemeroptera, Plecoptera, Trichoptera, and Coleoptera were not just reduced but were absent completely from urban sites.	

Sweeten Creek data:

	Control	Urban
Ave. density	197	584
Ave. taxa richness	35.3	10.3
Ave. diversity	3.5	1.5
Ave. biotic index	1.8	3.8

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
NC (con.)	Fourmile Creek (control) Urban runoff sites: Salem Creek (Winston-Salem) Tar Branch (Winston-Salem) Pigeonhouse Branch (Raleigh) Rocky Branch (Raleigh)	Urban runoff (storm water)	Associated causes of poor water quality at urban sites may include: • Sediment from quarry discharge (Asheville) • Organic pollution from cracks in aging sewer lines (Asheville, Winston-Salem, and Charlotte) • Illegal toxic discharges (Durham, Raleigh, Winston-Salem, and Charlotte) • Sediment from stream bank erosion (Raleigh) While discharge permit limits may be met, water quality assessment by macroinvertebrate sampling reveals that streams are not meeting water quality goals "to provide for the protection and propagation of fish, shellfish, and wildlife."	Duda, Lenat, and Penrose, 1979

(continued)

State	Waterbody	NPS pollutant	Impacts on aquatic biota	Source
NC (con.)	Sevenmile Creek (Orange County)	Construction activities (Highway runoff from Interstate I-85)	A field monitoring program was conducted at the I-85/Sevenmile Creek site in North Carolina. The highway/receiving water interaction at this site can be characterized as a major interstate (25,500 vehicles per day) passing through a primarily forested rural region. Runoff is discharged into both headwater tributaries and the main stream channel. Again, a rural design with flush-shoulder, grassy-ditch drainage was used. In addition to runoff pollutant loads, treated sanitary wastewater discharges to the receiving water from two rest area extended-aeration package plants also contributed pollutants. Only a small percentage of the total watershed pollutant load was contributed by I-85 runoff. The right of way (ROW) comprised only 2.5% of the total watershed area. The results of monthly baseline and wet weather event (7 discrete events) sampling surveys demonstrated little effect from I-85 runoff on stream water quality. Although certain parameters had elevated concentrations at a station close to runoff discharge points compared to control stations, the magnitude of this impact was not severe. Neither water quality standards for the State of North Carolina nor water quality criteria issues by EPA were exceeded during these events at this station. Furthermore, these concentrations were reduced to background levels through dilution/sedimentation at the downstream station. I-85 runoff did not cause high accumulations of pollutants in the sediments. Although certain parameters at times had higher concentrations at influenced stations compared to controls, there was no consistency between surveys, between all influenced stations, or even between replicates at a given station and survey. The highway had no detectable effect on the macroinvertebrates of Sevenmile Creek. The taxa collected and their abundance showed no recognizable trends, either qualitatively (Hester-Dendy samples) or quantitatively (Surber samples), that would suggest a highway influence. Authors determined mean density (grams of organisms/m^2) biomass, richness, and biotic index for all macroinvertebrate data.	Dupuis et al., 1985

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State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
NC (con.)	Beech Flats Creek	Construction activities (runoff from acid rock used in road fill for highway construction)	Fish surveys by electroshocking indicated that no brook trout (*Salvelinus fontinalis*) or other fish were present 1.6 km downstream from a construction road-fill site. An instream experiment showed that 30 control trout (held in baskets upstream of construction site) survived 2 days in situ and 3 additional months in the laboratory. The 30 fish held downstream of construction site exhibited 100% mortality in 49 hours at pH 4.6-4.9. Survival of the shovel nosed salamander (*Leurognathus marmoratus*) was 100% after 7 days at the upstream site (pH 6.9-7.2) but was 40% at the downstream site (pH 4.5-4.9). Control subjects were lost in a flash flood; however, 42 days after exposure began, 83% of downstream salamanders were dead.	Huckabee, Goodyear, and Jones, 1975
	Walker Prong River	Naturally occurring acid creek (stream bedrock erosion and leaching)	Brook trout in control tributary (pH 5.2-6.5) had survival of 90% and 100% at 2 sites over a 14-day period. Brook trout at Walker Prong River sites (pH 4.5-5.0) had survival of 20% and 60%. All dead fish had gill hyperplasia (a symptom of both zinc and aluminum poisoning). This was further evidence of the leaching of acid rocks concomitant with the release of soluble metals and depression of pH.	

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
NC (con.)	Smith Creek (Granville County) Devil's Cradle Creek (Franklin County) March Creek (Wake County)	Land use comparisons between forested (control), agricultural, and urban runoff sites	Macroinvertebrate Collections were made by the kick method. Relative to the forested control (Smith Creek), the agricultural stream (Devil's Cradle Creek) had significantly lower taxa richness for most intolerant groups, Ephemeroptera, Plecoptera, and Trichoptera. Lower taxa richness was also observed for Odonata, Megaloptera, and Coleoptera, although some of these were not significant. These declines were offset by increases in Mollusca and Oligochaeta. Much greater declines in taxa richness were observed at the urban site (March Creek) as compared to both the control and agricultural site. Significant declines were seen in all 8 Insecta groups and in the Crustacea. Only the Oligochaetes increased in diversity. The observed reductions in taxa richness indicate moderate stress at the agricultural site and severe stress at the urban site. Total taxa richness was reduced by 4-16% at the agricultural site and 40-52% at the urban site. Greater reductions were seen for the Ephemeroptera, Plecoptera, and Trichoptera (intolerant groups) taxa richness: 47-40% at the agricultural site and 74-81% at the urban site. Density (abundance) values usually mirrored the pattern observed for taxa richness with several exceptions. Densities of Ephemeroptera and Plecoptera were lower at the agricultural site than at the control site; however, no decline in Trichoptera density was seen. Rather, Coleoptera declined. Chironomidae and Oligochaeta densities increased at both the urban and agricultural sites. June densities at the agricultural site were the highest measured, while the control and urban densities were highest in November. Based on yearly average densities, the control site was 3,910, the agricultural site was 5,383, and the urban site was 879. Community structure at the control site was Ephemeroptera (30-46%), Diptera (24-29%), and Trichoptera (10-16%). At the agricultural site, dominance switched from intolerant Ephemeroptera to tolerant Diptera (51%). . At the urban site, Diptera and Oligochaeta comprised 70% of invertebrate fauna. Agricultural runoff appears to have less impact on the aquatic biota than urban runoff. Many intolerant groups are eliminated at the agricultural site, but are partially compensated for by an increase in more pollution-tolerant species.	North Carolina Division of Environmental Management, 1986

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
NC (con.)	Smith Creek (Granville County) Devil's Cradle Creek (Franklin County) March Creek (Wake County) (con.)	Land use comparisons between forested (control), agricultural, and urban runoff site	Land use is clearly a major factor influencing the development of the macroinvertebrate community. Fish Collections were made by rotenone, electroshocking, and seining. Both the control and agricultural sites had high species richness (19), substantial numbers of game fish, and 3 to 4 darter/sucker species. Slightly better water quality was indicated at the control site by the presence of 2 rare species--the Eastern mudminnow (*Umbra pygmaea*) and the Carolina darter (*Etheostoma collis*). The agricultural site fish community indicated only minor environmental impacts. Fish were generally larger at the agricultural site, probably benefitting from the greater amounts of invertebrates and periphyton. The fish community at the urban site was characterized by low species richness, low standing crop, and the absence of any sensitive species.	North Carolina Division of Environmental Management, 1988

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
NC (con.)	Cullowhee Creek	Forestry activities (sediment) Construction activities (residential) Agricultural activities (fertilizer runoff from pastures)	9 riffle areas studied, Zone 1 (no inorganic or organic inputs, Zone 2 (sedimentation only), and Zone 3 (sedimentation and nutrient enrichment). Stream insect populations were monitored with a circular Hess sampler from March to October 1978. Zone 1 A total of 64 species; 12 Plecoptera, 18 Trichoptera, 5 Coleoptera, 17 Ephemeroptera, and 10 Diptera. Zone 2 A total of 50 species; 9 Plecoptera, 12 Trichoptera, 3 Coleoptera, 12 Ephemeroptera, and 10 Diptera. Zone 3 A total of 38 species; 6 Plecoptera, 10 Trichoptera, 2 Coleoptera, 10 Ephemeroptera, and 8 Diptera. There was a significant difference in number of species between the control (Zone 1) and polluted Zones 2 and 3, as well as between Zones 2 and 3. Diversity, species richness, density, and biomass of 3 orders (Plecoptera, Trichoptera, and Ephemeroptera) were significantly greater in Zone 1. The density and biomass of Diptera were significantly greater in Zone 3, but no difference was found in species richness of Diptera between the other 2 zones. Turbidity, suspended load, and bed load were found to have significant influences on species richness and diversity of the insect community but not on density due to large numbers of chironomids in zones receiving sedimentation. Many of the insects collected in Zones 2 and 3 were found to have a heavy buildup of inorganic particles on their body surfaces and respiratory structures. Addition of nitrates and phosphates, in association with sedimentation, resulted in growth of the filamentous bacterium *Sphaerotilus natans* on the insect's body and respiratory surfaces, which eventually smothered the insect.	Lemly, 1982

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State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
NC (con.)	Sandhill Cluster Bones Fork Rocky Ford Branch Bells Creek (Richmond County)	Agricultural activities (sediment) Comparison of control, well-managed, and poorly managed agricultural sites	Macroinvertebrates were collected by "Kick" method. Bones Fork (control) had lower taxa richness for Ephemeroptera, but higher taxa richness for Trichoptera and Chironomidae than the 2 agricultural sites. Numeric composition was stable. A diverse Diptera assemblage (mostly Chironomidae) was 33% of density. Plecoptera did not decline in August sample. Rocky Ford Branch (well-managed) was numerically dominated by Ephemeroptera (39%), but was otherwise similar to the control. Numeric composition was relatively stable. Taxa richness was comparable to that at the control. Plecoptera, the most pesticide-sensitive group, declined to 1% of fauna in August. Bells Creek (poorly managed) taxa richness for Trichoptera, Odonata, and Chironomidae was consistently low. The taxa richness value was 16% less than that at the control. Numerical composition was the least stable. Density was dominated by Plecoptera in January, Ephemeroptera-Diptera in May, and by Coleoptera in August. A pesticide-tolerant Coleoptera (*Stenelmis* sp.) was tolerant at this station. Plecoptera, the most pesticide-sensitive group, declined to 1% of fauna in August.	Lenat, 1984
	Piedmont Cluster Olin Creek Buffalo Shoals Little Creek (Iredell County)		Olin Creek (control) had the highest taxa richness for Ephemeroptera, Diptera (Chironomidae), and Trichoptera. Density values at the control site were stable. Buffalo Shoals (well-managed) was characterized by severe reductions in taxa richness for pollution-intolerant groups--Ephemeroptera, Plecoptera, and Coleoptera. Variations in density were greater than at the control site; considerable variation occurred between dates. Trichoptera increased in spring and summer sample. The taxa richness value was 23% less than that at the control site. Little Creek (poorly managed) was characterized by severe reductions in taxa richness for pollution-intolerant groups--Ephemeroptera, Plecoptera, Trichoptera, and Coleoptera. Variations in density were higher than at the other two stations. The taxa richness value was 39% less than that at the control.	

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
NC (con.)	Mountain Cluster Bee Tree Creek Cane Creek Avery Creek (Buncombe County)	Agricultural activities (sediment) Comparison of control, well-managed, and poorly managed agricultural sites	Bee Tree Creek (control) had a taxa richness comparable to that at the well-managed site (Cane Creek). Ephemeroptera, Diptera (Chironomidae), and Trichoptera predominated. The density value was most stable at the control site. Cane Creek (well-managed) site was very similar in taxa richness to the control site; taxa richness declined only for Plecoptera. The density value was less stable than at the control site. Avery Creek (poorly managed) site was characterized by a reduction in taxa richness for Ephemeroptera, Plecoptera, and Trichloptera. Taxa richness was reduced 6% as compared to that at the control site. Shifts in dominance were greatest at this site. General trends over three clusters Total and average taxa richness for well-managed stream sites were always greater than at poorly managed stream sites. Taxa richness at well-managed sites (Richmond and Buncombe Counties) exceeded that at the control site. The increase was due to the creation of a stable sand community. Average density was higher at 4 of the 6 agricultural sites as compared to at the control site, but differed significantly only for Buncombe County. Development of stable sand communities during low flow periods can influence density. Stability of benthic communities differed significantly at poorly managed sites as compared to at well-managed and control sites. Intolerant taxa declined at all three poorly managed sites but at only one well-managed site. In all three clusters, there were more unique species at the control sites than at the agricultural sites; a mean of 32 taxa appeared at control sites versus 19-21 taxa at agriculturally stressed sites. This difference was significant. Plecoptera, Ephemeroptera, and Trichoptera were most severely affected by runoff. Large temporal shifts in taxonomic composition (% abundance) occurred at agriculturally stressed sites.	Lenat, 1984

(continued)

EPA REGION 4 (continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
NC (con.)	Mountain Cluster Bee Tree Creek Cane Creek Avery Creek (Buncombe County)	Agricultural activities (sediment) Comparison of control, well-managed, and poorly managed agricultural sites	Stability of benthic community was greater at control sites. Taxa favored by agricultural runoff included collector-gatherers, scrapers, and filter feeders.	Lenat, 1984

(continued)

State	Waterbody		Nonpoint source	Impacts on aquatic biota				Source
NC (con.)	Unidentified urban streams		Urban runoff (small urban streams)	Macroinvertebrate samples were collected by the Kick net method.				Lenat and Eagleson, 1981
				Taxa Richness	Density	Biotic Index	% O/D[a]	
	Goldsboro	1[b]		59	786	2.9	66	
		2[c]		24	405	3.5	98	
	Greenville	1[b]		30	169	3.5	66	
		2[c]		24	372	3.7	98	
	Wilson	1[b]		20	104	3.5	91	
		2[c]		6	76	4.7	99	
	Dunn	1[b]		34	226	3.1	60	
		2[c]		18	198	3.8	87	
	Brevard	1[b]		36	110	2.3	22	
		2[c]		24	98	2.7	21	
	Asheboro	1[b]		41	319	2.0	23	
		2[c]		20	192	3.0	20	
		3[c]		23	276	2.0	21	
	Morganton	1		50	1,446	1.9	9	
		2		35	113	3.3	54	

Summary

The biological community was severely stressed at most sites receiving urban runoff. Taxa richness at all downstream sites was low (6-25 taxa), an average reduction of 45% relative to the upstream control. Density values show no clear trend between the five city sites. Runoff sites may have densities higher or lower than the control. Biotic index values increased ~0.8 units at all downstream sites. The Piedmont and mountain cities had generally lower biotic index values, suggesting less severe water quality problems. The greatest declines in taxa richness were associated with reductions in the Trichoptera and Diptera. The three Oligochaetes that increased in numbers at all downstream stations were Limnodrilus hoffmeisteri, L. udekemianus and Nais sp. Pollution-tolerant species predominated at the polluted downstream urban sites. Effects were most severe in the coastal plain streams as compared to the mountain streams or Piedmont streams. Runoff effects were related to the size of the city for Piedmont and mountain streams. The larger the city, the worse the effects of runoff on the macroinvertebrate community.

[a]% Oligochaeta/Diptera.

[b]Control upstream site.

[c]Downstream site.

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
NC (con.)	Spainhour Creek and Warrior Creek (Caldwell County)	Highway construction (sediment from road construction) Spainhour Station S1 (control) Stations S2 and S3 (impact) Warrior Station W1 (control) Stations W2 and W3 (impact)	Benthic invertebrate samples collected by "Kick" method showed a reduction in average density at Stations S3 and W2 and W3; however, there was an unexpected increase in density at S2, a channelized area. Rainfall greater than 6 cm was associated with reduced densities at S2 and S3 which were 80% and 6% of the control S1 density. Rainfall was a good predictor of density only at Station S3, the area of greatest sedimentation. Benthic densities at Spainhour and Warrior Creek were high at sediment-stressed areas only during low flow periods because of high periphyton growths. Habitat reduction is of greater importance in predicting species richness than habitat change. Ephemeroptera increased at sediment-impacted stations (S2, S3, and W3). This increase coincided with low rainfall and development of stable sand community. Ephemerella catawba, Baetis sp., and Pseudocloen sp. were responsible for the increased density. Reaction of benthic community is dependent on stability of habitat (sand substrates) which depends on flow. During high flow periods, sand substrate becomes an unsuitable habitat for all benthic species as a result of reduced available habitat area.	Lenat, Penrose, and Eagleson, 1981

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
NC (con.)	Neuse River	Agricultural activities (fertilizer runoff, sediment erosion, feedlot runoff, and urban runoff)	From both nutritive (inorganic N and P) and productivity perspectives, the Lower Neuse River exhibits both eutrophic and hypereutrophic characteristics, raising concern with respect to poor water quality conditions often accompanying such "advanced" states. Overall, trophic states reveal distinct seasonal as well as year-to-year variation. As is common among temperate river and lake ecosystems, while ambient nutrient levels may remain extremely high all year, primary productivity and resultant phytoplankton biomass accumulations (including blooms) can vary dramatically on a seasonal basis. Surface primary productivity rates range from a wintertime and early spring low of less than 5 mg $C \cdot m^{-3} \cdot h^{-1}$ (which by biological standards would reflect oligotrophic conditions) to rates in excess of 300 mg $C \cdot m^{-3} \cdot h^{-1}$ in late spring and summer months (eutrophic to hypereutrophic conditions). This tremendous range is largely governed by physical factors such as light (PAR) availability, ambient temperature and, perhaps most importantly, discharge and resultant flushing rates of this river. A good example of flushing rates dictating production rates can be seen during sizeable late spring and early summer rainfall and high runoff events. Such events invariably enhance discharge and residence time of phytoplankton communities. The shorter the residence time, the less opportunity exists for phytoplankton communities to develop appreciable biomass, since the inherent cell doubling rates are eclipsed by short water residence times. As a result, biomass development is curtailed, and relatively few phytoplankton cells are responsible for observed primary productivity rates as well as chlorophyll a content. Dramatic "dilution" impacts on these parameters were observed during rainy spring and mid-summer months in 1981 (primary productivity in late August was as low as 6 mg $C \cdot m^{-3} \cdot h^{-1}$), 1982 (primary productivity in mid to late July was 5-8 mg $C \cdot m^{-3} \cdot h^{-1}$), 1984 (which had a very wet summer in which rates of 5-15 mg $C \cdot m^{-3} \cdot h^{-1}$ were reported), as well as late August in 1985 (when tropical storm activity lowered the productivity to less than 25 mg $C \cdot m^{-3} \cdot h^{-1}$). In contrast, during dry spring and summer periods of low discharge and long water residence time, phytoplankton productivity and biomass can rapidly develop, since during these periods nutrient supplies appear plentiful, temperature and light conditions are near optimal, and long residence times ensure that cell division rates compensate for flushing (dilution). In these periods, phytoplankton cell division seemingly proliferates in an uncontrollable fashion, being limited only by nutrient availability and/or intermittent flushing events. Such conditions ultimately lead to the development and dominance by blue green algal nuisance species, which manifest themselves as surface blooms (scums) optimizing warm, stagnant, nutrient and PAR rich conditions while competitively shading sub-	Paerl, 1987

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
NC (con.)	Neuse River	Agricultural activities (fertilizer runoff, sediment erosion, feedlot runoff, and urban runoff)	surface nonbuoyant and often more desirable chlorophycean and diatom species. There is little doubt that lengthy residence times favor bloom development, since the major taxa responsible for such blooms (M. aeruginosa, Anabaena spp., Aphanizomenon flos aquae) exhibit growth rates and doubling times (even during optimal growth conditions) that are slower than more desirable eukaryotes. A lengthy residence therefore "buys time" for these blue-green algae to develop; once development has taken place, the maintenance of warm, nutrient and radiant energy-rich conditions, all of which are effectively exploited by these surface-dwellers, represents insurance for bloom proliferation and maintenance. When examined in concert, the physical, chemical and biotic data presented for 1983 typify optimal nutritive and physical conditions, as well as the proper sequence in which such conditions must occur, needed for massive nuisance bloom development. No single feature, such as nutrient status, temperature, discharge (and resultant flushing), can by itself dictate whether or not nuisance blooms will occur in any given year. Whereas it is well-known, from hydrocorral data and field observation, that blooms develop only during persistent low discharge, long residence, stagnant conditions, these conditions were prevalent during at least 3 years (1983, 1985, 1986). Such amenable physical conditions were most extreme and persistent in 1985 and 1986. Despite such seemingly ideal bloom conditions, nuisance blue-green algal biomass development was lower in these years than virtually all other years examined between 1981-1986. Clearly, these observations point to both additional regulatory conditions, including synergistic interactions of low discharge and long retention times with nutritive factors as playing critical roles in bloom development. Both the magnitudes and timing of late winter - early spring nutrient, and specifically nitrogen, loading play crucial roles in dictating whether or not nuisance blooms will manifest themselves in subsequent mid to late summer months. Nutrient addition and dilution bioassays strongly supported the fact that excessive (with respect to phytoplankton nutrient requirements) nutrient loading exists in years featuring high spring runoff and discharge. These same assays showed that, while enhanced nutrient loading might periodically expose phytoplankton to excessive nutrient concentrations, phytoplankton nutrient uptake in periods immediately following runoff events effectively ushers in periods of nitrogen-limited growth. To some extent, the amount of nutrient overloading that occurs during spring months dictates how long it will take for nitrogen limitation to set in once discharge has receded. It has been estimated that water residence times in the lower Neuse River downstream of Kinston can vary	Paerl, 1987

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
NC (con.)	Neuse River	Agricultural activities (fertilizer runoff, sediment erosion, feedlot runoff, and urban runoff)	from less than 1 week (during storm-runoff events) to as much as 3-4 months (Paerl 1983; Christian et al. 1986) (during drought-stricken periods). Such highly changeable hydrological conditions are by and large responsible for a great deal of fluctuation in physical, nutritive, and biological characteristics. Furthermore, rapid changes in physical and chemical conditions, such as the onset of a relatively dry period following massive discharge and nutrient loading events, can lead to conditions where exceedingly high nutrient loads remain in the system long enough to overlap with proper physical conditions for bloom development. This appears to have been the case in 1983, when within a 1-1/2 month period (early April-Mid June), record-high NO_3^- loading over-lapped with sudden decreases in discharge, leaving a sizeable NO_3^- "pulse" residing in the lower Neuse River at this time. During this same period, M. aeruginosa developed as a dominant phytoplankter; this biomass development ultimately proliferated itself as surface blooms as the river further stagnated during July-September. Collectively, nutrient loading and bioassay results strongly implicate inorganic nitrogen availability as a key regulatory factor in M. aeruginosa bloom development; both nutrient addition and dilution bioassays indicated that inorganic nitrogen was consistently the most limiting phytoplankton nutrient. Therefore, constraints on its input would be the most effective step in reversing both general trends in eutrophication as well as bloom development of this organism. In the previous paragraphs, evidence was presented pointing to the strong linkage between excessive spring loading of inorganic nitrogen and subsequent nuisance blooms, particularly during hot and persistently dry summer months. Taking into consideration additional evidence that in some bloom years (specifically 1983), excessive inorganic nitrogen loading took place during spring and early summer months, and that M. aeruginosa is capable of optimizing its growth under these conditions, it would seem appropriate to restrict inorganic nitrogen loading during such months as well as subsequent summer and fall months. Dilution bioassays revealed that, during high discharge periods in the spring of 1983, inorganic nitrogen availability exceeded phytoplankton demands by approximately 30%. In subsequent nonbloom years, excess availability ranged from 0 to approximately 20%. Accordingly, it is recommended that a basin-wide effort aimed at reducing spring (and summer) inorganic nitrogen loading by at least 30% (of average yearly loading values) be considered for effective control of M. aeruginosa blooms. Such reductions occurred through natural means in 1985 and 1986, largely due to very dry spring months, leading to	Paerl, 1987

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
NC (con.)	Neuse River	Agricultural activities (fertilizer runoff, sediment erosion, feedlot runoff, and urban runoff)	decreased nonpoint source loading. The results of these decreases in spring inorganic nitrogen loading were evident in the phytoplankton communities which developed and dominated ensuing summer months; M. aeruginosa was virtually absent from such communities in both years, despite the fact that physical (flow, temperature, irradiance) conditions were very favorable for bloom development. Additional evidence for the linkage of rainfall-mediated nutrient loading to M. aeruginosa bloom development came during the writing of this report, when, following a break in the drought of 1986, appreciable rainfall arrived in the Neuse River Basin in September. These rainfall events were substantial enough to enhance both discharge (flow) and nutrient (especially NO_3^-) loading significantly. River discharge and flow conditions returned to typical summer levels by early October. As flow rates decreased, M. aeruginosa blooms developed near Vanceboro and New Bern by mid-October. These blooms persisted for at least 2 weeks until additional rainfall in late October flushed the bloom populations out of the lower Neuse River. Subsequent decreases in river water temperature by November negated further bloom activity. Thus, even though the entire summer of 1986 exhibited flow conditions favorable for M. aeruginosa bloom development, it wasn't until appreciable rainfall, accompanied by enhanced nutrient loading, that such blooms finally began to appear. Fortunately, favorable bloom conditions occurred late enough in the fall to avoid nuisance conditions.	Paerl, 1987

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State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
NC (con.)	Cox Creek (Henderson County)	Agricultural activities (pesticide runoff from apple orchards)		Penrose and Lenat, 1982
		Station 1 (upstream control)	Ephemeroptera (67%), 11 species; Plecoptera (2%), 1 species; Trichoptera (8%), 3 species; Diptera (6%), 6 species; Coleoptera (6%), 2 species. Several pollution-sensitive taxa were found only at the control site: mayflies (Epeorus sp., Baetis tricaudatus), stonefly (Pteronarcys sp.), and caddisflies (Diplectrona modesta, Rhyacophila sp.). Taxa richness was highest; density was usually highest.	
		Station 2 (receiving some apple orchard runoff)	Ephemeroptera (56%), 10 species; Plecoptera (6%), Trichoptera (7%), 3 species; Diptera (4%), 2 species; Coleoptera (7%), 2 species. Taxa richness was somewhat reduced from control value. Species density exceeded control in April-May 1977 period, but was less than control during May 1977-March 1978. Station was periodically stressed.	
		Station 3 (receiving primarily apple orchard runoff)	Ephemeroptera (45%), 9 species; Plecoptera (6%); Trichoptera (13%), 1 species; Diptera (2%), 2 species; Coleoptera (13%), 2 species. Tolerant species included mayfly (Ephemerella catawba), beetle (Optioservus ovalis), caddisfly (Cheumatopsyche sp.), and flies (Cricotopus bicinctus and Orthocladius obumbratus). Taxa richness was severely reduced from control values; density was greatly reduced and was especially low from September 1977 to January 1978. The decline was possibly linked to elevated endrin concentrations found in sediment from January to March 1978. Station exhibited chronic stress.	

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
TN	Lynn Branch Long Branch Crooked Creek (mile 18.5) (control sites) Crooked Creek (mile 16.7) Unnamed tributary of Crooked Creek Crooked Creek (mile 15.9) (acid-mined sites) (Fentress County)	Mining activities (strip-mining runoff)	Fish Fish were collected by electroshocking techniques coupled with block nets. Streams were dominated by the creek chub (*Semotilus atromaculatus*). This species was found at every station; however, its abundance was severely restricted at sites impacted by siltation. Other species present included the fathead minnow (*Pimephales promelas*) and the blacknose dace (*Rhinichthys atratulus*). Several nonstream species bluegill (*Lepomis macrochirus*), spotted bass (*Micropterus punctulatus*), and the largemouth bass (*Micropterus salmoides*) were collected at the impacted sites; however, the collections did not indicate any reproduction for the introduced species. Fish assemblages in the streams differ, and these differences seem to be related to strip-mine inputs into the basin. Macroinvertebrates Macroinvertebrates were collected by 1-ft^2 Surber samplers. Macrobenthic biomass varied little among the various sites, with the exception of the mine-impacted site on Crooked Creek (at mile 16.7). The large variation in biomass at this station probably resulted from a shifting, unstable, eroding substrate. Another mine-impacted site (Crooked Creek, mile 15.9) exhibited the lowest mean quantity of insect biomass. Periphyton Periphyton was collected on glass slides at all stations. The Crooked Creek control station contained the highest algal biomass primarily because there was less erosion at the control sites. These sites had less erosion because there was less suspended matter to scour away the algal communities and because the forest canopy was more open, allowing greater incident radiation. The mine-impacted sites contained the lowest algal biomass.	Cox et al., 1979

EPA REGION 5

EPA REGION 5

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
IL	Fox River Three sites; 1. At Elgin below a small flood control dam with combined industrial, sewage, and storm-water effluents. 2. A pond located downstream of Elgin on a mid-channel island (water from ground seepage and flooding of river). 3. At Algonquin no significant industrial or sewage discharge).	Urban runoff and sewage treatment facility discharge (heavy metals)	Significantly higher concentrations of cadmium and lead were found at the Elgin site in algae and benthic insects. Cadmium and lead occurred at concentrations in crayfish Orconectes virilis associated with environmental input concentrations. Copper and zinc were trace metals that were regulated by crayfish irrespective of environmental concentration. Gills and viscera contained the highest concentration of cadmium, copper, and zinc. The exoskeleton contained the highest concentration of lead. Muscle concentrations of the heavy metals were generally lower than other tissues. Crayfish are good biomonitoring organisms to assess cadmium and lead pollution.	Anderson and Brower, 1978

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State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
Il (con.)	Fox River at Algonquin (control) and Elgin (runoff site)	Urban runoff (heavy metals)	Biota were analyzed for heavy metals. Detritus and algae were collected in grab samples. Macroinvertebrates were collected by Surber net. The 4 metals studied fell into two categories; copper and zinc are essential elements and components of metallo-enzymes; cadmium and lead are biologically non-essential and can be highly toxic. There were no significant differences in copper or zinc concentrations between species that were present at both sites. Within sites only the crustaceans and damselfly nymph (Argia) have significantly greater copper concentrations compared to other biota. In Crustacea, the crayfish Orconectes copper in the porphyrin ring of hemocyanin may account for these high concentrations. Significantly different patterns of cadmium and zinc concentration were found within and between sites. Lead and cadmium concentrations were generally higher at Elgin for species common to both sites. The mayfly nymph, Hexagenia, and chironomid larvae collected around a small boat launch ramp at Algonquin had significantly higher lead concentrations than other invertebrates at the same site. Juvenile black bullheads collected at the boat ramp site also had higher lead concentrations than other fish species at the site. There was a graded decrease in cadmium and lead body burdens from herbivores to higher trophic levels. Lead and cadmium may accumulate to a greater degree in organisms where environmental concentrations are higher, but were not found to demonstrate trophic magnification.	Anderson, Vinikour, and Brower, 1978

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
IL (con.)	Illinois River	Agricultural activities (cropland, pasture, and some woodland, and some sewage diversion from Chicago since 1900)	140 species from 27 fish families were collected. Richest taxa were: Cyprinidae (41 species) Percidae (10 species) Catostomidae (10 species) Centrarchidae (14 species) Water diversion from Lake Michigan has had the greatest effect on fish species. In 1900, 10% of freshwater commercial fish catch was from the Illinois River; in 1980 there is virtually no fishery. 6% of species declining (8 species) 61% of species locally extinct or present in isolated refuges (82 species) 23% of species stable (31 species) 5% of species increasing in number or geographic range (7 species) 5% of species introduced (7 species) Largest decline in fish populations (73%) occurred in midriver reaches, followed by a 60% decline in fish species in both headwater and large river reaches. Insectivores, herbivores, carnivores, and planktivores showed more species decreasing than increasing. Omnivores had similar percentages of species declining and increasing. Habitat degradation had the greatest impact on fish populations.	Karr, Toth, and Dudley, 1985
	Maumee River	Agricultural activities (90% of river basin agricultural and 2 small urban areas of Toledo and Fort Wayne)	98 species of fish were collected. Richest taxa were: Cyprinidae (28 species); Percidae (16 species); Catostomidae (13 species); Centrachidae (12 species); Species composition has changed significantly since 1850. Drainage of the Black Swamp caused the decline of many commercially valuable species (muskellunge [Esox masquinongy], northern pike [Esox lucius], lake sturgeon [Acipenser fulvescens], walleye [Stizostedoin vitreum], smallmouth bass [Micropterus dolomieui]) and increase in less valuable species (quillback carp sucker [Carpiodes cyprinus], gizzard shad [Dorosoma cepedianum], freshwater drum [Aplodinotus grunniens], buffalo [Ictiobus sp.], and carp [Cyprinus carpio]).	

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EPA REGION 5 (continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
IL (con.)	Maumee River	Agricultural activities (90% of river basin agricultural and 2 small urban areas of Toledo and Fort Wayne)	17% of species declining (17 species) 27% of species locally extinct or present in isolated refuges (27 species) 35% of species stable (34 species) 10% of species increasing in numbers or geographic range (10 species) 11% of species introduced (11 species) Headwater streams have suffered greatest declines in fish populations (50% of 20 species), followed by midriver areas (44% of 54 species), and lastly by large river areas (only 31% of 16 species). Insectivores, herbivores, and top carnivores declined (40-50%). Planktivores showed 100% increase and omnivores increased in medium-sized rivers. Fauna shifted most in medium-sized rivers.	Karr, Toth, and Dudley, 1985

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
IN	Eagle Creek (Hamilton, Boone, Hendricks, and Marion Counties) Stotts Creek (Morgan and Johnson Counties) Rattlesnake Creek (Owen County)	Agricultural activities (comparison of land use impacts on three watersheds)	From 1978 through 1980 fish and macroinvertebrate communities were examined from three watersheds ranging from predominately forested (Rattlesnake Creek) to progressively more heavily agricultural (Stotts Creek [50% cropland; 35% forest] and Eagle Creek [70% cropland; 14% forest]). In addition to biotic communities, riparian vegetational patterns, stream morphology, and habitat were examined. These investigations were coordinated with concomitant studies on land use and soil loss simulation studies. <u>Fish surveys</u> Fish populations at 14 sites were sampled twice each summer with an electric seine. Estimates of standing crop, obtained by the DeLury method, and several community parameters were examined in relation to the intensity of agricultural development. Standing crop estimates of fish were not, in themselves, of great value in evaluating chronic agricultural effects. Depressions in standing crop occurred in response to sporadic influences by animal feed lots and also to a chronic problem downstream from a chemical recycling plant and landfill. Standing crop and the proportion of piscivores (centrarchids) and insectivores appear to best indicate the extent to which sustained agriculture affects the fish community. Moderate agriculture permits an expansion of the standing crop while maintaining good populations of sunfish, crappie, and bass. Heavy agriculture ultimately causes great declines in centrarchids and catostomids, and an expansion of omnivores, detritivores, and herbivores, first in smaller streams and then progressing downstream. A statistically significant negative relationship was found between percent cropland in watersheds and percent piscivores and insectivores (% P+I) in the fish communities. The amount of cropland in subwatersheds accounted for 51% of the variation in % P+I in Eagle Creek and 81% in Stotts Creek. Statistically signficant negative relationships also occurred between percent cropland and mean depth and between percent cropland and insect diversity. <u>Macroinvertebrate studies</u> Three Surber samples of macroinvertebrates were collected monthly from May through October. Biomass was not a reliable indicator of environmental conditions, but diversity based upon density of insect families was useful. The best collecting stations generally yielded from 10 to 20 insect families. Chironomids were major components of all locations during May and June, but declined in importance in July and August in the "good" sites while remaining abundant in the "poor" sites. Trichoptera, especially Hydropsychidae, became the dominant insect group following the decline in Chironomidae.	Gammon et al., 1983

(continued)

EPA REGION 5 (continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
IN (con.)	Eagle Creek (Hamilton, Boone, Hendricks, and Marion Counties) Scotts Creek (Morgan and Johnson Counties) Rattlesnake Creek (Owen County)	Agricultural activities (comparison of land use impacts of three watersheds)	Point-source disturbances altered the taxonomic composition by eliminating or severely reducing usually uncommon families and the overall diversity, while increasing numbers of Chironomidae, Oligochaeta, and Nematoda. Heavy agriculture led to a depression in density of non-chironomid insects. Recovery from a single event was rapid, while chronic depressions in the macroinvertebrate community occurred in areas of high agricultural utilization. The presence of a vegetative buffer between agricultural fields, including grazed pastures, residential areas, or meadows and a stream is very important to the stream ecosystem. The smaller the stream the more important is this buffer strip.	Gammon et al., 1983

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
MI	Saline River (Raisin River Basin)	Agricultural activities (pesticide effects of methoxychlor 0.2-ppb treatments to control Simuliidae larvae)	This study was conducted for 1 year from July 1972 to July 1973. Riffle invertebrates were allowed to colonize artificial substrates for 30 days. 2 control and 2 treated stations were examined. Changes in species diversity were comparable to individual population changes. After dosing, diversity decreased because of reduced species richness and reduced population densities. Baetis intercalaris, B. levitans, Perlesta placida, Allocapnia sp., Isoperla sp., and Hyalella azteca populations were temporarily reduced. Hyalella azteca was not observed in dosed riffles for 9 months of the 12-month pesticide dosing period. Populations of Hydropsyche sparna and Cheumatopsyche sp. were initially reduced but recovered rapidly. Density of most invertebrates returned to predosing levels within 30 days. Bottom invertebrate collections exhibited less variability in species diversity than artificial plate samplers. The community response (as measured by species diversity) indicated that the methoxychlor dosing resulted in no substantial change in diversity.	Eisele and Hartung, 1976

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
MN (con.)	North Branch Creek Blackhoof River Caribou River (all of the pristine sites studied were located in deciduous forests)	Agricultural activities (organic material)	North Branch Creek, in addition to having the highest alkalinity and nitrates, had the highest fine-particle proportion in the substrate, a quality probably related to its slower current velocity. Since, of the three streams, North Branch Creek was the only stream near any agricultural area, it is possible that agricultural organic input, accumulated in the fine sediments, was an important factor in the higher benthic production. Total fish standing stocks appeared to have a positive association with both invertebrate herbivore-detritivore and carnivore production. Caribou river, which had the lowest invertebrate production for both trophic levels, also had the lowest fish standing stock. Similarly, the Blackhoof River was intermediate and North Branch Creek was highest for these estimates. Since most of the fish species in these streams utilize benthos for food, it is not an unexpected result that the production by the lower trophic level (invertebrates) was positively associated with standing stock of a higher trophic level (fish). The results of the present study emphasize the role of invertebrate food production in determining fish biomass; the maximum attainable fish standing stock is probably set by invertebrate production but may be regulated at some lower level by other factors such as space.	Krueger and Waters, 1983

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
MN	North Branch Creek Blackhoof River Caribou River (all of the pristine sites studied were located in deciduous forests)	Agricultural activities (organic material)	Annual production of macroinvertebrates in three Minnesota streams of different water quality was determined using modified Surber sampler. Standing fish stocks were assessed by electrofishing. Annual production of herbivore-detritivore macrobenthos was lowest in the Caribou River (wet mass: 27.0 g/m^2), intermediate in the Blackhoof River (36.9 g/m^2), and highest in North Branch Creek (119.6 g/m^2). Annual production by invertebrate carnivores was 5.5, 6.5, 12.0 g/m^2 in Caribou River, Blackhoof River, and North Branch Creek, respectively, following the same pattern as herbivore-detritivores. In the Caribou River, Oligochaeta and Stenonema vicarium (Ephemeroptera) were the most significant contributors to benthic production. Tipula (Diptera) dominated the shredder production estimates, while Hydropsyche (Trichoptera) and Simuliidae comprised the majority of the collector-filterer production. Ephemeroptera and Oligochaeta accounted for 68% of the annual production from the collector-gatherer/deposit-feeder group. Hirudinea, Odonata, and Polycentropus (Trichoptera) comprised 86% of the carnivore estimate. In the Blackhoof River, Hydropsyche (Trichoptera) was the most significant contributor to macroinvertebrate annual production. Tipula and Prostoia similis (Plecoptera) accounted for 63% of the shredder production estimate. Hydropsyche (Trichoptera) and Simuliidae comprised the majority of the collector-filterer production. Much of the production in the collector-gatherer/deposit-feeder group was by Ephemeroptera nymphs (notably Baetis). Isogenoides olivaceus (Plecoptera) and Atherix (Diptera) constituted 74% of the carnivore production. In North Branch Creek, Chironomidae and Oligochaeta were the most significant contributors to benthic production. Tipulidae comprised 78% of the shredder annual production, while Hydropsyche and Brachycentrus (Trichoptera) constituted the majority of the collector-filterer production. Ephemeroptera and Diptera accounted for 74% of the annual production for the collector-gatherer/deposit-feeder group. The greater part of the carnivore production was by Tabanidae and Sialis dreisbachi (Megaloptera). In the present study there were observable differences in autotrophy among study sites. In North Branch Creek, plant growths of Ranunculus and algae were abundant, whereas similar autotrophs were not observed in the other streams. Contributions of such inputs to invertebrate production may be direct through animals such as scrapers (scraper annual production was highest in North Branch Creek), or indirect through detrital pathways. As a result, energy inputs from autochthonous sources may have provided an additional energy source for invertebrates in North Branch Creek. Plant abundance in North Branch Creek may have been related to the higher nitrate levels observed in the stream (Hynes 1970) and may have contributed to the association between invertebrate production and nitrate.	Krueger and Waters, 1983

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
MN (con.)	Cottonwood River (Lyon County) natural stream Highwater Creek (Cottonwood County) natural stream Fort Ridgely Creek (Nicollet and Renville Counties) modified stream Ramsey Creek (Redwood County) modified stream	Agricultural activities (assess downstream effects of channelization and agricultural drainage development)	Macroinvertebrate samples were collected with a Surber sampler. Ten percent of all comparisons of benthic invertebrate populations indicated a difference between natural and modified stream pairs, and individual natural and modified streams differed in less than 20% of their comparisons. The two modified streams, Fort Ridgely and Ramsey, were different in 4% of the comparisons and the natural streams, Highwater and Cottonwood, differed in about 20%. These results reflect the inherent variability in samples from small stream ecosystems while at the same time emphasizing the similarity between the two pairs. Over the 21-month study period, mean abundance, biomass, and drift of total insects and total benthos were similar in all streams, and monthly means of these measures showed few significant differences between natural and modified pairs. The abundance, biomass, and drift of total noninsect invertebrates, abundance and biomass of two predominant insect orders (Trichoptera and Coleoptera), and drift of Plecoptera varied significantly among streams. With the exception of noninsect and plecopteran drift, all measures were greater in natural than in modified streams, although differences between streams within each type also occurred. The abundance of dipteran insects, which accounted for 40-60% of all faunas, was similar among all streams. Previously published studies provide a sufficient basis to conclude that if agricultural drainage development had resulted in levels of siltation and turbidity which would be major impacts on benthic organisms, the two modified streams investigated would have had depauperate invertebrate assemblages as compared with the natural streams. Reductions in fauna should be especially apparent for taxa that are intolerant of such conditions: <u>Pseudocloeon</u> sp., Hydropsychidae, <u>Simulium</u> sp., <u>Physa gyrina</u>, <u>Ferrissia</u> sp., Pelecypoda, and others. The present results indicate clearly that this was not the case. In general terms, the benthic invertebrate faunas of the four study streams were similar. Over the entire study period, and with few exceptions on a monthly basis, numerical abundances, biomass, and drift rates were similar. Species diversity as represented by the number of taxa encountered and the distribution abundance among them was similar for all streams (Highwater 3.83, Cottonwood 3.85, Fort Ridgely 4.09, Ramsey 4.00). Because silt and turbidity were similar in all streams, these did not appear to be causal factors differentially affecting the benthos in the two modified streams as compared with the natural streams. In fact, the similar turbidity levels found in all streams probably accounted for the similarity in benthos and drift among all streams.	Marsh and Waters, 1980

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
MN (con.)	Cottonwood River (Lyon County) natural stream Highwater Creek (Cottonwood County) natural stream Fort Ridgely Creek (Nicollet and Renville Counties) modified stream Ramsey Creek (Redwood County) modified stream	Agricultural activities (assess downstream effects of channelization and agricultural drainage development)	While the 4 study streams were generally similar, there were a number of statistically significant differences between natural and modified stream pairs. However, these differences were primarily a result of invertebrate numbers, biomass, or drift rates being exceptional in one stream compared with the other three. Also, in most instances in which differences were found between natural and modified stream pairs, there were also differences within pairs. The 6 significant differences in total drift rate (Allocapnia sp., Stenonema sp., Tipula sp., Hyalella azteca, and Physa gyrina) showed that in each instance rates were greater in modified than natural streams. Downstream reaches of modified streams did not experience different regimes of silt and turbidity loading compared with the natural streams. Differences in benthic invertebrate faunas between streams were primarily attributable to local differences in substrate and other site-specific factors rather than agricultural activities.	Marsh and Waters, 1980

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
WI (con.)	Nemahbin Lake (Jefferson County)	Construction activities (highway runoff from Interstate I-94)	A field study was conducted at the I-94 site in Wisconsin. Lower Nemahbin Lake is a relatively small (271 acre [110 ha]) lake of glacial origin located in a watershed whose predominant land uses were undeveloped and low-density residential. A major interstate highway (I-94) passes directly over the northern portion of the lake. The highway design is primarily flush-shoulder, grassy-ditch drainage throughout the right of way (ROW) within the direct tributary area of the lake's watershed. There is a 0.25-mi (0.40-km) curbed bridge deck with direct to lake scupper drain stormwater discharges. Traffic volume at the site was moderate (15,600 vehicles per day). Pollutant loads from sources other than highway runoff were predominant. The ROW accounted for about 3 percent of the direct tirbutary drainage area, and from 0.02 to 5 percent (depending on the pollutant) of the pollutant load to the lake from all sources. Runoff pollutants are well dispersed and diluted by lake water or rapidly settle out, preventing water quality degradation, even in nearshore areas. State standards were not exceeded during these events as the result of I-94 runoff loads. No water quality effects occurred as a result of highway salting. Prolonged (or even short-term) salt stratification was not observed in profundal areas of the lake during winter months even though approximately 22 tons of salt were applied to the I-94 ROW within the site and high salt concentrations were measured in the runoff. Direct discharge of highway runoff from the bridge deck scupper drains caused a localized increase in metals and salts in nearshore sediments and cattails. The ultimate impact of these accumulations is uncertain. However, it can be inferred from the quarterly benthos sampling and *in situ* flow-through bioassays that the impact is minimal. Metal concentrations found in cattails collected from marshy areas near scupper drains decreased to background levels within 65 ft (20 m) of the input point. Data indicated that deicing salts were not as effectively retained in the cattail marsh as the metals. Cattails collected from the site did not display a toxic response to elevated metals and salt levels. Qualitative sampling of benthic invertebrates at Lower Nemahbin Lake indicated little effect of highway runoff. Although several taxa considered facultative to intolerant of pollution (*Fredricella*, *Stenacron*, and *Stenonema*) were found exclusively at control stations, other taxa considered intolerant were found either exclusively at highway-influenced stations or at both control and influenced stations (*Enallagma*, *Amnicola*, *Hydracarina*, and *Daphnia*). Field microcosm experiments using 5 indigenous species and 1 transplanted species (*Daphnia magna*) showed that highway runoff had minimal impact on these test species. The species were exposed for approximately 3 weeks in both highway runoff-influenced and control stations.	Dupuis et al., 1985

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
WI	Sugar Creek (Walworth County)	Construction activities (runoff from rural highway)	The Wisconsin Highway 15 site is representative of many rural highway/receiving water interactions; i.e., low traffic volume (7,400 vehicles/day), flush-shoulder highway design, and a predominantly agricultural watershed. Annual pollutant loadings from the highway right of way (ROW) comprised a very small percentage of the total watershed loads (0.03 to 0.30% of the stream load depending on the pollutant). The ROW accounted for only 1.6% of the total watershed area. Water quality impacts from highway runoff during storm events were not apparent. State water quality standards were not exceeded as a result of Highway 15 runoff, nor were EPA acute (15-min) criteria. Median wet weather load concentrations at all stations were below the EPA chronic criterion; however, several discrete samples from highway-influenced stations exceeded this criterion. Stream sediments likewise did not contain consistently elevated concentrations of runoff-related pollutants such as heavy metals. Metals concentrations in cattails and willow samples taken from Sugar Creek were not elevated at runoff-influenced stations relative to control stations or reported background levels from uncontaminated areas. Salt concentrations had no apparent effect on the health or growth of either cattail or willow samples in spite of elevated concentrations when compared to control stations and background values reported in the literature. There was no substantial evidence that longitudinal variations in abundance, distribution, and composition of the benthic invertebrate fauna collected on Hester-Dendy samplers were attributable to runoff from Wisconsin State Highway 15. Rather, these variations were attributed mainly to intrinsic physical-chemical characteristics of the stream (i.e., turbidity, substrate, and current velocity). The effects of highway runoff on macroinvertebrate sampling were minimal. Statistical differences between runoff-influenced stations and controls were related more to ecosystem conditions (current, substrate, etc.) than to water quality. The authors determined the mean density (g/m^2), biomass, richness, and biotic index for macroinvertebrate samples. The effects of highway runoff from Wisconsin State Highway 15 on periphyton communities of Sugar Creek were minimal. There were some instances where the control station had greater mean monthly densities than stations affected by highway runoff. However, there were many instances where the control had lower densities than the other stations. Number of taxa collected over the 1-year sampling period were similar between stations. This similarity of mean monthly and mean annual densities and diversity between stations suggests no, or very little, toxic effects of highway runoff on stream periphyton in Sugar Creek.	Dupuis et al., 1985

(continued)

EPA REGION 6 (continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
WI (con.)	Lawrence Creek	Agricultural activities (sedimentation in redds of brook trout, *Salvelinus fontinalis*)	<u>Laboratory experiment on emergence of alevins</u> Sand inhibited emergence; the percentage of fry emerging decreased significantly with increasing sand composition. <u>Field experiments using artificial and natural redds</u> Fewer nonviable eggs or dead fry were found in artificial redds (24% sand) as compared with natural redds (31% sand). More nonviable eggs and dead fry were found in natural redds. Emergence of brook trout is likely to be reduced from spawning gravel containing more than 20% sand.	Hausle and Coble, 1976

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
WI (con.)	Experimental ponds near Lake Nagawicka	Agricultural activities (Dipotassium endothall herbicide treatment for macrophyte control)	The herbicide-treated pond had the greatest zooplankton density, but both ponds exhibited the same overall trends in abundance and generic composition. There was no significant difference in the Copepoda (Cyclopoids and Calanoids) between the control and herbicide treated pond for any months sampled. The chlorophyll a content of the treated pond decreased to nearly zero 2 days posttreatment; however, 4 days posttreatment the chlorophyll a concentration had returned to pretreatment levels.	Serns, 1975

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
WI (con.)	Sugar Creek (Walworth County)	Construction activities (highway runoff from rural roadway with some associated agricultural activities)	Macroinvertebrates were collected with a Surber sampler. Station 1 (control) 48 total taxa 10 taxa of Plecoptera, Trichoptera, and Coleoptera; 995 specimens collected. 10.5 g^{-2} yearly arithmetic mean biomass. Largest number of taxa and percentage of sensitive organisms. Station 2 (slight runoff) 40 total taxa 7 taxa of Plecoptera, Trichoptera, Coleoptera, and Diptera; 178 specimens collected. 5.2 g^{-2} yearly arithmetic mean biomass. Decreased percentages of Trichoptera, Coleoptera, and Simuliidae. Depressed densities and biomass of pollution-sensitive fauna. Station 3 (moderate runoff) 40 total taxa 8 taxa of Plecoptera, Trichoptera, Coleoptera, and Diptera; 595 specimens collected. 10.5 g^{-2} yearly arithmetic mean biomass. Similar species composition to control with slightly higher percentage of chironomidae and simuliidae. Station 4 (heavy runoff) 46 total taxa 11 taxa of Plecoptera, Trichoptera, Coleoptera, and Diptera; 3,069 specimens collected. 82.2 g^{-2} yearly arithmetic mean biomass. Despite having heaviest runoff, this station had 2nd highest number of taxa, highest biomass and highest percentage of sensitive organisms. General Comments Physical stream characteristics (e.g., substratum and current) at Station 4 may have masked the effects of highway runoff on the benthic community. Results suggest disruption of benthic invertebrate communities by rural highway runoff was negligible. Authors suggest closer monitoring of physical stream parameters between stations chosen for comparison should be made when assessing pollution impacts.	Smith and Kaster, 1983

EPA REGION 6

EPA REGION 6

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
NM	Mimbres River (Grant County)	Hydromodification activities (irrigation diversion and extensive levee construction)	Benthic macroinvertebrates were collected quantitatively using a circular sampler. At 3 sampling sites, 69 taxa of macroinvertebrates were identified. Samples were collected in March and July 1984. Diversity indices (Shannon-Weaver) and the biotic condition index (BCI) of Winget and Mangum (1979) were calculated. The BCI is calculated as the ratio of the predicted biological community (CTQ_p) to the actual biological community (CTQ_a) x 100. A high-quality environemnt is indicated by a CTQ_a less than 60 and a BCI greater than 90; a moderately degraded environment by a CTQ of 61-74 and a BCI of 76-89; and a poor-quality environment by a CTQ_a greater than 75 and a BCI less than 75. The predicted community tolerance quotients (CTQ_p = 88) for all sites indicated a lower quality system than the best predicted for high-quality coldwater fishery streams (CTQ_p = 60). This was mainly due to uniform rubble substrate found throughout the stream. The CTQ_a of 66 for the upstream site indicated a dominance of sensitive macroinvertebrate taxa typical of coldwater streams. The BCI (116) also indicated a high-quality community. The quality determined from the BCI decreased at all downstream sites. Channel modifications have altered the stream environment by reducing substrate heterogeneity. In addition, low summer flow rates, coupled with canopy loss, livestock grazing, and possible septic-tank leakage may be responsible for temperature, coliform, and total phosphorus exceedances.	Jacobi and Potter, 1984

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
NM (con.)	Mora River (Mora County)	Agricultural activities (livestock grazing)	Benthic macroinvertebrates were collected qualitatively by the traveling kick-screen method and quantitatively using a circular sampler in July 1986. At 4 stations, 33 macroinvertebrate taxa were identified. Ephemeroptera, Trichoptera, and Diptera dominated the benthos at all sites. Diversity indices (Shannon-Weaver) and the biotic condition index (BCI) of Winget and Mangum (1979) were calculated. The BCI is calculated as the ratio of the predicted biological community (CTQ_p) to the actual biological community (CTQ_a) x 100. A high-quality environment is indicated by a CTQ_a less than 60 and a BCI greater than 90; a moderately degraded environment by a CTQ_a of 61-74 and a BCI of 76-89; and a poor-quality environment by a CTQ_a greater than 75 and a BCI less than 76. The predicted community tolerance quotients (CTQ_p) based on physical chemical criteria indicated high-quality habitats at all sites (50-53). The actual CTQ_a showed that moderately tolerant to tolerant organisms dominated the benthos at all sites (65.0 - 86.4). This finding, coupled with the low BCI (61.3 - 70), indicated that water quality may be the controlling factor regarding the macroinvertebrate community. Ephemeroptera, Trichoptera, and Diptera dominated the benthos at all sites. Downstream increases in total inorganic nitrogen concentration may be attributable to cumulative effects of cattle grazing, agriculture, irrigation, and onsite disposal systems.	Smolka, 1988

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
NM (con.)	Costilla Creek (headwaters to mouth - 4 stations monitored) Stations 1 and 4 upstream controls Stations 9 and 11 downstream of ski area	Construction activities (ski road and parking lot runoff) Agricultural activities (cattle grazing)	<u>Macroinvertebrates</u> Benthic macroinvertebrates were collected qualitatively by the traveling kick-screen method and quantitatively using a circular sampler during February 1987. (see Stations table below) While Costilla Creek has excellent water quality, parking lot and road runoff (along with unstable stream banks) caused minor problems by increasing total dissolved solids (TDS), total suspended solids (TSS), and turbidity. In addition, phosphorus concentrations increased as a result of cattle-grazing activities. While the water quality of Costilla Creek is excellent, the number of taxa, total number of organisms/m², and the biotic condition index (BCI) all decreased progressively from the headwaters to the mouth of the creek. This trend suggests conditions are being slightly degraded from runoff from a ski area, stream bank erosion, and cattle-grazing activities.	Smolka, 1987

Stations

	1	4	9	11
Number of taxa	28	22	23	19
Total number of organisms/m^2	2001	2198	1811	1644
BCI	110.4	119.0	122.1	106.3

EPA REGION 7

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
KS	Experimental ponds near Lawrence, KS	Agricultural activities (pesticide runoff) Two ponds received 20 µg/L atrazine; two ponds received 500 µg/L atrazine; and 2 ponds served as controls	A 4-month study was conducted in 6 experimental ponds to monitor the effects of atrazine (2 concentrations) in phytoplankton, zooplankton, aquatic plants, and 3 species of fish (bluegill sunfish, *Lepomis macrochirus*; channel catfish, *Ictalurus punctatus*; and gizzard shad, *Dorosoma cepedianum*). Phytoplankton biomass in 500-µg/L atrazine ponds declined severalfold below levels found in the other ponds during the first 16 days of the study. After 24 days biomass returned to levels found in the other ponds but was dominated by resistant species. Declines in biomass were not observed in the 20-µg/L atrazine-treated ponds or in the controls. The most immediate impact of photosynthetic inhibitors such as atrazine in aquatic communities is on the plants. C-14 uptake declines within a few hours. C-14 uptake by the phytoplankton community exposed to 500 µg/L atrazine significantly declined to 5% of control pond rates. At day 24 rates returned to control pond rates with the establishment of resistant species. Phytoplankton species distribution was altered particularly in the 500-µg/L atrazine-treated ponds. *Tetraedron minimum* and *Peridinium inconspicuum* were rare or absent after 2 days exposure (500 µg/L), while no such declines were noted in the 20-µg/L ponds. Phytoplankton succession in the 3 treatment groups was highly variable, and may in part have been related to zooplankton responses to the atrazine. The resistance of some species of phytoplankton to the effects of atrazine on photosynthesis was suggested by the successional responses of certain species. *Zooplankton* The zooplankton community was dominated at the beginning of each study by the Cladocerans *Diaphanosoma brachyurum* and several species of cyclopoid copepods, principally *Tropocyclops prasinus mexicanus*. Zooplankton numbers declined between days 2 through 10 postapplication, following the decline in phytoplankton.	deNoyelles and Kettle, 1980

(continued)

EPA REGION 7 (continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
KS (con.)	Experimental ponds near Lawrence, Kansas	Agricultural activities (pesticide runoff) Two ponds received 20 μg/L atrazine; two ponds received 500 μg/L atrazine, and 2 ponds served as controls.	*Daphnia pulex* and *Simocephalus serrulatus* experienced significant population declines in the 500 μg/L atrazine-treated pond. Both species exhibited a reduction in the total number of young produced and the daily production of young. At 20 μg/L atrazine *Daphnia* exhibited the same pattern of reduction, but *Simocephalus* reductions were not significant. Herbivorous zooplankton experienced both direct toxic effects of atrazine and indirect effects of reduced food availability. Algae and macrophytes Filamentous algae and macrophytes remained rare in all ponds throughout the study. Benthic invertebrates Little effect on the benthic invertebrate community was demonstrated. No mortality occurred in the macroinvertebrates monitored. Fish No significant difference was found in mortality of *Lepomis*, *Dorosoma*, and *Ictalurus* in the control and 20 μg/L atrazine-exposed groups. Reduced fish growth was noted in the 500 μg/L atrazine-treated ponds for fish species as percent less growth (length mm) than controls (*Lepomis* 26%, *Dorosoma* 31%, and *Ictalurus* 16%).	deNoyelles and Kettle, 1980

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
KS (con.)	Cottonwood River (Chase and Lyon Counties)	Agricultural activities (feedlot runoff)	Macroinvertebrate community changes during and after closure of 2 feedlots were noted in the river from 1968 to 1971. During 1968-69, 62 separate taxa were identified. At all stations, Ephemeroptera, Diptera (Chironomidae), and Coleoptera (Elmidae) predominated. During 1970-71, 65 separate taxa were identified. The difference between control- and effluent-affected stations decreased. A decrease in Diptera (Chironomidae) and an increase in Ephemeropta occurred at all stations.	Prophet and Edwards, 1973
	Elmdale (control)		Most diverse taxa (61 species) occurred with highest species diversity in 1968-69 (2.86 as compared to 2.02 - 2.70 for impact sites).	
	Cottonwood Falls West Emporia Soden's Grove Neosho Rapids (runoff affected sites)		Differences in species composition among stations were not great (32% of taxa occurred at all stations). A marked tendency for the number of taxa to decrease downstream was influenced by the station distance below feedlot and accumulative organic load from feedlots, municipal, and natural sources. Species diversity during 1970-1971 study (period when 2 feedlots closed) was higher at all stations than during 1968-69 survey. Results of this study provided evidence that runoff from large commercial feedlots had an adverse effect on the environmental quality of the Cottonwood River and demonstrated that the effect continues even after water quality returns to acceptable levels. Recovery is rapid once the level of environmental stress is reduced.	

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
MO	All rivers contained within the Clark National Forest of the Missouri Ozarks	Mining activities (acid mine drainage including lead, zinc, copper, and silver discharges)		Gale et al., 1973
	Upper Bee Fork (control)		Typical of a clean Ozark stream. Modest season blooms of algae occurred, which were closely followed by the appearance of consumer organisms throughout the year.	
	Bee Fork (impact site)		A persistent diatomaceous mat developed in late spring, which was encouraged by nutrients derived from mine waters. A stalked diatom (*Cymbella*) was the predominant genus, with a variety of other diatoms and several genera of filamentous algae that varied seasonally also present. The absence of many consumers was typical of the control site. Nematodes and rotifers were the greatest part of consumers. Manganese concentrations were elevated at this site and were probably associated with the high density and diversity of the diatom community.	
	Neals Creek (impact site)		Concentrations of heavy metals in algae (including *Potamogeton* sp. and *Cladophora* sp.) were greatest at sites nearest the tailing ponds from mill operations.	
	Strother Creek (heavy impact site)		In general, lead, zinc, copper, manganese, and cadmium were not concentrated in aquatic biota (crayfish, tadpoles, snails, small fish).	

EPA REGION 8

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
CO	Coal Creek (Gunnison County)	Mining activities (acid mine drainage - recovery of biological community after application of flocculation-coagulation technology in May 1981)	Drainage from Keystone Mine (lead, zinc, and copper mine) for 40 years rendered the lower section of Coal Creek biologically dead. Before commencement of treatment facility, pH was extremely low (3.5) and concentrations of 6 heavy metals were in toxic range (cadmium, 320 µg/L; copper, 1,450 µg/L; lead, 400 µg/L; iron, 45,000 µg/L; manganese, 40,000 µg/L; and zinc, 55,000 µg/L at the discharge). After treatment, concentrations were cadmium, 0.5 µg/L; copper, 20 µg/L; lead, <10 µg/L; iron, 450 µg/L; manganese, 150 µg/L; and zinc, 300 µg/L at this discharge. Macroinvertebrates 6 months after facility initiation there was rapid recolonization by benthic macroinvertebrates collected in Surber sampler. At the control station, 37 taxa were collected prior to operation of the plant with 0 taxa collected at discharge stations. Three discharge stations had 21, 24, and 23 taxa, respectively, after 6 months, and had 17, 23, and 24 taxa after 12 months of plant operations. Species composition changed after plant operation. Dipterans, principally chironomidae, which are metal-tolerant, were 85% of invertebrates collected in 1981 at station nearest to facility. In 1982, 51% of invertebrates were Plecoptera (*Paraperla frontalis* dominating). This shift was indicative of improving in-stream environmental conditions. At downstream stations to facility, Ephemeropterans predominated (*Pseudocloeon* sp., *Rhithrogena robusta*, and *Epeorus longimanus* with some Trichoptera (*Arctopsyche grandis*). Fish Fish were collected by electroshocking. Prior to plant startup, brook trout (*Salvelinus fontinalis*) were found only upstream of the acid mine drainage area. 2 months after startup, downstream stations showed presence of brook trout, white sucker (*Castostomus commersoni*), and brown trout (*Salmo trutta*). Most specimens were the young of the year brook trout, indicating improved water quality.	Todd et al., 1982

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
MT	Muddy Creek (Cascade County)	Agricultural activities (sediment)	Periphyton production was monitored on artificial substrate. Samplers allowed to collect samples for 2 weeks. Macroinvertebrate basket samplers were used over 5 weeks to monitor this community. Algae Below the confluence of Sun Creek (natural stream) and Muddy Creek (modified by receiving irrigation water), 3 genera of green algae (surface collections), 8 genera (midwater), and 8 genera (bottom), disappeared from samplers. Many of these genera were collected further downstream. Diatoms Several diatom species increased at stations in the Muddy River which had a higher turbidity and organic load than the Sun River. These species included: *Diatoma vulgare*, *Navicula radiosa*, *N. salinarum*, *N. tripunctata*, *N. viridula*, and *Nitzschia dissipata*. Only one diatom decreased--*Achnanthes minutissima* (one that prefers stable substrate). The void left by *A. minutissima* was filled with several nitrogen-loving taxa, better adapted to the mesotrophic and unstable bottom downstream from Muddy Creek. The decline in the total taxa below Muddy Creek reflects the physical impact of suspended solids, while the increase in total taxa farther downstream is a function of environmental variability and perhaps modest nutrient enrichment. Macroinvertebrates Diptera, Trichoptera, and Ephemeroptera accounted for 94% of all macroinvertebrates at each station. There was no significant difference in the relative importance of these three major orders suggesting biological recovery at the downstream stations. *Hydropsyche*, *Cheumatopsyche*, *Stenonema*, and *Heptagenia* increased at the two downstream stations. The presence of these 4 species indicates that the large concentrations of inorganic suspended solids in Muddy Creek do not interfere with feeding. There was a significant decline in the number of organisms colonizing the samplers at the Muddy Creek confluence station and the one downstream of that. An increase of ≈120 mg/l suspended solids resulted in an 80% decrease in numbers of invertebrates. The diversity index value was highest for the Muddy River station. Although this was the most polluted by sediment. The authors suggest care must be exercised in the interpretation of the results. First, colonization of artificial substrate samplers is by	Ingman, Weber, and Bahls, 1984

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
MT (con.)	Muddy Creek (Cascade County)	Agricultural activities (sediment)	chance and the diversity depends on the stage of community succession. The *confluence* station may harbor a transitional fauna composed of representatives of both the Sun and Muddy River. The higher diversity could be a spatially limited artifact of this admixture. Midges were keyed only to family and counted as one genus. It is possible fewer species were actually present at the confluence of Muddy Creek. The authors conclude that *measures of diatom* and macroinvertebrate diversity proved to be unreliable as indicators of biological impact of sediment and inorganic constituents.	Ingman, Weber, and Bahls, 1984

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
MT (con.)	Bluewater Creek (Carbon County) 5 stations (I-V) sampled from head-water area to down-stream confluence with the Clarks Fork River	Agricultural activities (sediment)	Fish sampling was conducted using electrofishing coupled with blocknets at three 4,000-ft^2 sections at each station. Over a 2-year period, median sediment concentrations were 10, 79, 107, 186, and 319 ppm for stations I to V, respectively. A progressive downstream decrease occurred in water temperature in the winter and a progressive downstream increase occurred in the summer. The following fish species were sampled: brown trout (*Salmo trutta*), rainbow trout (*Salmo gairdneri*), flathead chub (*Hybopsis gracilis*, longnose dace (*Rhinichthys cataractae*), white sucker (*Catostomus commersoni*), longnose sucker (*Catostomus catostomus*), and mountain sucker (*Pantosteus phebelus*). All nontrout species are referred to as rough fish). Ratio of trout species to rough fish species decreased from stations I to V as follows: I (210/7), II (197/17), III (56/225), IV (0/1201), and V (0/379). Mark and recapture study results estimated total number of trout per station as I (266), II (197), III (102), IV (0), and V (0). Average mortality of eyed rainbow trout eggs was 3% (I), 22% (II), 54% (III), 70% (IV), and 47% (V). Sedimentation concentrations were shown to influence trout populations directly; however, indirect changes in water temperature and stream flow also influenced survival.	Peters, 1967

EPA REGION 8 (continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
SD	Lake Oahe and Lake Sharpe	Agricultural activities (bank slumping sedimentation)	Experimental field study results indicated that embryos and larvae of northern pike (*Esox lucius*) were susceptible to silt deposition and temperature changes. Highest mortalities occurred during early embryonic development and were associated with heavy silt deposition (up to 3 mm in 24 h) resulting from bank slumping and wave action. Temperature changes and silt deposition appear to have little effect on yolk-sac larvae. Early embryonic development was a critical stage. Variations in year classes in the northern pike of Lakes Oahe and Sharpe were associated with variations in spring water levels and available spawning substrate. Deposition of only 1 mm sediment per 24-h period during early embryonic development caused mortalities of 97%.	Hassler, 1970

EPA REGION 9

EPA REGION 9

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
CA	Pacific Ocean inshore waters from the mouth of San Francisco Bay to Los Angeles	Agricultural activities (pesticide runoff and point-source sewage outfall)	The surf-zone sand crab (<u>Emerita analoga</u>) was collected along the California coast at 19 beach areas and analyzed for residues of DDT, DDE, and DDD. Peak concentrations of total DDT were observed in <u>Emerita</u> collected at the mouth of San Francisco Bay, in the vicinity of Monterey Bay, and off the Palos Verdes Peninsula. The most dramatic concentrations occurred in <u>Emerita</u> collected off the Palos Verdes Peninsula. The San Francisco Bay and Monterey Bay peaks are attributed to drainage from adjacent agricultural areas; the San Joaquin and Sacramento Valleys drain into San Francisco Bay and the Salinas Valley drains into Monterey Bay. The most dramatic peak was attributed to the Los Angeles County Sewer outfall, which receives effluent from the Montrose Chemical Company, the sole manufacturer of DDT in the United States. Bottom sediments appear to be a major reservoir for DDT residues that may become available for biological uptake when these sediments are stirred up. No adverse affects of DDT in <u>Emerita</u> <u>analoga</u> were reported.	Burnett, 1971

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EPA REGION 9 (continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
CA (con.)		Forestry activities (logging and road construction)	Each study stream was monitored for three summers before, during, and after either logging or road construction.	Burns, 1972
			Fish were captured using electroshocking by the single-census, mark-and-recovery method or by the two-catch removal method.	
	Bummer Lake Creek		Water quality remained within limits tolerated by salmonid populations after clearcutting in blocks.	
			Some increase (3%) in fine sediments occurred after logging, but this was not a significant change.	
			Biomass of salmonids was slightly lower during logging and increased after logging. The 19% increase in salmonid biomass was within the range of natural variation for unlogged California streams.	
			Yearling and older trout were fewer after logging but young-of-the-year were more abundant.	
			All age groups of steelhead trout (Salmo gairdneri) and cutthroat trout (Salmo clarki) had longer mean lengths after the logging. Sculpins (Cottus sp.) also increased in biomass after logging.	
	South Fork Yager Creek		No abnormalities in water quality were detected after logging. Care was taken to leave buffer strip around stream.	
			Some increase (5.6%) in fine sediment occurred after logging, but this was primarily associated with an upstream collapse of a tree-jam-and-rock barrier.	
			Fish populations increased after logging. The biomass of all age groups of steelhead trout increased and their mean lengths were longer after the logging. The 100% increase in biomass was greater than the natural variation in unlogged streams.	
			Sculpin and threespine stickleback (Gasterosteus aculeatus) decreased after logging.	
	Little North Fork Noyo River		No abnormalities in water quality were detected after logging; however, bulldozer activity greatly increased stream turbidity.	
			There was a significant 13.3% increase in fine sediment after logging activities.	
			Fish populations decreased as watershed and stream disturbances progressed.	

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
CA (con.)	Little North Fork Noyo River (con.)	Forestry activities (logging and road construction)	Steelhead trout populations remained about the same but the trout were smaller after logging. The biomass decreased 82% and this decrease was greater than that of unlogged streams. Sculpin abundance decreased each time the stream bed became heavily silted but the sculpin quickly recovered.	Burns, 1972
	South Fork Caspar Creek		Some abnormalities in water quality were detected after logging and major road construction which relocated part of the stream bed. This site was the most severely impacted by forestry activities. Most of the fill slopes and stream banks were fertilized with urea and seeded with annual rye grass. Dissolved oxygen dropped to 5 ppm in some pools during logging compared to 10 ppm in undisturbed streams. The drop in dissolved oxygen was due to decaying slash. There was a significant increase (14%) in fine sediment after logging activities. Logging was detrimental to the stream macroinvertebrates although conditions favored Diptera and Plecoptera. Increases in these 2 latter groups offset losses in other taxa causing a 120% increase in density immediately after road building and fertilization. Within 2 years, the benthos increased 370% over prelogging levels. Ephemeroptera took longer to recover than most insect orders. Trichoptera recovered rapidly and along with Plecoptera and Diptera made up the majority of the benthos. Trichoptera drift increased most after road construction--by 47% the first year and 100% the 2nd year. Salmonid populations decreased immediately after road construction. Recovery began the following spring and the salmonid biomass was only 20% lower than predisturbance biomass levels. All age groups of salmonids had greater mean lengths after road construction. Road construction may have reduced the total yield of salmon and trout smolts. The population of young-of-the-year steelhead trout decreased 85%, older steelhead trout decreased 84% and coho salmon decreased 82%. These rates are higher than would be expected for unlogged streams. Stickleback biomass fluctuated widely during the study, showing an overall increase after road construction.	

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EPA REGION 9 (continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota			Source
CA (con.)	62 Northern California streams	Forestry activities (effects of logging with and without streamside buffer strips)	Macroinvertebrate sampling was made with a modified Surber sampler. Results from Logged (L) and Control (C) streams.			Erman, Newbold, and Roby, 1977
			Total organisms (No./m^2)	Shannon diversity	Chironomidae (No./m^2)	
	Indian Creek (C)		2640	2.17	1221	
	Upper Four Bit (C)		3884	2.46	1304	
	Lower Four Bit (L)		5145	1.94	2580	
	Two Bit Creek (L)		3332	2.06	1437	
	North Fork Copper (C)		1424	1.92	165	
	Copper "B" (C)		746	1.79	237	
	Copper "A" (L)		10687	1.17	6929	
	East Branch Lights (C)		640	2.61	160	
	Upper Taylor (C)		1116	2.70	261	
	Lower Taylor (L)		2174	2.20	1049	
	Upper New York (C)		2332	2.76	630	
	Carney Creek (C)		1174	2.23	672	
	Mid New York (L)		3576	1.77	2230	
	New York Tributary (L)		1468	1.06	562	

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
CA (con.)	62 Northern California streams	Forestry activities (effects of logging with and without streamside buffer strips)	Results from Control (C), Wide (W), and Narrow (N) Buffer strip streams.	Erman, Newbold, and Roby, 1977

Stream	Total organisms (No./m²)	Shannon diversity	Chironomidae (No./m²)
South Fork Noyo (C)	598	2.44	29
North Fork South Fork Noyo (C)	314	2.20	20
Hare Creek (N)	700	2.04	60
Fall Creek (C)	1144	2.06	300
Upper Packsaddle (C)	1576	2.25	144
Lower Packsaddle (N)	2548	2.15	1002
Fall (same as above) (C)	1144	2.06	300
North Packsaddle (C)	759	2.16	285
Knopki Creek (N)	378	2.77	58
Bear Creek (C)	2640	2.80	300
Upper Doolittle (C)	2349	2.60	299
Lower Doolittle (W)	1231	2.77	233
Cub Creek (C)	2004	3.00	320
McCash Creek (C)	1560	2.57	163
Rogers Creek (W)	648	2.84	88
Irving Creek (W)	1230	2.48	422
Big Creek (C)	502	2.60	92
Murphy Creek (C)	1236	2.96	102
Callahan Creek (W)	1134	2.90	85
Gordon Creek (N)	1569	1.75	279
Haskell Creek (C)	976	2.60	101
Upper Chapman (C)	958	2.75	206
Lower Chapman (W)	1314	2.61	560

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
CA (con.)	62 Northern California streams	Forestry activities (effects of logging with and without streamside buffer strips)	Diversity was significantly lower in the logged streams than in the controls. Diversity of narrow bufferstrip streams was lower than corresponding control in 4 of 6 cases. Diversity of wide bufferstrip streams was as high or higher than corresponding control. There was a positive correlation (Spearman's r=0.71) between buffer width and diversity. At logged sites Chironomidae, *Baetis* and *Nemoura*, were consistently more abundant than at control sites. Diversity of streams logged over 10 years earlier was significantly lower than diversity in control streams.	Erman, Newbold, and Roby, 1977

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
CA	60 northern California streams from coastal to mid-elevation Sierra Nevada Mountains	Forestry activities (logging)	The macroinvertebrate community (collected in modified Surber samplers) was used to evaluate effects of logging in control, buffered (narrow buffer zone (30 m and wide buffer zone ≥30 m), and logged watershed streams. Logging occurred 1-5 years prior to macroinvertebrate sampling. Shannon diversity indices were significantly lower at logged sites than at control sites. The number of taxa collected was not significantly lower at logged sites. The low diversity appears to be a result of higher densities of Baetis, Nemoura, and Chironomidae at logged sites. Total density of macroinvertebrates was higher at logged sites than at control sites. Effectiveness of buffer strip protection Using Euclidean distances, there was a significant effect of logging on narrow buffered streams. Logging with a wide buffer zone of protection produced no measurable effects on macroinvertebrates as compared to control areas. Shannon diversity indices were lower at 3 of 4 narrow buffer zone streams than at the respective controls, but the trend was not significant. At wide buffer zone streams, diversity gave no indication of logging effects. Using Kruskal-Wallis, (nonparametric one-way ANOVA) showed the streams at logged sites were significantly lower in diversity than in wide buffer zone or control streams. Narrow buffer zone streams could not be distinguished from the other groups.	Newbold, Erman, and Roby, 1980

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
CA (con.)	Coyote Creek	Urban runoff	A 3-year monitoring study was conducted to assess the impacts of urban runoff on the biota of Coyote Creek. Bioaccumulation Tissue samples of the mosquitofish (*Gambusia affinis*), filamentous algae (*Cladophora* sp.), crayfish (*Procambarus clarkii*), and cattail plant (*Typha* sp.) were analyzed for heavy metals at 3 nonurban and 3 urban runoff sites. Lead concentrations were generally higher in algae, crayfish, and cattails (by a factor of 2-3, relative to the corresponding non-urban site) while lead concentrations in fish did not seem to differ when comparing urban and non-urban sites. Concentrations of lead in biota exceeded water concentrations by a factor of 100. Zinc concentrations were greater by a factor of three in urban vs. non-urban site samples for algae and cattails, but were comparable for crayfish and fish. Concentration of zinc in biota exceeded water concentrations by a factor of 500. Fish populations In nonurban reaches of Coyote Creek native fish species tended to predominate. Of 2,379 specimens collected, 36% were hitch (*Lavinia exilicauda*), 27% threespine stickleback, (*Gasterosteus aculeatus*), 12% Sacramento sucker (*Catostomus occidentalis*), 8% prickly sculpin (*Cottus asper*), 4% Sacramento blackfish (*Orthodon microlepidotus*), 2% California roach (*Hesperoleucus symmetricus*), which made up 89% native species and 11% introduced species. In urban reaches 7% of fishes were native species and 93% were introduced species including 67% mosquitofish (*Gambusia affinis*), 21% fathead minnows (*Pimephales promelas*), and 2% threadfin shad (*Dorosoma petenense*). Benthic macroinvertebrates Collections were made with both natural and artificial substrate samplers. The abundance and diversity of taxa generally were greater in the nonurbanized sections of the creek. Benthos at control stations consisted primarily of amphipods and a diverse assemblage of aquatic insects. Together, these groups made up 80% of the benthos collected. Clean water forms including the amphipod, *Hydella azteca*, mayflies, caddisflies, black flies, craneflies, alderflies, and riffle beetles were abundant.	Pitt and Bozeman, 1982

(continued)

EPA REGION 9 (continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
CA (con.)	Coyote Creek (con.)	Urban runoff	Benthos at the urban runoff stations consisted almost exclusively (97% of all benthos) of pollution-tolerant oligochaete worms (tubificids). Total number of benthic taxa were 2 to 8 for urban stations and 8 to 30 for nonurban sites. General comments - Some potentially harmful concentrations of ammonia, nitrates, phosphorus, and mercury do occur in Coyote Creek in both the nonurban and urban reaches. Water quality criteria in the urban area that are generally exceeded included dissolved oxygen, copper, lead, and zinc. Changes in the stream substrate also occur as a result of silt and debris from urban runoff. These various conditions are responsible for decline in species diversity and abundance in the urban reaches of Coyote Creek.	Pitt and Bozeman, 1982

EPA REGION 10

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
ID	Knapp Creek	Hydromodification activities (Granitic sediment was added artificially to simulate stream bank slumpage.)	Aquatic insects were collected by 0.093-m^2 bottom samplers at 2 days before and 1, 3, 14, and 23 days following sediment addition. The artificially added sediment did not have a significant immediate or long-term impact on the benthic insect community except for a correlation between insect density and level of cobble imbeddedness for Ephemeroptera and the Trichoptera (Brachycentrus sp.). Extreme ranges in substrate parameters were not present under the test conditions; therefore, Knapp Creek results are more restricted in applicability than those of Elk Creek. Density and diversity of benthic invertebrate community were adversely affected when large amounts of sediment were present in riffle areas (i.e., >2/3 cobble imbeddedness in Elk Creek). Predominant sediment was fine sand (<6.35 mm diameter). Sedimented streambeds with cobbles more than 2/3 imbedded in sand adversely affected the benthic insect community because sand tends to restrict subsurface habitation by many insects and to reduce permeability. Cobbles imbedded in coarser sediments generally support a richly diverse insect community. Large pebbles and cobble (6.4-12.7 cm diameter) unimbedded or partially imbedded provide good riffle habitat for insects.	Bjornn et al., 1977
	Elk Creek	Hydromodification activities (Granitic sediment was manually cleaned from some riffle areas and compared to uncleaned [control] areas. Cleaned areas were 25% imbedded by sand by the last sampling date [45 days after cleaning].)	After 45 days, the total number of insects on the manually cleaned plots was 1.5 times the number on the control (uncleaned) plots. The number of species on cleaned plots was 1.3 times the number on uncleaned plots. Ephemeroptera and Plecoptera constituted more than 50% of the insects on the cleaned plots. Four times more Ephemeroptera and 8 times more Alloperla sp. (Plecoptera) appeared on the cleaned plots. All Ephemeroptera had greater densities on the cleaned plots than on the heavily sedimented control plots. Rhithrogena robusta was 10 times more abundant on cleaned plots.	

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
ID (con.)	Elk Creek	Hydromodification activities (Granitic sediment was manually cleaned from some riffle areas and compared to uncleaned [control] areas. Cleaned areas were 25% imbedded by sand by the last sampling date [45 days after cleaning].)	Ameletus sparsatus which favors slow-moving streams was found in equal numbers at control and cleaned sites before cleaning. After cleaning this species was 6 times more abundant on cleaned plots. Neophylax sp. uses fine sand grains for case building. On second sampling, it was more abundant on uncleaned control plots but, by the third sampling, the cleaned plots were 25% embedded with sand and Neophylax was more abundant at cleaned sites. Riffle beetles (Optioservus sp. and Heterlimnius corpulentus larvae) favored uncleaned plots and were 5 times more numerous than on cleaned plots. The burrowing cranefly larvae (Hexatoma sp.) was 4 times more numerous on uncleaned plots.	Bjornn et al., 1977
	Knapp Creek	Hydromodification activities (Granitic sediment was artificially added to stream.)	Fish counting by snorkeling was carried out prior to sediment addition, 1 day after 1st addition, 1 and 4 days after 2nd addition, and 3 and 13 days after 3rd addition of sediment. Fish densities in pools were affected by sediment addition, but benthic invertebrate densities remained relatively unaltered. The amount of cover for fish decreased. The volume of pools decreased with sediment addition to 48% the original volume, and fish density decreased by 38%. Fish species included Chinook salmon, steelhead trout, and mountain white fish (Prosopium williamsoni). Reduction of fish was due more to pool volume and areas of preferred depth for the fish.	

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
ID (con.)	Emerald Creek	Mining activities (sedimentation from garnet mining)	Riffle insects were sampled with basket samplers and driftnets concurrently to determine if the riffle insects successfully passed through long, low-velocity sandy runs. The control driftnet was positioned immediately upstream of a riffle area. Driftnets A, B, and C were set in the riffle zone and progressively downstream from the control net. The control driftnet consistently collected higher numbers of species, higher total numbers of individuals, and higher drift density than any of the riffle area nets. Basket sample counts at the sites showed counts at the control site increased during each successive sampling period while counts at site B were higher than at A or C. Drift and basket colonization results indicated appreciable downstream movement (drifting and crawling) by insects on a sandy substrate despite low current velocities. The dominant "drift" species were not the dominant "basket" species. *Ephemerella hecuba* and *Optioservus seriatus* (weak swimmers) were the dominant drift species in July. In August, *Centroptilium* sp. and *Arcynopteryx* sp. (active swimmers) predominated. Basket samples were frequently colonized by insects common to the immediate basket area (Chironomidae and *Centroptilium* sp.) or strong swimmers (*Centroptilium* sp., *Baetis tricaudatus*, and *Ephemerella alberta*e). The combination of exposure to current and instability of sand grains is believed responsible for restricting upstream movement by insects on sandy reaches of Emerald Creek and other streams having heavy sand deposition.	Luedtke and Brusven, 1976

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
OR	Flynn Creek (Lincoln County)	Forestry activities (logging)	Flynn Creek watershed (not logged) Filamentous algae were never observed in the stream during the sampling period. Periphyton sampling showed 3 dominant species in 1966; Achnanthes lanceolata, Cocconeis placentula, and Eunotia arcus. In 1967, samples C. placentula became somewhat more dominant.	Hansmann and Phinney, 1973
	Deer Creek (Lincoln County)		Deer Creek watershed (patch cut) Filamentous algae were never observed in the stream during the sampling period. Periphyton sampling showed the same 3 dominant species as in Flynn Creek; A. lanceolata, C. placentula, and E. arcus. A. lanceolata predominated in winter and spring 1966 and C. placentula predominated in summer and fall. In 1967, same general trend; however, E. arcus was more abundant.	
	Needle Branch (Lincoln County)		Needle Branch watershed (clearcut) Abundant growth of Sphaerotilus natans colonized all available mud and slash in the stream. In the summer, Chlorophyta formed a mat over most of the pool areas. Species included Chlamydomonas sp., Draparnaldia glomerata, Spirogyra gravilleana, and Tetraspora sp., and the Cyanophyta species Anabaena affinis and Oscillatoria amphibia. Periphyton sampling showed 4 species were dominant in 1966. A. lanceolata decreased in summer and increased in fall. C. placentula followed a pattern similar to that of Deer Creek but rapidly declined in September and remained there for the remainder of the study period. C. placentula was replaced as a dominant species by Nitzschia palea in August through October and Eunotia arcus in September and October. In 1967, with increasing stream temperatures, C. placentula became very dominant as did Synedra rumpens and Achnanthes minutissima. Primary productivity of the clearcut stream was higher after logging.	

(continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
OR (con.)	Flynn Creek--control (Lincoln County) Deer Creek--25% of watershed logged (Lincoln County) Needle Branch--entirely clearcut (Lincoln County)	Forestry activities (logging)	Water temperature of three salmon and trout streams in Oregon were monitored for a period of 12 months beginning 2 years after their respective watersheds had been subjected to total clearcutting, staggered logging, and no logging activities (control). Intragravel temperatures were monitored by thermographic probes buried 25 cm deep in artificial and natural redds. Intragravel water was sampled through standpipes to determine oxygen concentrations. Both mean temperature and diel fluctuations in temperature within the redd gravel increased in relation to the extent of spawning. Mean surface temperatures between January and June were 9.0, 8.3, and 7.5 °C for Needle Branch, Deer Creek, and Flynn Creek, respectively. Almost no temperature gradient existed in the control stream and the gradient in the partially logged watershed stream was relatively small. Dissolved oxygen concentration in redds of the clearcut stream were consistently lower than in the partially logged watershed stream. Needle Branch redds contained 20% less O_2 than Deer Creek. An increase in suspended sediment in the stream water has been documented for the clearcut stream. Decreases in dissolved oxygen in the clearcut stream were evidently caused by increased levels of fine sediment in the gravel. Nylon fly trap collections of coho salmon fry (Oncorhynchus kisutch) showed that survival to emergence was not seriously affected by changes in the intragravel environment. The population of resident cutthroat trout (Salmo clarki) has been reduced by 33% of its pre-logging level. The reduction has persisted through 6 years following logging and may be related to the observed changes in the intragravel water. The difference in responses of the cutthroat and coho populations suggests that salmonid species differ in their ability to withstand an altered environment.	Ringler and Hall, 1975

EPA REGION 10 (continued)

State	Waterbody	Nonpoint source	Impacts on aquatic biota	Source
WA	Lake Washington	Urban runoff (heavy metals)	Three sites were chosen for sampling; site SD (storm drain), site CSO (combined sewer overflow) outfall, and a control site with no heavy metal inputs. The test crayfish, Pacifasticus leniusculus were placed for 14 days at one of the three sites. Highest tissue mercury levels were found in abdominal muscle. Cadmium concentrations were highest in the viscera. Copper concentrations were highest in the viscera, followed by the exoskeleton and abdominal muscle. Lead concentrations were highest in the exoskeleton followed by the viscera. Tissue lead concentrations were significantly less in the female in muscle, exoskeleton and the whole body. There was no significant difference between the storm drain and combined sewer overflow site cray fish.	Stinson and Eaton, 1983

Appendix D

Annotated Bibliography

Title: Patterns of Trace Metal Accumulation in Crayfish Populations

Author(s): R. V. Anderson and J. E. Brower

Publication date: 1978

Published by: Bulletin of Environmental Contamination and Toxicology, 20:120-127

Number of pages: 8 pp.

Report number(s): (Not applicable)

Available from: Bulletin of Environmental Contamination and Toxicology
Springer-Verlag New York, Inc.
175 Fifth Avenue
New York, NY 10010

Abstract:

The study of the occurrence and effects of heavy metals in aquatic systems has increased and an excellent review has been presented by Leland et al. (1974). Much of the information available on freshwater invertebrates, however, deals with lethal concentrations or the determination of tolerance limits. There are relatively few studies of heavy metals in freshwater invertebrates from field studies, and these studies usually involve only a descriptive survey of the metal concentrations (Mathis and Cummings, 1973; Namminga et al., 1974; Anderson, 1977). Gale et al. (1973) reported concentrations of Pb, Zn, Cu, Mn, and Cd in crayfish from Missouri's lead belt and indicated some of the effects of the variation of these metals in the environment on their concentration in organisms. Vermeer (1972), working with crayfish, and Nehring (1976), working with insect nymphs, indicated these organisms could be used in the field to monitor heavy metal inputs. Our study investigated concentrations of Cd, Cu, Pb, and Zn in three populations of the crayfish, Orconectes virilis (Hagen). Two of the populations were collected at the same location but at sampling sites with different inputs of the trace metals. The third population was from a site on the same river but where metal input was low. These sites allowed an evaluation of the effects of different sublethal environmental concentrations on accumulation and concentration of the metals in crayfish. Various tissue concentrations from crayfish at the high input site were also examined to determine if particular body parts were sites of accumulation.

Region 5: IL

Title: Distribution of Cd, Cu, Pb, and Zn in the Biota of Two Freshwater Sites with Different Trace Metal Inputs

Author(s): R. V. Anderson, W. S. Vinikour, and J. E. Brower

Publication date: 1978

Published by: Holarctic Ecology, 1:377-384

Number of pages: 8 pp.

Report number(s): (Not applicable)

Available from: Scandinavian Society Oikos
Munksgaard
35 Noerre Soegade
DK-1370
Copenhagen K
Denmark

Abstract:

Concentrations of Cd, Cu, Pb, and Zn were determined in the abiotic and biotic components at two Fox River sites in Illinois. Analysis of the metals was completed on solutions of wet-ashed or dry-ashed samples with a single-beam atomic absorption spectrophotometer. Despite different inputs of the trace metals, no significant differences in the concentration of Cu or Zn occurred in the biota between the two sites. This was postulated to be due to physiological control of these metals. However, Cd and Pb concentrations were higher in the biota and substrate at the high-input site. No accumulation of Cd or Pb occurred at higher trophic levels. Cu and Zn concentrations were similar for all biota with the exception of crayfish and snails, which had higher Cu and Zn concentrations, respectively.

Region 5: IL

Title: Effects of Urbanization on Stream Ecosystems

Author(s): A. C. Benke, G. E. Willeke, F. K. Parrish, and D. L. Stites

Publication date: November 1981

Published by: School of Biology, Environmental Resources Center, Georgia Institute of Technology

Number of pages: 64 pp.

Report number(s): ERC 07-81

Available from: School of Biology
Environmental Resources Center
Georgia Institute of Technology
Atlanta, GA 30332

Abstract:

The effects of urbanization on 21 stream ecosystems (with 1- to 3-mi^2 watersheds) were studied in the Atlanta area. Watersheds varied from 3 to 100% green space, from 0 to 98% residential-commercial, and with house densities from 0 to 941/mi^2. The primary index of stream quality was community composition of aquatic macroinvertebrates. Two independent sampling methods were used to assess their respective efficiencies: (1) modified Hester-Dendy artificial substrate samplers, collecting all animals retained by a 0.3-mm sieve, and (2) time-standardized qualitative collections made by two investigators for 40 man-minutes.

Standard water chemistry measures showed little relationship to degree of urbanization, although conductivity, hardness, and orthophosphate were somewhat higher in urbanized streams. None of the water chemistry parameters indicated any major degree of pollution.

Using artificial substrate samplers, the mean number of species per sampler varied across streams from 8.8 to 30; mean number of families from 3.8 to 16. However, species diversity varied only from 1.37 to 2.43. There was a significant relationship between urbanization and number of species (and families), but there was none with species (or family) diversity. The apparent reason for the surprising lack of relationship between urbanization and diversity was that even in undisturbed streams with a high number of species, a very uneven distribution of species (resulting from retention of very abundant species less than 4 mm in length) can result in a low diversity value. Thus, a diversity index appears to be less useful than simply considering number of taxa when analyzing aquatic communities in which individuals vary in size (biomass) by several orders of magnitude.

The number of taxa qualitatively collected from each stream was reasonably consistent on three different dates (June, August, November). While there was a methodological bias against collecting small animals, the mean

number of species collected per date varied across streams from 3 to 23. There was a highly significant relationship between urbanization and number of species (and number of families), suggesting that identifying animals to the family level is sufficient in assessing differing degrees of stress in streams.

Multivariate analyses were performed using numbers of families found in each order as the variables. Cluster analysis helped distinguish three major groups of streams: clean, intermediate, and degraded. Using these three groupings, discriminant function analysis identified the orders Plecoptera, Trichoptera, Ephemeroptera, and Coleoptera as the most discriminating variables. Discriminant analysis using urbanization parameters for these three groups showed that high percentages of land in residential use, low percentages in green space, and high house densities were associated with degraded streams.

Title: Investigation of Acid Mine Drainage Effects on Reservoir Fishery Populations

Author(s): A. Benson

Publication date: April 1976

Published by: West Virginia University

Number of pages: 145 pp.

Report number(s): EPA 600/2-76-107; PB-252-703

Available from: Bureau of Sports Fisheries and Wildlife
U.S. Department of the Interior
Washington, DC 20240

Industrial Environmental Research Laboratory
U.S. Environmental Protection Agency
Cincinnati, OH 45268

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161

Abstract:

A limnological, water quality and quantity and lake fluction, transparency, and ice cover study was made of the Tygart Lake, West Virginia, and its tributaries. The watershed of this lake has been extensively mined for coal, and acid mine drainage (AMD) is discharged throughout the area. The significant sources of AMD were found to be the Tygart River and Sandy Creek. Net changes in lake depth were 14-16 meters, and the maximum change 22 meters. Transparency depth ranged from 0.1 m in December to 7.5 m in the summer. The major factors related to the development of acidity gradients in Tygart Lake were found to be (1) hydrological characteristics including inflow, outflow, and the operational interaction between the inflow and outflow resulting in storage or drawdown, (2) thermal relationships including the spring and the winter thermal minimum, and (3) water chemistry, including the existing chemical stratification or its lack at the beginning of a seasonal period and the chemical quality of inflow.

Title: Transport of Granitic Sediment in Streams and Its Effect on Insects and Fish

Author(s): T. C. Bjornn, M. A. Brusven, M. P. Molnau, J. H. Milligan, R. A. Klant, E. Chacho, and C. Schaye

Publication date: September 1977

Published by: University of Idaho, College of Forestry, Wildlife and Range Sciences

Number of pages: 43 pp.

Report number(s): Bulletin Number 17

Available from: Office of Water Research and Technology
U.S. Department of the Interior
Washington, DC 20240

Abstract:

We assessed the transport of granitic bedload sediment (<6.35 mm diameter) in streams flowing through central Idaho mountain valleys and the effects of the sediment on juvenile salmonids and aquatic insects. We measured bedload sediment transported in the streams during the spring snowmelt runoff and the summer lowflow periods for 2 years to test the applicability of the Meyer-Peter, Muller equation for estimating such transport. In both years the streams transported all the sediment available, including that under the armor layer of the stream bottom in the first year. The modified Meyer-Peter, Muller equation proved accurate in estimating the transport capacity of such streams using measurements of slope, hydraulic radius, and mean diameter of streambed material.

In artificial stream channels, benthic insect density in fully sedimented riffles (>2/3 cobble imbeddedness) was one-half that in unsedimented riffles, but the abundance of drifting insects in the sedimented channels was not significantly smaller. In a natural stream riffle, benthic insects were 1.5 times more abundant in a plot cleaned of sediment, with mayflies and stoneflies 4 and 8 times more abundant, respectively. Riffle beetles (Elmidae) were more abundant in the uncleaned plot.

During both summer and winter, fewer fish remained in the artificial stream channels where sediment was added to the pools. The interstices between the large rocks in the pools provided essential cover necessary to maintain large densities of fish. Fish in sedimented channels exhibited hierarchical behavior, while those in unsedimented channels were territorial in behavior. In small natural pools (100 to 200 m^2), a loss in pool volume or in area deeper than 0.3 m from additions of sediment resulted in a proportional decrease in fish numbers. We did not, however, find significant correlations between riffle sedimentation and fish density in the two natural streams we studied. Fish abundance was significantly correlated with insect drift

Bjornn et al., 1977 (con.)

abundance in one stream, but not in the other. The amounts of sediment in the two streams studied did not have an obvious adverse effect on the abundance of fish or the insect drift on which they feed.

Title: DDT Residues: Distribution of Concentrations in *Emerita analoga* (Stimpson) Along Coastal California

Author(s): R. Burnett

Publication date: 1971

Published by: Science, 174:606-608

Number of pages: 3 pp.

Report number(s): (Not applicable)

Available from: American Association for the Advancement of Science
1333 H Street, NW
Washington, DC 20005

Abstract:

The total concentrations (tDDT) of DDT [1,1,1-trichloro-2,2-bis(p-chlorophenyl)ethane], DDD [1,1-dichloro-2,2-bis(p-chlorophenyl)ethane], and DDE [1,1-dichloro-2,2-bis(p-chlorophenyl)ethylene] in *Emerita analoga* from 19 California beaches reflect tDDT contamination nearby. Animals near the Los Angeles County sewer outfall contain over 45 times as much tDDT as animals near major agricultural drainage areas. Sediments near the outfall probably contain over 100 metric tons of tDDT—a reservoir for input into marine organisms. The effluent from a plant that manufactures DDT is a probable source.

Title: Some Effects of Logging and Associated Road Construction on Northern California Streams

Author(s): J. W. Burns

Publication date: January 1972

Published by: Transactions of the American Fisheries Society, 101(1):1-17

Number of pages: 17 pp.

Report number(s): (Not applicable)

Available from: American Fisheries Society
5410 Grosvenor Lane
Suite 110
Bethesda, MD 20814

Abstract:

The effects of logging and associated road construction on four California trout and salmon streams were investigated from 1966 through 1969. This study included measurements of streambed sedimentation, water quality, fish food abundance, and stream nursery capacity. Logging was found to be compatible with anadromous fish production when adequate attention was given to stream protection and channel clearance. The carrying capacities for juvenile salmonids of some stream sections were increased when high temperatures, low dissolved oxygen concentrations, and adverse sedimentation did not accompany the logging. Extensive use of bulldozers on steep slopes for road building and in stream channels during debris removal caused excessive streambed sedimentation in narrow streams. Sustained logging prolonged adverse conditions in one stream and delayed stream recovery. Other aspects of logging on anadromous fish production on the Pacific Coast are discussed.

Title: Fish and Food Organisms in Acid Mine Waters of Pennsylvania

Author(s): R. L. Butler, E. L. Cooper, D. C. Hales, C. C. Wagner, W. G. Kimmel, and J. K. Crawford

Publication date: February 1973

Published by: Department of Biology and Cooperative Fisheries Unit, Pennsylvania State University

Number of pages: 157 pp.

Report number(s): EPA-R3-73-032; PB 221-515

Available from: National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161

Abstract:

The three parts of this project relate respectively to the three objectives: (1) to develop a rapid and nonlethal bioassay for acid water using changes in utilization of cover and activity of fish, (2) to determine the effect of different levels of acid mine drainage on the presence or absence of fish populations in the watersheds of Pennsylvania, and (3) to determine the median tolerance limits to low levels of pH of five aquatic insects chosen on the basis of their wide occurrence and common association in soft-water streams. Analysis of variance revealed there was no relationship between cover utilization and pH levels or between activity and pH levels for four species of fish (smallmouth bass, longnose dace, rock bass, and brook trout). The failure of cover utilization and activity to reflect changes in water quality conditions makes this bioassay technique as tested unsuitable for the establishment of water quality criteria.

In part II of the project it was found that common fish species normally distributed over several watersheds were absent where there was severe acid mine drainage. Of the 116 species of fishes found, 10 species exhibited some tolerance to acid mine drainage (values of pH 5.5 or less). An additional 38 species were found at pH values between 5.6 and 6.4, with the remaining 68 species at pH levels above 6.4. Severe degradation occurred at pH levels between 4.5 and 5.6.

In part III all five aquatic species survived exposure for 4 days to pH levels from 6.5 to 4.0. The 96-hour TLm values ranged from 3.31 for the most sensitive animal, *Stenonema* sp., to 1.72 for the most tolerant insect, *Nigronia fasciata*.

Title: Stress and Recovery of Aquatic Organisms as Related to Highway Construction Along Turtle Creek, Boone County, West Virginia

Author(s): J. L. Chisholm and S. C. Downs

Publication date: 1978

Published by: U.S. Department of the Interior, U.S. Geological Survey

Number of pages: 40 pp.

Report number(s): Geological Survey Water-Supply Paper 2055; Stock No. 024-001-03045-4

Available from: U.S. Government Printing Office
Washington, DC 20402

Abstract:

During and after construction of Appalachian Corridor G (a divided, four-lane highway), five benthic invertebrate samples were collected at each of four sites on Turtle Creek, and, for comparative purposes, three samples were collected at each of two sites on Lick Creek, an adjacent undisturbed stream. Diversity index, generic count, and total count initially indicated severe depletion or destruction of the benthos of Turtle Creek, but within 1 year after highway construction was completed, the benthic community of Turtle Creek was similar to that of Lick Creek. The greatest degradation occurred near the headwaters of Turtle Creek because of erratic movement of sediment resulting from high streamflow velocity. Diversity indices ranged from 0 to 3.41 near the headwaters in the original channel, but only from 0.94 to 2.42 farther downstream in a freshly cut channel. The final samples from Turtle Creek, which were similar to those taken from Lick Creek at the same time, had generic counts of 10 at the most upstream site and 16 near the mouth. A total of 147 organisms was found near the headwaters, whereas a total of 668 was found near the mouth of the stream. The total number of organisms collected at each site was proportional to the drainage area upstream from the site. As a result of tributary inflow from unaltered drainage areas and organism drift, rapid repopulation and stabilization of the benthic community occurred. Channel relocation, bank recontouring, and reseeding also accelerated the recovery of the benthic community.

Title: Biological and Chemical Assessment of Nonpoint Source Population in Georgia: Ridge-Valley and Sea Island Streams

Author(s): W. L. Cook, F. Parrish, J. D. Satterfield, W. G. Nolan, and P. E. Gaffney

Publication date: November 1983

Published by: Georgia State University

Number of pages: 175 pp.

Report number(s): (Not applicable)

Available from: Department of Biology
Georgia State University
Atlanta, GA 30303

Abstract:

This report presents a portion of the Nonpoint Source Impact Assessment Study of the State of Georgia. The goal of this study was to determine the extent and magnitude of the impact of nonpoint sources of pollution on water quality in Georgia. This report is mainly concerned with the influences of nonpoint sources of pollution on changes in the biology and chemistry of streams.

Two major physiographic regions of the State of Georgia were selected for the study. Four streams in the Ridge and Valley Province (Cluster I) in Northwestern Georgia representing streams near agriculture, forestry, and urban activities were compared with a control stream. The Ridge and Valley Province has weathered, leached, and acidic soils that have a low water permeability. Steep slopes and soils with high clay content cause a high erodibility factor. Four other streams in the Sea Island Province (Cluster V) of Southeastern Georgia were similarly compared. Streams in Sea Island Province have low degree of slope, sandy soils, highly permeable soil, and acid soil with a low erodibility potential.

Approximately twice monthly between 1981 and 1983, water in the streams was measured for temperature, flow volume, ammonia, nitrite-nitrates, phosphorus, alkalinity, turbidity, color, conductivity, biological oxygen demand (BOD), pH, total residue, total organic carbon, hardness, and most probable number (MPN) fecal coliforms. Approximately every quarter from 1981 to 1983, the streams were measured for fecal coliforms (obtained by the MFC method), trace metals in the stream, macroinvertebrates, periphyton, and fishes. Measurement of trace metals in fish tissue was also made.

In the Ridge and Valley Province, as well as the Sea Island Cluster, the urban stream was the most polluted, followed by the agricultural stream. These streams differed the most biologically and chemically from those conditions present in the control streams. The high fecal coliform counts would make the urban stream waters a potential biohazard.

Cook et al., 1983 (con.)

The forestry stream diverged the least from the conditions found in the control streams. The northern forestry stream was most affected by deforestation, causing an increase in siltation and a drastic (although temporary) shift in the biota. The nonporous clay soils, steep slope, and poor management of cutting, exacerbated the effects of deforestation. The forestry stream in the southern part was not altered by deforestation because of good management, porous soil, and natural buffer zones.

This study stressed the importance of comparing measurements to a control stream in the same physiographic region because physical, chemical, and biological parameters are not comparable in different geographical regions. For example, the dissolved oxygen levels and pH values in the control stream in North Georgia are closer numerically to those of the urban stream in South Georgia than to the control stream in South Georgia. However, these differences are not indicative of differences in stream quality but rather in the above parameters. Therefore, comparison of the two numerically would lead to erroneous interpretations of the conditions of the stream.

Nonpoint source pollution is present in streams in the Ridge and Valley Province. The high slopes and nonporous soil lead to rapid runoff of pollutants into the stream. Nonpoint source pollution in the Sea Island Cluster was directly proportional to the accessibility of the pollutants to the water. Except for the area around the urban stream, natural buffer zones of vegetation and porous sandy soil will trap the majority of pollutants.

Title: Short- and Long-Term Effects of Forest Spraying of Carbaryl (Sevin-4-Oil) on Stream Invertebrates

Author(s): D. L. Courtemanch and K. E. Gibbs

Publication date: 1980

Published by: Canadian Entomologist, 112:271-276

Number of pages: 6 pp.

Report number(s): (Not applicable)

Available from: Entomological Society of Canada
1320 Carling Avenue
Ottawa K1Z 7K9
Ontario
Canada

Abstract:

The effect on stream invertebrates of carbaryl (Seven-4-oil) applied at a rate of 840 g A.I./ha for spruce budworm suppression in Maine was studied. Three streams in each of three different treatment areas were monitored: streams in areas sprayed with carbaryl for the first time, streams in areas sprayed two consecutive years, and streams in unsprayed areas.

Initial postspray response was an increase in drift up to 170x in treated streams. Benthos samples showed significant declines among Plecoptera, Ephemeroptera, and Trichoptera on subsequent sampling dates. Plecoptera did not repopulate any treated stream by 60 days after treatment. Streams treated for the second consecutive year had very low prespray Plecoptera populations compared with those unexposed to carbaryl. Diptera, with the exception of *Microtendipes*, and Oligochaeta were unaffected.

Title: Strip Mine Drainage Aquatic Impact Assessment

Author(s): D. B. Cox, R. P. Betson, W. C. Barr, J. B. Crossman, and R. J. Ruane

Publication date: February 1979

Published by: Division of Natural Resources Services, Tennessee Valley Authority

Number of pages: 85 pp.

Report number(s): EPA-600/7-79-036; TVA/ONR-79/11; PB80-133192

Available from: National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161

Abstract:

This research program is aimed to demonstrate methodologies for predicting the impact of strip mining on downstream biotic communities.

To accomplish this objective and provide data for model verification, sampling programs were initiated at contour- and area-type mining operations. These programs included streamflow and rainfall gaging at both types of mines and surveys of fisheries, periphyton, and macrobenthos at area-mined sites.

Preliminary findings of these field studies indicate that: (1) drainages from mined areas are alkaline rather than acid, and (2) calcium and magnesium concentrations increase as a result of mining in almost every instance. Furthermore, values for iron and sulfate increase in some areas, but not in others, whereas values for trace metals are generally low in all areas. The predominant fish in small Cumberland Plateau streams is the creek chub (*Semotilus atromaculatus*), and its primary food source is aquatic invertebrates, including midge larvae, springtails, and aquatic mites.

Several model components have been developed, including a water quality model for nonpoint sources, a continuous streamflow model, and a storm hydrograph model. Other model components being developed or evaluated include additional small-basin water quality models, water quality and quantity routing models, a low-trophic-level stream biota model, and a fisheries resource model.

Region 4: TN

Title: Georgia Nonpoint Source Impact Assessment Study: Blue Ridge/Upland Georgia Cluster, Piedmont Cluster, and Gulf Coastal Plain Cluster (Final Project Report)

Author(s): CTA, Inc., Environmental and Energy Consultants

Publication date: November 1983

Published by: State of Georgia

Number of pages: 314 pp.

Report number(s): (Not applicable)

Available from: Environmental Protection Division, Department of Natural Resources, State of Georgia or CTA, Inc., 1955 Cliff Valley Way, NE, #220, Atlanta, GA 30029

Abstract:

The impacts of urban, agricultural, and forestry land uses on stream biological systems were assessed in the Blue Ridge/Upland Georgia, Piedmont, and Gulf Coastal Plain areas. Fourteen primary sites were sampled over 10 seasonal surveys from August 1981 through August 1983. Major study components included habitat composition, conventional water quality analyses, macroinvertebrates, periphyton, fish, and pesticide/herbicide/metal contamination in the sediments, water column, and fish tissues.

The results of the study indicated that impacts of land use were greatest in the urban basins. Beneficial uses were impaired or denied in all three urban basins. Fish communities were essentially absent in two basins and reduced in the third. The indigenous macroinvertebrate community was altered by the effects of land use and was replaced by a pollution-tolerant, facultative assemblage. The periphyton community structure of the urban basins was highly dissimilar to the periphyton community of the control basins and was dominated by species known to create taste and odor problems in water. Accumulation of organic compounds and metals over background conditions was observed in urban streams. Elevated coliform densities were also characteristic of urban basins. Forestry activities had severe impacts associated with sedimentation and hydrologic modifications and also had resultant habitat alterations. Direct impacts of these alterations were the elimination or drastic reduction of indigenous fish and macroinvertebrate species. The degree of impact from forestry land uses was not as severe as impacts from urban land uses. A wide range of impacts was documented in the agricultural basins. The primary mechanisms of habitat alterations were by sedimentation, removal of riparian vegetation, and hydrologic modifications. Elevated concentrations of metals were occasionally found. Beneficial uses were impaired but not denied at any of the agricultural sites.

CTA, Inc., 1983 (con.)

Coupled with conventional water quality data, the extensive use of biological indicators provided an accurate measure of the extent of biotic community alterations and other environmental damages due to land use activities. The effects of land use activities were generally most pronounced in the Blue Ridge/Upland Georgia Cluster, moderate in the Piedmont Cluster, and reduced in the Gulf Coastal Plain Cluster. The reduction of discernible impacts in the latter area was primarily due to the naturally occurring low flows, low dissolved oxygen, and limited habitat diversity associated with the small coastal plain streams.

Title: Phytoplankton Productivity of an Acidic Lake

Author(s): J. DeCosta and C. Preston

Publication date: 1980

Published by: Hydrobiologia, 70:39-49

Number of pages: 11 pp.

Report number(s): (Not applicable)

Available from: Kluwer Academic Publishers Group
Distribution Center
P.O. Box 322, 3300 AH Dordrecht
The Netherlands

Abstract:

The phytoplankton productivity over 2 years in a lake heavily loaded by acid mine drainage was very low. Algal assays indicated that below pH 5.5 the water, if buffered and fertilized with phosphorus, resulted in log growth. Above pH 5.5 algal log growth could be induced with phosphorus addition only. However, an in situ bag experiment was done in the lake and immediate bloom conditions of the indigenous algae resulted from phosphorus addition only, despite pH values below 5.

Region 3: WV

Title: Herbicides in Kansas Waters—Evaluations of the Effects of Agricultural Runoff and Aquatic Weed Control on Aquatic Food Chains

Author(s): F. deNoyelles and D. Kettle

Publication date: December 1980

Published by: Kansas Water Resources Research Institute

Number of pages: 38 pp.

Report number(s): W8206304 OWRTA-092-Kan(1); PB82-256504

Available from: Office of Water Research and Technology
U.S. Department of the Interior
Washington, DC 20240

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161

Abstract:

Experimental ponds were used to study the effects of an agricultural herbicide on aquatic food chains. Atrazine, one of the most heavily used herbicides in Midwest agriculture, was added to ponds and the ensuing responses were followed through 4 months. With single 20-µg/L and 500-µg/L additions to the ponds, effects were recorded throughout the food chain. After 1 day of exposure, rates of phytoplankton photosynthesis declined at both levels, with the higher level causing an almost complete inhibition. Phytoplankton succession was altered within a few days at both levels, with resistant species increasing in abundance. The actual resistance of these species to atrazine, which is known to be a photosynthetic inhibitor affecting a wide variety of plants, was verified in the laboratory. The grazing zooplankton were also affected within the first few weeks of exposure as their phytoplankton food source was altered. The growth of aquatic flowering plants was also reduced at both levels. Some members of the aquatic food chain were unaffected, particularly the benthic insects, although effects were recorded at the highest level of these food chains, the fish. Of the three types of fish (bluegill sunfish, channel catfish, gizzard shad) originally stocked in the ponds, all survived but with reduced growth at the 500-µg/L level. The only fish to reproduce in the ponds, bluegill sunfish, showed greatly reduced numbers of progeny at both levels. The concentrations of atrazine in the ponds were monitored, showing its persistence with 75% of the original concentration present after 114 days. In Midwest waters concentrations of 500 µg/L are recorded in waters directly associated with agricultural operations, such as irrigation waters, while 20 µg/L is at the high extreme of concentrations found more widespread. Though data from monitoring atrazine concentrations in natural habitats are sparce, 1 µg/L to 5 µg/L seem common in many Midwest waters. In laboratory experiments with these more common concentrations, we

deNoyelles et al., 1980 (con.)

also demonstrated reductions in phytoplankton photosynthesis. This indicates the possibility, awaiting further demonstration, that even at common concentrations atrazine may be affecting phytoplankton photosynthesis in many Midwest waters. Other herbicides studied in this project included five other triazine herbicides (propazine, metribuzin, terbutryn, cyanazine, simazine), which in the laboratory were similar to atrazine in the intensity of reducing phytoplankton photosynthesis. In the state of Kansas triazine herbicides accounted for one-third of the total herbicide usage in 1978.

Title: Water Quality Degradation in Urban Streams of the Southeast: Will Non-Point Source Controls Make Any Difference? In: Proceedings of the International Symposium on Urban Storm Runoff (University of Kentucky, Lexington, KY, July 23-26), pp. 151-159.

Author(s): A. M. Duda, D. R. Lenat, and D. Penrose

Publication date: 1979

Published by: North Carolina Division of Environmental Management

Number of pages: 9 pp.

Report number(s): (Not applicable)

Available from: North Carolina Department of Natural Resources and Community Development
Division of Environmental Management
512 North Salisbury Street
Raleigh, NC 27611

Abstract:

A methodology is presented for using aquatic biological monitoring to assess whether the water quality impact of urban stormwater runoff is severe enough to warrant abatement. Sampling was conducted in seven urban streams in four North Carolina cities.

Biological communities indicative of grossly degraded water quality were found in each urban steam reach compared to upstream or adjacent rural control stations. Traditional measurements of water chemistry were compared to the biological results.

Observations were made concerning the sources of water pollution in the seven urban watersheds. While no major point sources were known to exist, numerous unrecorded sources of pollution--other than urban washoff--may have contributed to the problem.

Three general types of urban streams were identified: the inner city stream, the suburban stream, and the receiving stream. If enough funding was expended, biological integrity might be restored to suburban and receiving streams. However, the cost of discovering unrecorded urban sources of pollution through monitoring and the economic (and political) costs of requiring pollution abatement may make the restoration of biological integrity an unattainable goal in inner-city urban streams.

Title: Effects of Highway Runoff on Receiving Waters, Volume II—Research Report

Author(s): T Dupuis, J. Kaster, P. Bertram, J. Meyer, M. Smith, and N. Kobriger

Publication date: August 1985

Published by: Rexnord, Inc.

Number of pages: 406 pp.

Report number(s): FHWA/RD-84/063, Volume II—Research Report; PB86-228202

Available from: National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161

Abstract:

Results of comprehensive field monitoring programs at three sites are reported in this volume. One stream site (WI Hwy 15/Sugar Creek) and one lake site (I-94/Lower Nemahbin Lake) were located in southeastern Wisconsin. The third site (I-85/Sevenmile Creek) was located in the Piedmont region of North Carolina.

Monitoring at each site was conducted for 1 year. The scope of these programs included meteorological and hydrological monitoring, runoff, and receiving water quality sampling during both dry and wet weather, and sediment, benthic macroinvertebrate, and macrophyte sampling.

The results of extensive bioassay testing are also included in this volume. Runoff samples from both urban and rural highways were used with a variety of test organisms.

Region 4: NC
Region 5: WI

Title: Effects of Methoxychlor on Riffle Invertebrate Populations and Communities

Author(s): P. J. Eisele and R. Hartung

Publication date: 1976

Published by: Transactions of the American Fisheries Society, 105(5):628-633

Number of pages: 6 pp.

Report number(s): (Not applicable)

Available from: American Fisheries Society
5410 Grosvenor Lane
Suite 110
Bethesda, MD 20814

Abstract:

A study was conducted to evaluate the chronic effects of a toxicant on interacting stream invertebrate populations in the Raisin River, MI. The study involved the continuous dosing of a small stream at 0.2 µg/L methoxychlor for over 1 year. Invertebrate populations were monitored by artificial substrate and bottom sample collections of riffle invertebrates.

Most invertebrate populations experienced some reduction due to the stream dosing. Some taxa (baetids and plecopterans) were affected as reflected by population reductions in dosed areas. Many taxa (hydropsychids, simulids, and aeschnids) were temporarily affected, experiencing initial population reductions in dosed areas but then recovering to control levels. Other taxa (chironomids and elmids) were not affected by the pesticide dosing.

The riffle invertebrate community colonizing artificial substrates experienced a temporary decrease in diversity through both reduced richness and evenness. Diversity was not decreased in bottom sample collections. In general, most long-term effects were minor in comparison to naturally occurring phenomena such as flooding.

Region 5: MI

Title: Evaluation of Streamside Bufferstrips for Protecting Aquatic Organisms

Author(s): D. C. Erman, J. D. Newbold, and K. B. Roby

Publication date: September 1977

Published by: California Water Resources Center

Number of pages: 48 pp.

Report number(s): Contribution No. 165

Available from: California Water Resources Center
University of California
Davis, CA 95616

Abstract:

An evaluation of logging impacts on streams was based on an extensive survey during 1975 of 62 northern California streams. Streams had been: (1) logged without stream protection measures, (2) logged with protective bufferstrips, (3) affected by localized disturbances (such as logging road stream crossings), or (4) were unaffected streams.

Benthic invertebrate communities of disturbed and undisturbed streams were compared by diversity index and ecological distance. Benthic invertebrate communities from streams logged without protective measures were significantly different from communities of unlogged (control) streams based on both diversity and ecological distance. Logging impacts were detected also in streams with buffer widths of less than approximately 30 m. Streams with bufferstrips wider than 30 m did not display logging impacts. There was a direct correlation between increases in an index of diversity and increases in buffer width, and hence probably the degree of stream protection increased with buffer widths up to 30 m.

Invertebrate communities of logged or disturbed streams had a lower diversity index and higher populations than unlogged streams. Increased populations were primarily in three taxa--Baetis, Nemoura, and Chironomidae.

Communities in localized disturbances were significantly different from control stream sections. The differences were qualitative (i.e., different taxa) and thus contrast with the differences noted in logged or narrow buffered streams.

Stream invertebrates were far more effective in discerning logging impacts than the physical and chemical parameters measured. Variation among watersheds and sampling error contributed to the failure of physical or chemical measures to detect logging impacts. Measurements of over 20 environmental variables from the streams are included, and give an excellent catalogue of both disturbed and natural stream conditions in northern California.

Region 9: CA

Title: Effects of pH on the Biology and Distribution of *Ephemerella funeralis* (Ephemeroptera)

Author(s): S. B. Fiance

Publication date: 1978

Published by: *Oikos*, 31:332-339

Number of pages: 8 pp.

Report number(s): (Not applicable)

Available from: Scandinavian Society Oikos
Munksgaard
35 Noerre Soegade
DK-1370
Copenhagen K
Denmark

Abstract:

The life history, emergence, sex ratio, fecundity, food habits, microhabitat, distributional pattern, and effects of experimental acidification on the emergence, growth, and recruitment of *Ephemerella (Eurylophella) funeralis* McD. are reported. *E. funeralis* is the only member of the Ephemerellidae yet known to have a 2-year life cycle. Emergence of adults was recorded from 1 June to 11 July in the Hubbard Brook watershed. Larval sex ratio from all study sites was approximately one male for every eight females. Sex ratio of adults was found to be site dependent, with males increasing in representation as stream size decreased. The average number of eggs per female was 1,853 ± S.E. 87. Facultative parthenogenesis is indicated by the successful development of 53% of 381 eggs taken from an unmated female subimago. Larvae were found in accumulations of organic matter in slower flowing portions of streams and also in permanent woodland pools. Gut contents of larvae were predominantly composed of detritus and decomposing higher plant matter, especially leaves and fungal growth of submerged wood. *E. funeralis* appears to decrease in abundance with decreasing stream pH and decreasing organic matter. The experimental acidification of Norris Brook [New Hampshire] had no effect on the emergence of adults but caused a decrease in growth and nearly eliminated recruitment of the new cohort. A direct relationship between pH and the abundance of *E. funeralis* in the Hubbard Brook watershed is indicated by the results.

Region 1: NH

Title: Aquatic Organisms and Heavy Metals in Missouri's New Lead Belt

Author(s): N. L. Gale, B. G. Wixson, M. G. Hardie, and J. C. Jennett

Publication date: August 1973

Published by: Water Resources Bulletin, 9(4):673-688

Number of pages: 16 pp.

Report number(s): (Not applicable)

Available from: American Water Resources Association
4104 Ohms Lane, Suite 203
Minneapolis, MN 55435

Abstract:

The New Lead Belt of southeastern Missouri has recently become the largest lead-producing region of the world. The impact of this rapid development on the previously rural and undeveloped region of the Missouri Ozarks is the subject of a continuing interdisciplinary study. Since the industrial development began, there have been a number of nuisance biological blooms in several of the small streams receiving effluent from the mines and mills. The major constituents of the problem algal growth were identified and found to include: Cladophora, Oscillatoria, Mougeotia, Zygnema, Spirogyra, Cymbella, and a variety of other stalked and nonstalked diatoms. Secondary blooms of Sphaerotilus were observed to reach problem proportions in some streams, particularly in the autumn. Finely ground rock flour and mineral particles escaping from tailings dams were found to be trapped by the stream vegetation. Concentrations of lead, zinc, copper, and manganese in the algal and bacterial mats were found to be inversely related to distance downstream from the tailings dams. Consumer organisms, including crayfish, snails, aquatic insects, tadpoles, minnows, and larger sunfish were analyzed to determine the extent of dissemination and concentration of the heavy metals through food chains. Preliminary results indicated insignificant concentrations of heavy metals in those consumer organisms studied, though in at least one problem stream the normal consumer organisms mentioned were markedly reduced in numbers.

Title: Effects of Agriculture on Stream Fauna in Central Indiana

Author(s): J. R. Gammon, M. D. Johnson, C. E. Mays, D. A. Schiappa, W. L. Fisher, and B. L. Pearman

Publication date: April 1983

Published by: Department of Zoology, DePauw University

Number of pages: 87 pp.

Report number(s): EPA-600/3-83-020; PB83-188755

Available from: Environmental Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
Corvallis, OR 97333

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161

Abstract:

From 1978 through 1980 the benthic macroinvertebrate and fish communities of three stream systems in Central Indiana were examined. The objective of this study was to describe the organization of these communities in relation to different land uses. The influence of agriculture on the 14 stream segments ranged from virtually none to intense, and included some drainage from animal feed lots. The results of the study suggest the pattern of change caused by the increasing development of agriculture in small watershed streams. Initially agriculture may lead to an expanded biomass of fish and macroinvertebrates without causing a large compositional reorganization. However, chironomids assume a dominant role for the macroinvertebrates, while other benthic groups become secondary in importance. These benthic changes appear to occur without strongly influencing the fish community, except for an increase in standing crop. Further development of agricultural stresses causes a sudden, pronounced shift in the composition of the fish community. Communities dominated by insectivores and piscivores (centrarchids in these streams) are converted to communities dominated by omnivores, herbivores, and detritivores. This alteration may occur with little or no change in standing crop biomass. At this stage the density of nonchironomid insect larvae becomes reduced. The near-stream riparian part of the watershed is vital to the maintenance of healthy aquatic communities, acting as a buffer between plowed fields and farm animals and the aquatic system.

Region 5: IN

Title: Distribution of Benthic Macroinvertebrates in a Stream Exposed to Urban Runoff

Author(s): H. L. Garie and A. McIntosh

Publication date: 1986

Published by: Water Resources Bulletin, 22(3):447-455

Number of pages: 9 pp.

Report number(s): (Not applicable)

Available from: American Water Resources Association
4104 Ohms Lane, Suite 203
Minneapolis, MN 55435

Abstract:

A study of benthic macroinvertebrate community composition was conducted at eight sites along Shabakunk Creek, a small stream in Mercer County, New Jersey, which receives urban runoff. The relationship between changes in substrate composition and the nature of the benthic macroinvertebrate community has been examined. Organisms were collected seasonally from natural substrates in riffles. Attempts to employ artificial substrates for invertebrate collection proved unsuccessful, because the population on the samplers was not representative of that in the stream bed.

Number of total benthic macroinvertebrate taxa collected declined from 13 in relatively undeveloped upstream areas to 4 below heavily developed areas, while population density decreased simultaneously in the same areas. Periphyton samples collected from natural substrates were analyzed for selected heavy metals. Significantly higher heavy metal concentrations are reported from substrates sampled below heavily developed areas, and changes in these values are discussed with regard to changes in benthic macroinvertebrate distribution.

Title: Effect of an Aerial Application of Carbaryl on Brook Trout (*Salvelinus fontinalis*)

Author(s): T. A. Haines

Publication date: 1981

Published by: Bulletin of Environmental Contamination and Toxicology, 27:534-542

Number of pages: 9 pp.

Report number(s): (Not applicable)

Available from: Bulletin of Environmental Contamination and Toxicology
Springer-Verlag New York, Inc.
175 Fifth Avenue
New York, NY 10010

Abstract:

The eastern spruce budworm (*Choristoneura fumiferana*) is a serious economic pest in the spruce-fir forests of northeastern North America. In the United States the major problem area is northern and western Maine. From 1954 to 1979, 6 different major chemicals and at least 21 experimental chemicals were applied on up to 3.5 million acres annually in attempts to control the budworm. The early use of DDT for this purpose caused extensive losses of Atlantic salmon (*Salmo salar* L.) and brook trout (*Salvelinus fontinalis* Mitchill) (Kerswill, 1967). Consequently, DDT was replaced by carbamate or organophosphorus compounds. Use of these compounds has not resulted in visible fish mortalities (Kerswill and Edwards, 1969), but sublethal effects may occur.

From 1975 to 1980 the most widely used chemical for spruce budworm control in Maine was a carbamate, carbaryl (Sevin-4-oil), usually applied at the rate of 1 lb of active ingredient (A.I.) per acre. Such applications have been shown to increase downstream drift of aquatic invertebrates, and depress population densities of some species of aquatic invertebrates (Courtemanch and Gibbs, 1978) and to depress brain acetylcholinesterase (AChE) activity in fish (Hulbert, 1978; Marancik, 1976). In the present study an experimental area was established in which the carbaryl was applied at the rate of 0.5 lb A.I./acre in two applications spaced 7 days apart. The study was conducted to evaluate the effect of this split application on brook trout mortality, condition factor, food, and brain AChE activity.

Region 1: ME

Title: Effects of Logging on Periphyton in Coastal Streams of Oregon

Author(s): E. W. Hansmann and H. K. Phinney

Publication date: 1973

Published by: Ecology, 54(1):194-199

Number of pages: 6 pp.

Report number(s): (Not applicable)

Available from: Allen Press, Inc.
1041 New Hampshire Street
P.O. Box 368
Lawrence, KS 66044

Abstract:

Changes in the stream algal flora were observed during a multidisciplinary logging study of small watersheds in Oregon. Clearcut logging was applied to one watershed of 71 ha, while a second watershed of 304 ha was patchcut, leaving a buffer-strip of vegetation along the stream channel. A third watershed of 203 ha was not logged but remained as a control. Prelogging and postlogging oxygen levels, temperature, and sedimentation loads were analyzed. Access roads were built in 1963, and logging was completed in 1966.

Analysis of the algal communities of the three watershed streams prior to the logging operation of 1966 indicated that the communities were predominantly a periphyton type composed mainly of diatoms. Immediately following the yarding operation of the clearcut watershed, large quantities of Sphaerotilus natans colonized all debris and mud in the stream, and a change in the algal flora appeared to take place. Large mats of green algae were observed colonizing all mud and slash. Results from gass substrates indicate that some changes may have taken place in the diatom community.

Title: Environmental Influences on Early Development and Year-Class Strength of Northern Pike in Lakes Oahe and Sharpe, South Dakota

Author(s): T. J. Hassler

Publication date: 1970

Published by: Transactions of the American Fisheries Society, 2:369-375

Number of pages: 7 pp.

Report number(s): (Not applicable)

Available from: American Fisheries Society
5410 Grosvenor Lane
Suite 110
Bethesda, MD 20814

Abstract:

Survival of artifically fertilized ova and larvae of northern pike (Esox lucius) was estimated from embryos held in natural spawning areas in Lake Oahe and Lake Sharpe, two main stem Missouri River reservoirs. Mortalities approaching 100% during early embryonic development were associated with sudden drops in water temperature below 10 °C or prolonged temperatures near 5 °C. Silt deposition of 1.0 mm per day was associated with mortality of 97% or above. After hatching, available food appeared to be a more important factor in survival than temperature change or silt deposition.

Estimates of year-class strength of northern pike in the two reservoirs suggest that large year classes were associated with stable to rising water level and temperature, flooded vegetation, and calm weather during the spawning season. Small year classes have been associated with abrupt water temperature fluctuations, dropping water level, and high silt deposits.

Title: Influence of Sand in Redds on Survival and Emergence of Brook Trout (*Salvelinus fontinalis*)

Author(s): D. A. Hausle and D. W. Coble

Publication date: 1976

Published by: Transactions of the American Fisheries Society, 15(1):57-63

Number of pages: 7 pp.

Report number(s): (Not applicable)

Available from: American Fisheries Society
5410 Grosvenor Lane
Suite 110
Bethesda, MD 20814

Abstract:

Alevins of brook trout (*Salvelinus fontinalis*) were buried in laboratory troughs in spawning gravel containing 0 to 25% sand. Sand slowed emergence and reduced the number of fry emerging. Weight of fry was not related to proportion of sand in the gravel, but was related to time; the fry were heaviest near the time of peak emergence and lighter before and after the peak. Survival was estimated to be 84% from egg deposition to hatching for brook trout in Lawrence Creek, Wisconsin, and 70% from hatching to emergence, providing a total estimate for survival from egg deposition to emergence of 59%.

Region 5: WI

Title: Acid Rock in the Great Smokies: Unanticipated Impact on Aquatic Biota of Road Construction in Regions of Sulfide Mineralization

Author(s): J. W. Huckabee, C. P. Goodyear, and R. D. Jones

Publication date: 1975

Published by: Transactions of the American Fisheries Society, 104:677-684

Number of pages: 8 pp.

Report number(s): (Not applicable)

Available from: American Fisheries Society
5410 Grosvenor Lane
Suite 110
Bethesda, MD 20814

Abstract:

After the completion of a highway construction project in Great Smoky Mountains National Park (North Carolina) in 1963, a fish kill was noted in a small stream draining an area of roadbed fill. After 10 years, the stream remained devoid of fish for at least 8 km downstream from the fill. The downstream water had a pH of 4.5 to 5.9; upstream from the fill the pH was 6.5 to 7.0. The rock material in the fill contains iron sulfide minerals. Other streams in the area flowing on the sulfide-rich rocks also showed low pH values. Survivability tests and stream surveys showed that brook trout cannot tolerate conditions in the stream below the road fill or in a stream flowing over natural outcrops of the same rock used in construction of the road fill. Native salamanders were also adversely affected downstream from the road fill. Chemical analyses of stream water and leaching tests indicated that lowered pH and increased sulfate and metals concentrations derived from the leaching of the sulfide-rich rocks were responsible for the trout and salamander mortalities.

Title: Mattawamkeag River Studies, II. Effects of Sevin, a Spruce Budworm Insecticide on Fish and Invertebrates in the Mattawamkeag River in 1976

Author(s): P. J. Hulbert

Publication date: December 1977

Published by: Department of Zoology, University of Maine

Number of pages: 29 pp.

Report number(s): FWS Contract 14-16-008-842, Final Report

Available from: University of Maine
Migratory Fish Research Institute and Maine
Cooperative Fishery Research Unit
Orono, ME 04473

Abstract:

Aerial applications of insecticides have been periodically employed over the last two decades to limit damage inflicted by the spruce budworm (*Choristoneura fumiferana*) on spruce-fir forests in Maine. Although overall impacts are poorly understood, investigations into some of the effects of these pesticides on nontarget fauna, including fish and stream macroinvertebrates, have been accomplished. Effects of DDT applications on brook trout growth and abundance in six streams were reported by Warner and Fenderson (1962). More recently, pesticides that are less persistent and less toxic to fish have been used in Maine. Marancik (1976) examined the effects of several pesticides, including Sevin-4-oil, on brain acetylcholinesterase activity levels in several fish species.

In 1976, headwater areas of the East and West Branches of the Mattawamkeag River were included in the Maine Bureau of Forestry's 9-million-hectare operational spruce budworm control program. The insecticide Sevin-4 was prepared at 0.84 kg/ha, diluted with kerosene, and sprayed from aircraft at 2.25 L/ha. Sevin-4-oil was the principal pesticide used in the operational spray program. The Mattawamkeag River system was being studied as potential habitat for anadromous Atlantic salmon. The overlapping of the spruce budworm control program with headwater areas of the Mattawamkeag River provided the impetus for a separate investigation into some effects of the pesticide application on fish populations. The principal objectives of this study were:

(1) To determine background pesticide residue concentrations in prespray fish samples.

(2) To determine changes in brain acetylcholinesterase levels over an extended postspray period in several fish species.

Hulbert, 1977 (con.)

(3) To compare growth of salmonids in sprayed and unsprayed streams during the summer.

(4) To determine if major changes in macroinvertebrate fish food populations occurred after pesticide application.

Title: The Effects of Muddy Creek on the Biology of the Lower Sun River

Author(s): G. L. Ingman, E. E. Weber, and L. L. Bahls

Publication date: January 1984

Published by: Water Quality Bureau, Montana Department of Health and Environmental Sciences

Number of pages: 74 pp.

Report number(s): (Not available)

Available from: Water Quality Bureau
Environmental Sciences Division
Montana Department of Health
and Environmental Sciences
Cogswell Building
Helena, MT 59620

Abstract:

Muddy Creek is Montana's worst water quality problem. Every year Muddy Creek dumps more than 200,000 tons of sediment and nutrients into the Sun and Missouri rivers west of Great Falls, Montana. The extremely high sediment and nutrient production of Muddy Creek is attributed to accelerated channel erosion caused by hydraulic overloading from unused irrigation water and return flows from the Greenfields Irrigation District.

In September and October of 1980 the Water Quality Bureau, Montana Department of Health and Environmental Sciences, conducted a comprehensive assessment of the impacts of Muddy Creek silt and nutrients on water quality and aquatic life in the Sun River. The study was designed to (1) determine the nature and severity of impacts on Sun River biology, (2) determine the downstream extent of biological impairment in the Sun River, and (3) establish Muddy Creek as the cause of impairment.

Samples were collected at one station above and three stations below Muddy Creek over a 5-week period. Measurements were made of 22 water quality and biological variables in five areas: suspended solids and water clarity, concentrations of algal nutrients, periphyton (algae) production, periphyton community structure, and macroinvertebrate (insect) community structure, all on artificial substrates. Standard methods and procedures sanctioned by the U.S. Environmental Protection Agency were used throughout the study.

Concentrations of sediment and nutrients in the Sun River below Muddy Creek were two to nine times higher than they were above the confluence, and water clarity below was less than a quarter of what it was above Muddy Creek. The attenuation of light by particles of sediment practically curtailed the growth of algae on the bottom of the Sun River for a short distance below its

Ingman et al., 1984 (con.)

confluence with Muddy Creek. As current velocity slowed, most of the sediment settled and the water cleared at the station farthest downstream, 11.7 mi below Muddy Creek. Here algae production recovered and surpassed that measured at the control station 2.1 mi above the confluence of the Sun River and Muddy Creek, presumably because of nutrient enrichment from Muddy Creek. Nutrient loving blue-green algae were much more common below Muddy Creek than they were above.

The Muddy Creek sediment plume initially reduced the number of fish food (macroinvertebrate) organisms colonizing artificial substrates in the Sun River by almost 85%. Like the algae, the macroinvertebrates also recovered, and at the station farthest downstream numbers surpassed those recorded upstream from Muddy Creek. However, suitable natural substrates for both algae and invertebrates may be limited in the lower Sun River.

Measures of diatom and macroinvertebrate diversity in the Sun River proved to be unreliable as indicators of the biological impact of the principal pollutants contained in the Muddy Creek plume, namely sediment and inorganic nutrients. Computed for both diatoms and macroinvertebrates, Shannon's diversity index (d) and equitability (e) indicated that the cleanest, least polluted water was to be found in the Sun River at the station just below its confluence with Muddy Creek. These findings point out the danger in relying on biological diversity alone as a measure of water quality.

Based on the findings of this study, the Sun River is not likely to support a good fishery for the first 2.0 mi below Muddy Creek. During the peak of the irrigation season when the sediment contribution of Muddy Creek is much larger, conditions for aquatic life will be worse, at times extending the impact zone all the way to the Missouri River at Great Falls.

Title: Water Quality and Benthic Macroinvertebrate Survey of the Mimbres River, March 14 and July 9-10, 1984

Author(s): G. Z. Jacobi and D. U. Potter

Publication date: October 1984

Published by: New Mexico Environmental Improvement Division

Number of pages: 21 pp.

Report number(s): EID/SWQ-84/6

Available from: Surveillance and Standards Section
Surface Water Quality Bureau
New Mexico Environmental Improvement Division
P.O. Box 968
Harold Runnels Building
1190 St. Francis Drive
Santa Fe, NM 87504-0968

Abstract:

The Surveillance and Standards Section conducted a 1-day reconnaissance survey in March and a 2-day intensive survey in July on the Mimbres River in Grant County, New Mexico. The study area encompassed a 20-mi reach of the upper Mimbres River beginning 1 mi downstream from San Lorenzo on private land and extending to 1/2 mi upstream from Cooney Campground in the Gila National Forest. Water quality and biological data were collected in order to: (1) examine water quality problems reported by the New Mexico Water Quality Control Commission (1982), (2) determine if designated instream uses such as fisheries could be limited by water quality (NMWQCC, 1975), and (3) determine if the present fishery-use designation of the Mimbres River upstream from the town of Mimbres (i.e., high quality coldwater fishery) is appropriate (NMWQCC, 1981). Significant instream water quality violations have been observed for temperature, total phosphorus, pH, organic carbon, and fecal coliform bacteria concentrations at the U.S. Geological Survey gaging station east of the town of Mimbres (NMWQCC, 1982).

Title: Fish Communities of Midwestern Rivers: A History of Degradation

Author(s): J. R. Karr, L. A. Toth, and D. R. Dudley

Publication date: 1985

Published by: *BioScience*, 35(2):90-95

Number of pages: 6 pp.

Report number(s): (Not applicable)

Available from: Allen Press, Inc.
1041 New Hampshire Street
P.O. Box 368
Lawrence, KS 66044

Abstract:

As human populations have grown, water resource quality has declined. Since 1850, 67% of the fish species from the Illinois River and 44% from the Maumee River have become less abundant or have disappeared. Reversing such trends demands innovative approaches to water resource management.

Region 5: IL

Title: Decline of Submerged Vascular Plants in Upper Chesapeake Bay: Summary of Results Concerning Possible Causes

Author(s): W. M. Kemp, R. R. Twilley, J. C. Stevenson, W. R. Boynton, and J. C. Means

Publication date: 1983

Published by: Journal of the Marine Technology Society, 17(2):78-89

Number of pages: 12 pp.

Report number(s): (Not applicable)

Available from: Allen Press, Inc.
1041 New Hampshire Street
P.O. Box 368
Lawrence, KS 66044

Abstract:

This paper provides a summary and synthesis of research conducted to investigate possible causes of the decline in abundance of submerged aquatic vegetation (SAV) in upper Chesapeake Bay beginning in the late 1960s. Three factors were emphasized in this study: runoff of agricultural herbicides; erosional inputs of fine-grain sediments; nutrient enrichment and associated algal growth. Widespread use of herbicides in the estuarine watershed occurred contemporaneous with the SAV loss; however, extensive sampling of estuarine water and sediments during 1980 and 1981 revealed that typical bay concentrations of herbicides (primarily atrazine) rarely exceeded 2 ppb. On two occasions relatively high values (20-45 ppb) were observed for brief (2- to 4-h) periods in a small cove following runoff events. Short (2- to 6-h) and long (4- to 6-wk) term experiments indicated that ephemeral phytotoxic effects would be expected in response to these highest herbicide concentrations followed by rapid recovery. However, normal concentrations (<5 ppb) had little measurable effect on plants. Historical increases in turbidity have been documented for some bay tributaries since the 1940s. During our study, light (PAR) attenuation by suspended fine-grain sediments contributed more to total turbidity in bay shallows (<1.5 m) than did phytoplankton chlorophyll a. Diel cycles of PAR available in SAV beds indicated that plant photosynthesis was light-limited for much of the day, and PAR often fell below the compensation level (I_c) needed for minimal plant growth. Although some SAV species exhibited considerable ability to adapt to reduced light by such mechanisms as increased pigmentation and stem elongation, increased turbidity has probably reduced overall depth distribution of SAV markedly. Effects of the continual increase in nutrient enrichment of the bay (documented since 1930) were tested by experimentally fertilizing pond mesocosms at levels common to the upper estuary. Moderate to high nutrient loadings resulted in significant increases in growth of epiphytic and planktonic algae and decreases in SAV production, as well as premature seasonal senescence of fertilized plant populations. Direct meas-

Region 3: MD

Kemp et al., 1983 (con.)

urements demonstrated the inhibitory effect of epiphytic growth on SAV photosynthesis, due largely to light attenuation. The results of these various experiments were synthesized into an ecosystem simulation model, which demonstrated the relative potential contributions of the three factors to SAV declines, where nutrients > sediments > herbicides. Other factors and mechanisms are also discussed along with possible resource management options.

Title: Blue Crab Mortality: Interaction of Temperature and DDT Residues

Author(s): C. C. Koenig, R. J. Livingston, and C. R. Cripe

Publication date: 1976

Published by: Archives of Environmental Contamination Toxicology, 4(1):119-128

Number of pages: 10 pp.

Report number(s): (Not applicable)

Available from: Archives of Environmental Contamination and Toxicology
Springer-Verlag New York, Inc.
175 Fifth Avenue
New York, NY 10010

Abstract:

Serial observations of DDT-contaminated and uncontaminated salt marshes in the northern Gulf of Mexico were made in November and December, 1973. Blue crab (Callinectes sapidus) mortalities observed in the DDT-contaminated marsh during this period were correlated with reduced daily temperature minima. Gas chromatographic analysis of hepatopancreas and swimmeret muscle tissue of dead and dying crabs revealed total DDT residue concentrations as high as 39.0 ppm and 1.43 ppm, respectively. It is suggested that the DDT body burdens and reduced temperatures interact to produce acutely toxic effects. Several physiological and behavioral mechanisms are proposed.

Region 4: FL

Title: Annual Production of Macroinvertebrates in Three Streams of Different Water Quality

Author(s): C. C. Krueger and T. F. Waters

Publication date: 1983

Published by: Ecology, 64(4):840-850

Number of pages: 11 pp.

Report number(s): (Not applicable)

Available from: Allen Press, Inc.
1041 New Hampshire Street
P.O. Box 368
Lawrence, KS 66044

Abstract:

Macroinvertebrate annual production was estimated in three Minnesota streams that differed in watershed geologic origin and in total alkalinity. Annual mean alkalinities (as $CaCO_3$) in the Caribou River, Blackhoof River, and North Branch Creek were 34, 83, and 245 mg/L, respectively. Annual production by herbivore-detritivore invertebrates was lowest in the Caribou River (wet mass: 27.0 g/m^2, intermediate in the Blackhoof River (36.9 g/m^2), and highest in North Branch Creek (119.6 g/m^2). Estimates of annual production by invertebrate carnivores followed the same pattern: lowest in the Caribou River (5.5 g/m^2), intermediate in the Blackhoof River (6.5 g/m^2), and highest in North Branch Creek (12.8 g/m^2). These estimates of annual production were positively associated with alkalinity, nitrates, and fish standing stocks.

Title: Some Thermal and Biological Effects of Forest Cutting in West Virginia

Author(s): R. Lee and D. E. Samuel

Publication date: 1976

Published by: Journal of Environmental Quality, 5(4):362-366

Number of pages: 5 pp.

Report number(s): (Not applicable)

Available from: American Society of Agronomy, Inc.
677 South Segoe Road
Madison, WI 53711

Abstract:

Water temperature, benthic fauna, and aquatic insect emergence were observed in four small watersheds to document the effects of forest cutting. During the summer months, complete cutting caused mean temperature increases >4 °C and maximum temperature increases >9 °C. The changes diminished to about one-half after 3 years of natural hardwood regeneration. Complete cutting more than tripled the mean weekly range of stream temperature during summer, and decreased mean minimum temperatures during winter months by about 2 °C. Two orders, Diptera and Pelecypoda, accounted for most of the benthic biomass in watershed weir ponds; the former predominated in clearcut watershed ponds, and the latter in a control (forested area) pond. The control pond produced by far the highest total numbers and biomass of benthic fauna, and the greatest numbers of aquatic insects.

Title: Modification of Benthic Insect Communities in Polluted Streams: Combined Effects of Sedimentation and Nutrient Enrichment

Author(s): A. D. Lemly

Publication date: 1982

Published by: Hydrobiologia, 87:229-245

Number of pages: 17 pp.

Report number(s): (Not applicable)

Available from: Kluwer Academic Publishers Group
Distribution Center
P.O. Box 322, 3300 AH Dordrecht
The Netherlands

Abstract:

Responses of the benthic insect community of a southern Appalachian trout stream [North Carolina] to inorganic sedimentation and nutrient enrichment were monitored over a period of 8 months. Entry of pollutants from point sources established differentially polluted zones, allowing an assessment of impacts due to sedimentation alone and in association with elevated nutrient levels. Input of sediment resulted in a significant increase in bed load and decrease of pH at the substrate-water interference ($P < 0.05$). The zone receiving nutrient runoff from livestock pasture exhibited elevated levels of nitrate and phosphate, but available data indicated such concentrations to be quite low. Species richness, diversity, and total biomass of filter feeding Trichoptera and Diptera, predaceous Plecoptera, and certain Ephemeroptera were significantly reduced in the polluted zones. Inorganic sedimentation, operating indirectly through disruption of feeding and filling of interstitial spaces, was considered to be the primary factor affecting filter feeding taxa. Decomposition of compounds associated with materials in the bed load may depress pH and eliminate acid sensitive species of Plecoptera and Ephemeroptera. Such processes of acidification may be particularly important to Appalachian streams since the pH of regional surface waters is characteristically acidic prior to sedimentation. Accumulation of particles on body surfaces and respiratory structures, perhaps as a function of wax and mucous secretion or surface electrical properties, appears to be the major direct effect of inorganic sedimentation on stream insects. Growths of the filamentous bacterium Sphaerotilus natans were also frequently associated with silted individuals in the zone receiving nutrient addition. Distribution of the bacterium suggested that silted substrates, perhaps as related to the presence of iron compounds, are required for colonization in dilute nutrient solutions. The primary effect of Sphaerotilus colonies appears to be augmentation of particle accumulation through net formation by bacterial filaments. Data indicate that inorganic sedimentation and nutrient addition operate synergistically, eliminating a significantly greater number of taxa than exposure to one pollutant alone.

Region 4: NC

Title: Agriculture and Stream Water Quality: A Biological Evaluation of Erosion-Control Practices

Author(s): D. R. Lenat

Publication date: 1984

Published by: Environmental Management, 8(4):334-344

Number of pages: 11 pp.

Report number(s): (Not applicable)

Available from: Environmental Mangement
Springer-Verlag New York, Inc.
175 Fifth Avenue
New York, NY 10010

Abstract:

Agricultural runoff affects many streams in North Carolina. However, there is little information about either its effect on stream biota or any political mitigation by erosion control practices. In this study, benthic macroinvertebrates were sampled in three different geographic areas of North Carolina, comparing control watersheds with well-managed and poorly managed watersheds. Agricultural streams were characterized by lower taxa richness (especially for intolerant groups) and low stability. These effects were most evident at the poorly managed sites. Sedimentation was the apparent major problem, but some changes at agricultural sites implied water quality problems. The groups most intolerant of agricultural runoff were Ephemeroptera, Plecoptera, and Trichoptera. Tolerant species were usually filter-feeders or algal grazers, suggesting a modification of the food web by addition of particulate organic matter and nutrients. This study clearly indicates that agricultural runoff can severely impact stream biota. However, this impact can be greatly mitigated by currently recommended erosion control practices.

Title: Ecological Effects of Urban Runoff on North Carolina Streams

Author(s): D. Lenat and K. Eagleson

Publication date: 1981

Published by: North Carolina Division of Environmental Management

Number of pages: 22 pp.

Report number(s): Biological Series #104

Available from: North Carolina Department of Natural Resources and Community Development
Division of Environmental Management
Water Quality Section
512 North Salisbury Street
Raleigh, NC 27611

Abstract (from p. 2 of "Introduction"):

The Biological Monitoring Group prior to this study had studied urban streams in five North Carolina cities (Penrose et al., 1980; Duda et al., 1979). These studies included data on eight streams in Asheville, Winston-Salem, Charlotte, Raleigh, and Durham. Although these cities are located in different geographic areas, the results were remarkably uniform.

Taxa richness (S) values were severely reduced in comparison with control data. Reduction in S was always greater than 50% (the criterion for severe stress) and usually near 70%. The average density (N) showed a similar reduction. The parallel reduction in both N and S suggested the presence of toxic materials. This hypothesis was reinforced by the very high variability of density estimates. High densities of pollution-tolerant organisms were occasionally recorded. The abrupt disappearance of these populations in succeeding sample periods suggested "slugs" of toxic materials originating from spills, sporadic discharges, or runoff. Chemical data from streams in the Winston-Salem area has shown Zn, Pb, and Hg to be present in high concentrations.

The biotic index values were extremely high for all streams, indicating "very poor" conditions. Intolerant macroinvertebrate groups (Ephemeroptera, Plecoptera, Trichoptera, and Coleoptera) were not just reduced in number; they were usually absent. Tolerant Chironomidae and Oligochaeta generally composed greater than 90% of the total fauna. Many of these organisms are associated with high organic loading. However, densities were usually well below that expected for a case of simple organic pollution. Most dominant organisms are also sediment tolerant.

Data from 1978 and 1979 suggested that urban streams were grossly polluted by a combination of toxic materials, organics and sediment. Chemical sampling, by itself, might easily underestimate the severity of the problems, because many pollutants show extreme temporal variability.

Lenat and Eagleson, 1981 (con.)

The studies described above were all conducted on "large" cities (1980 populations of 53,000-311,000). Could these same results be expected in smaller North Carolina towns? To answer this question, urban streams were sampled in seven small (1980 populations of 5,000-35,000) cities: Brevard, Asheboro, Morganton, Goldsboro, Greenville, Wilson, and Dunn.

Title: Variable Effects of Sediment Addition on Stream Benthos

Author(s): D. R. Lenat, D. L. Penrose, and K. W. Eagleson

Publication date: 1981

Published by: Hydrobiologia, 79:187-194

Number of pages: 8 pp.

Report number(s): (Not applicable)

Available from: Kluwer Academic Publishers Group
Distribution Center
P.O. Box 322, 3300 AH Dordrecht
The Netherlands

Abstract:

Two upper Piedmont streams in North Carolina were studied to determine the effects of road construction, especially sediment inputs. Benthic macroinvertebrate data suggest that the stream community responded to sediment additions in two different ways. Under high flow conditions the benthic fauna occurred mainly on rocky substrates. As sediment was added to a stream the area of available rock habitat decreased, with a corresponding decrease in benthic density. There was, however, little change in community structure. Under low flow conditions, stable-sand areas may have supported high densities of certain taxa. Density of the benthic macroinvertebrates in these areas may have been much greater than the density recorded in control areas, and there were distinct changes in community structure.

Region 4: NC

Title: Effects of Sand Sedimentation on Colonization of Stream Insects

Author(s): R. J. Luedtke and M. A. Brusven

Publication date: September 1976

Published by: Journal of the Fisheries Research Board of Canada, 33(9): 1881-1886

Number of pages: 6 pp.

Report number(s): (Not applicable)

Available from: Fisheries and Oceans
Scientific Information and Publication Branch
200 Kent Street
Ottawa, Ontario K1A 0E6
Canada

Abstract:

Driftnets, basket samplers, and artificial streams were used to investigate the influence of heavy sand accumulations on insect drift, colonization, and upstream movements in Emerald Creek, northern Idaho. Most riffle insects successfully passed through low-velocity, sandy reaches 80 m long. Upstream movements on sand were impeded by flows as low as 12 cm/s, except for the heavily cased caddisfly Dicosmoecus sp.

Title: Effects of Agricultural Drainage Development in Benthic Invertebrates *in Undisturbed Downstream Reaches*

Author(s): P. C. Marsh and T. F. Waters

Publication date: 1980

Published by: Transactions of the American Fisheries Society, 109:213-223

Number of pages: 11 pp.

Report number(s): (Not applicable)

Available from: American Fisheries Society
5410 Grosvenor Lane
Suite 110
Bethesda, MD 20814

Abstract:

The downstream effects of channelization and agricultural drainage development were evaluated in southwestern Minnesota by comparing benthic invertebrate populations in streams heavily modified by channelization and agricultural drainage development in upstream areas with those not so modified. Physicochemical characteristics, as well as invertebrate populations, were observed in relatively undisturbed downstream reaches. Turbidity, total alkalinity, and timing of discharge were similar in all streams. Species compositions of benthic invertebrates were similar in all streams, and there were no significant differences in total, seasonal, or monthly levels of standing stock in either numbers or biomass between modified and unmodified streams. Invertebrate drift, both insects and total invertebrates, was similar in all streams. Some differences in individual taxa were observed, but these were related to localized differences between streams, rather than to drainage development. Specific differences included higher numbers in drift of the snail Physa gyrina and the amphipod Hyalella azteca in one modified stream, apparently the result of more suitable upstream habitat in drainage ditches. It was concluded that, in these agricultural areas, the impact of upstream drainage development on benthic invertebrates in natural downstream reaches was negligible.

Title: Effect of Forest Clearcutting in New England on Stream-Water Chemistry and Biology

Author(s): C. W. Martin, D. S. Noel, and C. A. Federer

Publication date: July 1981

Published by: Water Resource Research Center, University of New Hampshire

Number of pages: 76 pp.

Report number(s): Research Report #34 (14-34-0001-8031)

Available from: Northeastern Forest Experiment Station
U.S. Forest Service
Durham, NH 03824

Abstract:

Changes in stream chemistry following clearcutting were sought in 56 streams at 15 locations throughout New England (Maine, New Hampshire, and Vermont). Streams draining clearcut areas were compared with nearby streams in uncut watersheds over periods of up to 2 years. In general, concentrations of all elements studied (inorganic N, SO_4 - S, Cl, Ca, Mg, K, Na), as well as pH and specific conductivity, varied as much among uncut streams at a location as between uncut and cutover streams. However, at most locations, at least one of these variables differed between uncut and cutover streams. The greatest differences occurred with nitrogen in northern hardwood forests in the White Mountains of New Hampshire. At four of the locations the effect of cutting on algae and invertebrates in the streams were also examined. Both algal and invertebrate densities were greater in cutover streams by factors of 2 to 4, probably because of increased light and temperature. The taxonomic composition of both algal and invertebrate populations was also changed by cutting. Partial cuts and sufficiently wide buffer strips can minimize both chemical and biological changes.

Region 1: ME, NH, VT

Title: An In Situ Assessment of the Acute Toxicity of Urban Runoff to Benthic Macroinvertebrates

Autnor(s): C. Medeiros, R. LeBlanc, and R. A. Coler

Publication date: 1983

Published by: Environmental Toxicology and Chemistry, 2:119-126

Number of pages: 8 pp.

Report number(s): (Not applicable)

Available from: Pergamon Press, Inc.
Journals Division
Maxwell House
Fairview Park
Elmsford, NY 10523

Abstract:

Colonized Hester-Dendy substrates were deployed for 96 h in an urban river reach, storm drain channel, and a control site (in Massachusetts) to assess the toxicity of urban runoff. The mean macroinvertebrate diversity during rain events was reduced from 1.7 at the control station to 1.0 at both urban stations. Snowmelt exerted the same effect on river substrate diversity, but only reduced channel values from 2.0 to 1.4. During periods of no runoff, however, mean channel and control diversities remained the same (1.5), while river values dropped to 0.8. Similarly, substrate population densities during rain were, respectively, two and seven times more limiting for the storm drain channel and river reach stations. The same trend was evident in heavy metals uptake, indicating that dry weather toxicity in urban river reaches originates from the sediments. Runoff, then, serves to reduce toxicity during input, but increases it over the long run.

Region 1: MA

Title: A Comparison of the Physiological Condition of the Blue Mussel *Mytilus edulis*, After Laboratory and Field Exposure to a Dredged Material

Author(s): W. C. Nelson

Publication date: 1987

Published by: *Pollution Physiology of Estuarine Organisms* (W. B. Vernberg, A. Calabrese, F. Thurberg, and T. J. Vernberg, eds.), the Belle W. Baruch Library, No. 17, pp. 185-205, Columbia: University of South Carolina Press.

Number of pages: 21 pp.

Report number(s): (Not applicable)

Available from: University of South Carolina Press
Columbia, SC 29208

Abstract:

The scope for growth (SFG) of the blue mussel (*Mytilus edulis*) was measured after exposure to Black Rock Harbor (BRH) dredged material in the laboratory and the field. A laboratory system was used to provide constant exposure levels, ranging from 0 to 10 mg/L of suspended BRH sediment. Results indicated that concentrations as low as 1.5 mg/L BRH material reduced SFG, clearance rates, and shell growth. In the field, mussels were placed along a transect from the center of the disposal mound to a clean area that was distant from the disposal mound. The estimated maximum BRH exposure in the field (0.8 mg/L) produced no apparent reduction in the SFG of mussels collected 1 m above the bottom at the field sites. The level of BRH material estimated to affect SFG in field-exposed mussels (>0.8 mg/L) was within the range estimated from laboratory experiments (0-1.5 mg/L).

Region 2: NY

Title: Effects of Logging on Macroinvertebrates in Streams With and Without Buffer Strips

Author(s): J. D. Newbold, D. C. Erman, and K. B. Roby

Publication date: 1980

Published by: Canadian Journal of Fisheries and Aquatic Sciences, 37:1076-1085

Number of pages: 10 pp.

Report number(s): (Not applicable)

Available from: Canadian Government Publishing Centre
Supply & Services Canada
Ottawa, Ontario K1A 0S9
Canada

Abstract:

The impact of logging with and without buffer strip protection on stream macroinvertebrates was examined through comparisons of community structure in commercially logged and control watersheds throughout northern California. A nonparametric test of community dissimilarities within matched blocks of two control and one or two treated stations showed significant ($P < 0.05$) logging effects on unprotected streams when Euclidean distance and mutual information were used as dissimilarity indices, but not when chord distance was used. Shannon diversity in unprotected streams was lower ($P < 0.01$) than in control (unlogged) streams; densities of total macroinvertebrate fauna and of Chironomidae, *Baetis*, and *Nemoura* were higher in unprotected streams than in controls ($P < 0.05$). Streams with narrow buffer strips (<30 m) showed significant effects by the Euclidean distance test, but diversity varied widely and was not significantly different from that in either unprotected or control streams. Macroinvertebrate communities in streams with wide buffers (≥30 m) could not be distinguished from those of controls by either Euclidean distance or diversity; however, diversity in wide-buffered streams was significantly greater than in streams without buffer strips, indicating effective protection from logging effects.

Region 9: CA

Title: Effect of Land Use on the Biota of Piedmont Streams: Comparisons of Forested, Agricultural and Urban Watersheds

Author(s): North Carolina Division of Environmental Management

Publication date: June 1986

Published by: North Carolina Division of Environmental Management

Number of pages: 51 pp.

Report number(s): Biological Series 109

Available from: North Carolina Department of Natural Resources and Community Development
Division of Environmental Management
Water Quality Section
512 North Salisbury Street
Raleigh, NC 27611

Abstract:

Studies of nonpoint source runoff in North Carolina have documented the impact of many different types of land disturbance: agriculture, silviculture, construction, mining and urbanization (Lenat et al., 1979; Penrose et al., 1980). Two of these types of nonpoint runoff, agricultural and urban, were found to be a major problem in North Carolina streams. Agricultural runoff is of concern because of the extensive areas of cropland and pasture in North Carolina. Much of the agricultural land has been subject to severe erosion, contributing up to 67% of the eroded soil (North Carolina DEM, 1978). Urban areas constitute only a minor percentage of the land area in our state, but urban runoff has been associated with very severe pollution problems.

Title: Dynamics of Blue-Green Algal (Microcystis aeruginosa) Blooms in the Lower Neuse River, North Carolina: Causative Factors and Potential Controls

Author(s): H. W. Paerl

Publication date: April 1987

Published by: Water Resources Research Institute of the University of North Carolina

Number of pages: 166 pp.

Report number(s): UNC-WRRI-87-229

Available from: Water Resources Research Institute
of the University of North Carolina
North Carolina State University
225 Page Hall
P.O. Box 7912
Raleigh, NC 27695

Abstract:

The Neuse River Basin has over the past several decades supported some of North Carolina's most diverse and intense urban, rural, and agricultural development and growth. As such, both water use and nutrient-rich waste discharge have increased substantially in the Neuse River and its tributaries. Contemporaneously, symptoms of accelerated eutrophication, including summer-fall nuisance blue-green algal (Microcystis aeruginosa) blooms, have characterized the lower portions of this economically and recreationally important river. Perhaps the most alarming feature of the river's advanced trophic state is periodic winter-spring-early summer hypereutrophy, when magnitudes of both nitrogen and phosphorus loading can exceed resident phytoplankton growth requirements. Obviously, such characteristics represent an undesirable situation when viewed from both management and recreational/fishing resource/use perspectives.

With the need for a proper understanding of the complex interplay of nutritive and physical characteristics responsible for current eutrophication and associated water quality degradation, the following study, attempting to link the physiological ecology of nuisance blue-green algal blooms to environmental features making the lower Neuse River susceptible to such blooms, was initiated in 1981. Both field and laboratory monitoring efforts and experiments were carried out on a continuous basis until 1986 in order to assess the linkage between periodicity and magnitudes of nutrient inputs (loadings) as well as amenable physical conditions (water discharge, flow temperature, irradiance) responsible for bloom development and persistence during hydrologically diverse years. Clearly, it can be seen that variable hydrological conditions, particularly evident as wet vs. dry spring-summer months, play a crucial role in determining bloom potentials in respective years. Both adequate

nutrient (specifically nitrogen) loading during wet spring months as well as subsequent low-discharge (low-flushing) conditions in summer-fall months play joint roles in dictating the magnitudes and persistence of blooms. Optimal bloom development occurred in 1983, a year which featured both excessive winter-spring nutrient loading as well as dry, low-discharge summer months. Other years, such a 1982 and 1984, featured adquate (excessive) spring nutrient loading; however, continued high discharge in summer-fall months negated bloom potentials. Conversely, 1985 and 1986, while exhibiting record droughts and resultant extensive low summer discharge conditions, failed to support detectable nuisance blooms. These years also yielded extremely dry, low-discharge spring periods, thus minimizing associated nutrient loading during the months of February-May. Consequently, inadequate (for subsequent _M. aeruginosa_ bloom development) nutrient loading took place in these years.

Appropriate constraints on nutrient inputs appear to be the only manageable option for eliminating bloom potentials. Accordingly, it is suggested that minimal input constraints (30% for N and 50% for P) formulated in this study, as well as proper timing of input constraints, be considered as a "first approach" for addressing current water quality problems on the lower Neuse River.

Title: Effects of Apple Orchard Runoff on the Aquatic Macrofauna of a Mountain Stream

Author(s): D. L. Penrose and D. R. Lenat

Publication date: 1982

Published by: Archives of Environmental Contamination and Toxicology, 11:383-388

Number of pages: 5 pp.

Report number(s): (Not applicable)

Available from: Archives of Environmental Contamination and Toxicology
Springer-Verlag New York, Inc.
175 Fifth Avenue
New York, NY 10010

Abstract:

As part of a statewide evaluation of the impact of nonpoint sources of water pollution (relevant to Section 208 of the Federal Water Pollution Control Act Amendments of 1972), a study was conducted to determine the effects of surface runoff from apple orchards. It was conducted by the Biological Monitoring Group of the North Carolina Division of Environmental Management using aquatic macroinvertebrates as assessment organisms. Both taxa richness and total numbers were reduced below the orchards, particularly during two pesticide application periods. Results indicate chronically severe stress conditions at the most downstream site and periodic stress, followed by recovery, at an upstream site. Several taxa were especially susceptible to apple orchard runoff, including Epeorus (Iron) sp. and all Plecoptera.

Region 4: NC

Title: Effects on a Trout Stream of Sediment from Agricultural Practices

Author(s): J. C. Peters

Publication date: 1967

Published by: Journal of Wildlife Management, 31(4):805-812

Number of pages: 8 pp.

Report number(s): (Not applicable)

Available from: Allen Press, Inc.
1041 New Hampshire Street
P.O. Box 368
Lawrence, KS 66044

Abstract:

The effects of sedimentation rates, stream discharge, and water temperature were studied in Bluewater Creek, Montana. Trout of all ages were abundant where sediment concentrations or loads were low (range in daily load 0.2-11 tons) and stream discharge stable (range in mean daily discharge 10-12.0 cfs). Few trout were found where sediment concentrations or loads were high (range in daily load 2-1,800 tons) and discharge erratic (range in mean daily discharge 4-485 cfs). Water temperatures were higher than desirable for trout above 80 °F for more than 3 hours on summer days) in areas of the stream influenced by irrigation surface return flow. The best survival of trout eggs (97% survival) was found where stream discharge was stable and sediment concentrations were low.

Title: Sources of Urban Runoff Pollution and Its Effects on an Urban Creek

Author(s): R. Pitt and M. Bozeman

Publication date: December 1982

Published by: Municipal Environmental Research Laboratory, Cincinnati, OH

Number of pages: 141 pp.

Report number(s): EPA-600/S2-82-090; PB 83-111-021

Available from: National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161

Abstract:

Sources and impacts of urban runoff were studied for the Coyote Creek near San Jose, California. The 3-year monitoring study included three tasks: (1) identifying and describing important sources of urban runoff pollutants; (2) describing the effects of those pollutants on water and sediment quality, aquatic organisms, and associated beneficial uses of the creek; and (3) assessing potential measures for controlling the problem pollutants in urban runoff.

Results indicated that various urban runoff constituents (especially organics and heavy metals) may be responsible for many of the adverse biological conditions observed in Coyote Creek. But adequate control of pollutants would require extremely high removals that would be difficult as well as costly to achieve.

Region 9: CA

Title: Acid Precipitation and Embryonic Mortality of Spotted Salamanders, *Ambystoma maculatum*

Author(s): F. H. Pough

Publication date: 1976

Published by: Science, 192:68-70

Number of pages: 3 pp.

Report number(s): (Not applicable)

Available from: American Association for the Advancement of Science
1333 H Street, NW
Washington, DC 20005

Abstract:

Spotted salamanders breed in temporary pools formed in early spring by melted snow and rain. Many of these pools reflect the low pH of precipitation in the northeastern United States (as in New York). Egg mortality is low as (<1%) in pools near neutrality, but high (>60%) in pools more acid than pH 6. Developmental anomalies and the embryonic stage at which death occurs are the same in field situations as at corresponding pH's in laboratory experiments.

Region 2: NY

Title: Ecological Effects of Urban Stormwater Runoff on Benthic Macroinvertebrates Inhabiting the Green River, Massachusetts

Autnor(s): J. M. Pratt, R. A., Coler, and P. J. Godfrey

Publication date: 1981

Published by: Hydrobiologia, 83:29-42

Number of pages: 14 pp.

Report number(s): (Not applicable)

Available from: Kluwer Academic Publishers Group
Distribution Center
P.O. Box 322, 3300 AH Dordrecht
The Netherlands

Abstract:

Although it has been demonstrated that urban stormwater can alter the quality of receiving waters, the corresponding impact on aquatic biota remains essentially undocumented. A year-long intensive study, therefore, was implemented to monitor and describe the ecological effects exerted by urban runoff on benthic macroinvertebrates.

Rock-filled, basket-type artificial substrates deployed periodically in nonurban and urban river reaches yielded collections of macroinvertebrates that furnished data for: (1) species diversity (the Brillouin index, H), (2) hierarchical diversity, (3) major taxa composition, and (4) collection dissimilarity at the species level.

The overall results from these four analytical procedures strongly indicate that the macrobenthic community became progressively disrupted downstream in the urban reach. The high degree of correspondence between the known sources of urban runoff and the observed effects on the benthic community are forceful arguments that urban runoff is the causal agent of disruption. The impact is not confined to periods following heavy rains. Instead the pollutants appear to remain in the system. The stress imposed by them was most acute during the summer low flow and was probably localized in or near the stream bed.

To assess the impact of urban runoff on an aquatic ecosystem, physical, chemical, and biological monitoring should routinely consider the stream bed microzone. Urban runoff pollutant loading standards must take into account the apparent long-term residence of pollutants in the substrate and the associated stress of summer low flows.

Title: Benthic Macroinvertebrate Community Structure in a Great Plains Stream Receiving Feedlot Runoff

Author(s): C. W. Prophet and N. L. Edwards

Publication date: June 1973

Published by: Water Resources Bulletin, 9(3):583-589

Number of pages: 7 pp.

Report number(s): (Not applicable)

Available from: American Water Resources Association
4104 Ohms Lane, Suite 203
Minneapolis, MN 55435

Abstract:

The effect of feedlot runoff on the environmental quality of the Cottonwood River in east central Kansas was evaluated by analysis of community structure of benthic macroinvertebrates using the species diversity index (d). The benthic fauna along the study reach was dominated by mayflies, caddisflies, midges, riffle beetles, and the pelecypod, Sphaerium. Sixty-five taxa were identified during the study; the benthic fauna was most abundant during the 1968-1969 segment of the study. However, the mean d per station indicated the river was subject to moderate environmental stress, and d's of those stations immediately downstream from feedlots were significantly lower than the d at the control station. There was a significant increase in d's during the 1970-1971 segment of the study, following the closing of two feedlots. The results indicate periodic feedlot runoff had a continuing adverse effect on the environmental quality of the river, but recovery was rapid as the organic load on the river was reduced.

Region 7: KS

Title: Stream Community Response to Road Construction Sediments

Author(s): J. R. Reed

Publication date: June 1977

Published by: Virginia Water Research Center

Number of pages: 61 pp.

Report number(s): Bulletin 97

Available from: Virginia Water Research Center
Virginia Polytechnic Institute and State University
Blacksburg, VA 24061

Abstract:

This study investigated how aquatic macrobenthic and fish communities responded to the effects of siltation from highway construction. Community response was evaluated on the basis of community diversity and changes in the numbers of organisms and/or species. An innovative computer program was used to calculate the diversity indices, using the sequential comparison technique.

The primary response observed among the macrobenthic and fish communities was a reduction both in numbers of species and in organisms downstream from the construction. Responses of the macrobenthic community ranged from a reduction of 23% in numbers of species and 66% in numbers of organisms (based upon single comparisons) to a 40% reduction of species and an 85% reduction of organisms (based upon several observations of the same population). Single comparisons of fish communities showed reductions of approximately 20% in numbers of species and 40% in numbers of organisms. The diversity index also demonstrated a statistically significant long-term change in aquatic community structure, but was less meaningful for indicating initial effects or making single comparisons.

Findings suggest that drift is a major physical response of macrobenthos to increased siltation, and may be a primary mechanism for repopulating stressed habitats. This is contrary to the commonly held hypothesis that smothering is a major effect, and should be tested in further investigations. Fishes apparently vacated areas of increased siltation, but were able to repopulate such areas within 12 months after construction activities stopped, depending upon the stream's cleansing ability. In this connection, stream flow rate and gradient are significant factors.

In general, this study found that erosion-control measures as they commonly are applied in highway construction are of limited value in preventing damages to stream communities, especially in the early construction stages. This indicates a need for more comprehensive and particularly more timely application of appropriate erosion-control techniques.

Region 3: VA

Title: Effects of Logging on Water Temperature and Dissolved Oxygen in Spawning Beds

Author(s): N. H. Ringler and J. D. Hall

Publication date: 1975

Published by: Transactions of the American Fisheries Society, 104(1):111-121

Number of pages: 11 pp.

Report number(s): (Not applicable)

Available from: American Fisheries Society
5410 Grosvenor Lane
Suite 110
Bethesda, MD 20814

Abstract:

The temperature and dissolved oxygen content of intragravel water were measured in three Oregon coastal streams between June 1968 and June 1969. In 1966, the watershed of one stream had been completely clearcut, and that of a second stream partially clearcut in staggered settings. A third watershed was left unlogged.

Clearcut logging resulted in increased temperature of intragravel water in salmon and trout spawning beds and decreased concentrations of dissolved oxygen. The changes were related largely to reduced forest cover over the stream surface and to deposition of fine sediment in the gravel.

No serious reduction in survival to emergence of coho salmon occurred along with the observed changes in temperature or dissolved oxygen. A decrease in the resident population of cutthroat trout after logging may have been related to these changes.

Title: Effects of Sedimentation on the Algal Flora of a Small Recreational Impoundment

Author(s): G. L. Samsel, Jr.

Publication date: December 1973

Published by: Water Resources Bulletin, 9(6):1145-1152

Number of pages: 8 pp.

Report number(s): (Not applicable)

Available from: American Water Resources Association
4104 Ohms Lane, Suite 203
Minneapolis, MN 55435

Abstract:

Investigations were initiated to evaluate the effects of sedimentation on the algal composition, primary productivity rates, and chemical nutrient concentrations of a 17-acre recreational impoundment in central Virginia. Comparisons during the winter seasons of 1972 and 1973 indicated that as a result of sedimentation (from lakefront home construction) the total numbers of algal genera in the lake decreased from 24 to 16, productivity as measured by $^{14}CO_2$ and total extractable chlorophyll decreased two-fold, and several important nutrients (i.e., NH_4^+-N, SiO_2, and PO_4-P) increased significantly.

Title: Effects of Dipotassium Endothall on the Zooplankton and Water Quality of a Small Pond

Author(s): S. L. Serns

Publication date: December 1975

Published by: Water Resources Bulletin, 11(6):1221-31

Number of pages: 11 pp.

Report number(s): (Not applicable)

Available from: American Water Resources Association
4104 Ohms Lane, Suite 203
Minneapolis, MN 55435

Abstract:

Zooplankton samples and dissolved oxygen-temperature readings and water samples were taken from a treatment and control pond (in Wisconsin) on 41 and 42 separate occasions, respectively, both before and after the application of 5.0 mg/L (A.I.) dipotassium endothall to the 0.31-ha treatment pond on May 31, 1973. Seasonal fluctuations in the density of Cladocera and Copepoda coincided quite closely in both ponds and were similar to the fluctuations reported in the literature to be typical of temperate region ponds and lakes. An apparent seasonal shift in generic composition from *Daphnia* spp. in May to *Ceriodaphnia* spp. in June to *Chydorus* spp. from July/early September occurred in both ponds and is thought to be at least partially due to fish predation. No apparent changes in species composition or generic densities of Cladocerans was noted in the treatment pond that did not also occur in the control pond. There were no noticeable effects of the dipotassium endothall on either the Calanoida or Cyclopoida suborders of Copepoda. A later pulse of Ostracoda in the treatment pond, when compared to the control, may have been due to the dipotassium endothall or to a combination of the effects of the herbicide on the macrophytes and the method of sampling. A decrease in dissolved oxygen below saturation, occurring in the treated pond from 3 to 21 days after treatment, was attributed to an increase in biological oxygen demand associated with weed-kill. There was no noticeable increase in plant nutrients (N and P) in the treated pond following herbicide application, nor were there any apparent changes in the other chemical parameters studied.

Title: Role of Delaware River Freshwater Tidal Wetlands in the Retention of Nutrients and Heavy Metals

Author(s): R. L. Simpson, R. E. Good, R. Walker, and B. R. Frasco

Publication date: 1983

Published by: Journal of Environmental Quality, 12(1):41-48

Number of pages: 8 pp.

Report number(s): (Not applicable)

Available from: American Society of Agronomy, Inc.
677 South Segoe Road
Madison, WI 53711

Abstract:

Tidal cycle budgets for June, July, August, September, and November 1979 showed that inorganic N was imported to the wetland from the Delaware River (in New Jersey) early in the growing season and exported late in the growing season. Nitrate and organic nitrogen were imported following macrophyte dieback. Reactive P was never lost from the marsh, and was actually imported on three dates. Total P was imported in July, September, and November, but otherwise exported. The metal present in the lowest concentration, Cd, was always exported; Ni, Cu, and Zn were imported on all but one date. Lead was imported late in the growing season and following macrophyte dieback. Non-point-source inputs of Pb exceeded inputs from tidal waters.

The vegetation played a major role in the retention of N, P, Cu, Pb, and Ni entering the wetland through the growing season. The litter retained significant quantities of all heavy metals following macrophyte dieback, but it serves only as a temporary storage vehicle because rates of decomposition are high. The soil showed no definite seasonal pattern of nutrient or heavy metal retention. Elevated Pb levels occurred at sites near storm drains, reflecting the rapid sedimentation and retention of this metal as storm waters entered the wetland. It is concluded that freshwater tidal wetlands play an important seasonal role in reducing nutrient and heavy metal loading in the upper Delaware River estuary.

Title: Chlorinated Hydrocarbon Insecticide Residues in Winter Flounder, *Pseudopleuronectes americanus*, from the Weweantic River Estuary, Massachusetts

Author(s): R. M. Smith and C. F. Cole

Publication date: 1970

Published by: Journal of the Fisheries Research Board of Canada, 27(12):2374-2380

Number of pages: 7 pp.

Report number(s): (Not applicable)

Available from: Fisheries and Oceans
Scientific Information and Publication Branch
200 Kent Street
Ottawa, Ontario K1A 0E6
Canada

Abstract:

Residues of DDT, heptachlor, and dieldrin were found in tissues of winter flounder, *Pseudopleuronectes americanus* (Walbaum), from the Weweantic River estuary, Massachusetts, during 1966 and 1967. In nonmigratory juveniles, seasonal accumulation patterns were demonstrated for DDT, heptachlor, and two related breakdown products, DDE and heptachlor epoxide. Peak concentrations of the parent compounds were more closely associated with high runoff conditions than any specific application in the estuarine drainage. Dieldrin was present uniformly throughout the year.

Migratory adult flounder, present only between October and May, contained heptachlor and heptachlor epoxide levels similar to juveniles, but significantly less DDE. Adult female flounder sequentially concentrated DDT, DDE, and heptachlor epoxide in their ripening ovaries as the spawning season approached.

Title: Effect of Rural Highway Runoff on Stream Benthic Macroinvertebrates

Author(s): M. E. Smith and J. L. Kaster

Publication date: 1983

Published by: Environmental Pollution (Series A), 32:157-170

Number of pages: 14 pp.

Report number(s): (Not applicable)

Available from: Elsevier Science Publishers
Journal Information Center
52 Vanderbilt Avenue
New York, NY 10017

Abstract:

The impact of rural highway runoff on benthic macroinvertebrate abundance and composition was studied on a southeastern Wisconsin stream during 1980 and 1981. The study suggests minimal effect on stream macroinvertebrates by rural highway runoff from roadways of 7,000-8,000 vehicles per day traffic volume. Differences in mean annual numbers and biomass between the control (4,155 m^{-2}, 10.5 gm^{-2}) and the station receiving slight highway runoff (2,611 m^{-2}, 5.2 gm^{-2}), presumably resulted from slower current and siltation at the latter. The station that received the greatest amount of runoff had higher mean annual numbers (13,291 m^{-2}) and biomass (62.2 gm^{-2}) than the control. Increased current and better substratum were probably responsible for masking potential highway effects at this station. Another station with intermediate amounts of highway runoff had similar annual mean numbers (4,642 m^{-2}) and biomass (10.6 gm^{-2}) to the control. Similar values for richness were found between stations. Pollution-sensitive fauna were approximately half as abundant at the station with intermediate amounts of highway runoff, suggesting possible slight runoff influence.

Title: Water Quality Survey of the Mora River, Mora County, New Mexico, July 21-24, 1986

Author(s): L. R. Smolka

Publication date: December 1986

Published by: New Mexico Environmental Improvement Division

Number of pages: 29 pp.

Report number(s): EID/SWQ-86/19

Available from: Surveillance and Standards Section
Surface Water Quality Bureau
New Mexico Environmental Improvement Division
P.O. Box 968, Runnels Building
1190 St. Francis Drive
Santa Fe, NM 87504-0968

Abstract:

During the period of July 21-24, 1986, the Surveillance and Standards Section conducted a 4-day survey of a 60-mi reach of the Mora River and one of its major tributaries, Coyote Creek. The reach surveyed is found in water quality standard segments 2-305 and 2-306. The objectives of the survey were: (1) to assess the water quality of this reach of the Mora River, (2) to ascertain what effects, if any, the effluent from the Mora wastewater lagoons have on the water quality of the Mora River, (3) to determine whether water quality standards are being attained in segments 2-305 and 2-306, and (4) to evaluate the biological integrity of this reach by inventorying the macroinvertebrate community. Chemical, physical, and biological data collected during this survey are presented and discussed in this report.

Title: Intensive Water Qualitv Survey of Costilla Creek and Its Tributaries, Taos County, New Mexico, February 23-26, 1987

Aut ɔr(s): L. R. Smolka

Publication date: November 1987

Published by: New Mexico Environmental Improvement Division

Number of pages: 19 pp.

Report number(s): EID/SWQ-87/3

Available from: Surveillance and Standards Section
Surface Water Quality Bureau
New Mexico Environmental Improvement Division
P.O. Box 968
Harold Runnels Building
1190 St. Francis Drive
Santa Fe, NM 87504-0968

Abstract:

During the week of February 23, 1987, the Surveillance and Standards Section conducted a 4-day water quality survey along an 18-mi reach of Costilla Creek including its major tributaries, Commanche, Latir, Cordova, and Ute creeks. In addition, water quality data collected during the fall of 1986, March 31, 1987, and April 1, 1987 were also included in the survey data base. The river reach is located in water quality segment 2-120. The objectives of the survey were: (1) to assess the water quality of this reach of Costilla Creek, (2) to ascertain what effects, if any, the Rio Costilla Ski area has on the water quality of Costilla and Cordova creeks, (3) to determine whether water quality standards are being attained in segment 2-120, and (4) to evaluate the biological integrity of this reach by inventorying the macroinvertebrate community. Chemical, physical, and biological data collected during this survey are presented and discussed in this report.

Title: Concentrations of Lead, Cadmium, Mercury, and Copper in the Crayfish (*Pacifasticus leniusculus*) Obtained from a Lake Receiving Urban Runoff

Author(s): M. D. Stinson and D. L. Eaton

Publication date: 1983

Published by: Archives of Environmental Contamination and Toxicology, 12:693-700

Number of pages: 8 pp.

Report number(s): (Not applicable)

Available from: Archives of Environmental Contamination and Toxicology
Springer-Verlag New York, Inc.
175 Fifth Avenue
New York, NY 10010

Abstract:

Commercially caught crayfish (*Pacifasticus leniusculus*) were placed in a municipal lake (in Washington State) below a combined sewer overflow outfall and a storm drain outfall associated with elevated sediment metal concentrations. Abdominal muscle, viscera, and exoskeleton from each crayfish were analyzed for mercury, cadmium, lead, and copper. Crayfish metal concentrations for each sampling site were evaluated relative to unexposed samples from the commercial catch and samples held in the laboratory. Results indicated that: (1) mercury accumulated in muscle tissue, highest cadmium concentrations were in the viscera, and highest lead concentrations were in the exoskeleton, (2) uptake of copper is well-regulated by the organism at nontoxic water concentrations, and (3) viscera concentrations of cadmium, lead, and copper tended to be higher and more variable than in muscle tissue. A significant correlation was found between body weight and muscle mercury concentration. Relative to allowable limits for metals in foods, there was not sufficient accumulation of any metal to indicate that a significant health hazard would result from consumption of these organisms. These data indicate that analysis of trace metals in various body parts of *P. leniusculus* may be a useful biological indicator of trace metal pollution of freshwater lakes and streams.

Region 10: WA

Title: Effects of Coal Pile Runoff on Stream Quality and Macro-Invertebrate Communities

Author(s): M. C. Swift

Publication date: September 1982

Published by: Water Resources Research Center, University of Maryland

Number of pages: 50 pp.

Report number(s): Technical Report No. 68

Available from: Water Resources Research Center
University of Maryland
College Park, MD 20742

Abstract:

Samples of coal pile runoff and Georges Creek water and macrobenthos above and below two coal storage areas along Georges Creek, Allegany County, Maryland, were collected during the summer, fall, and winter of 1982 and 1983. Coal pile runoff was collected under high and low flow conditions. Water samples were analyzed for Hg, Zn, As, Fe, Mn, Al, SO_4^{-2}, pH, filterable and nonfilterable residue, conductivity, and acidity.

Leachate from coal piles along Georges Creek contains high concentrations of heavy metals, particularly manganese, aluminum, and zinc. Iron and sulfate are very high and the pH ranges from 1.4 to 3.1. Because of dilution, Georges Creek water has much lower concentrations of metals, iron, and sulfate and a pH of about 7.0.

The distribution of macrobenthos in Georges Creek shows the effects of both runoff from coal storage piles and periodic drought. Brillouin's diversity index values were low even in areas that did not dry up. Densities of tubificid worms and chironomid larvae were very high above the coal storage areas where organic inputs were high. At all the rest of the sampling stations, macroinvertebrate densities were very low.

Where coal pile runoff enters Georges Creek, it compounds the effects of periodic drought and further stresses the aquatic community.

Region 3: MD

Title: Recovery of a Colorado Stream Affected by Acid Mine Drainage
In: Issues and Technology in the Management of Impacted Western Wildlife, Proceedings of a National Symposium, Steamboat Springs, Colorado, November 15-17, 1982, pp. 220-227

Author(s): J. W. Todd, J. Woodling, D. W. Reiser, and G. Andes

Publication date: 1982

Published by: Thorne Ecological Institute

Number of pages: 8 pp.

Report number(s): Technical Publication No. 14

Available from: Thorne Ecological Institute
4860 Riverbend Road
Boulder, CO 80301

Abstract:

The lower segment of Coal Creek, located in Gunnison County, Colorado, and flowing through the town of Crested Butte, Colorado, was biologically dead for approximately 40 years because of acid mine drainage from the Keystone Mine. Mine drainage was highly acidic (pH ≤ 3.6) and contained levels of metals acutely toxic to fish. In May 1981, a wastewater treatment plant using flocculation-coagulation technology was placed in operation at the mine site. A study was undertaken to determine changes in water quality and to monitor benthic invertebrate and fish populations following startup of the plant. Two months after startup, brook trout and brown trout were found in the previously affected segment of Coal Creek. Four months later, aquatic macroinvertebrates had recolonized the previously impacted segment of the creek. Sixteen months after plant startup, macroinvertebrate taxa were typical of clean high mountain streams, and several age classes of brook trout and brown trout were distributed throughout the formerly dead stream segment.

Region 8: CO

Title: A Rapid Change in Methylmercury Tolerance in a Population of Killifish, *Fundulus heteroclitus*, from a Golf Course Pond

Author(s): J. S. Weis and P. Weis

Publication date: 1984

Published by: Marine Environmental Research, 13:231-245

Number of pages: 15 pp.

Report number(s): (Not applicable)

Available from: Elsevier Applied Science Publishers Ltd.
Crown House
Linton Road
Barking Essex IG11 8JU
England

Abstract:

Embryos of killifish (*Fundulus heteroclitus*) from Bullhead Bay, Southampton, New York, showed considerable variation in tolerance to methylmercury (meHg) in 1980, 1981, and 1983, in that some females produced eggs that were tolerant to the teratological effects of 0-05 ppm, while other females produced susceptible eggs. However, in 1982, over 40% of the females produced clutches of nonviable eggs (which could not be tested for meHg tolerance) and those fish that produced viable eggs generally produced tolerant ones. After hatching, the larvae were also more tolerant. Accompanying the shift in meHg tolerance was a trend of increasing fin ray count of the females, a parameter which has previously been correlated with the production of more tolerant embryos. In 1982 a nearby population exhibited a distribution of embryonic and larval tolerance and fin ray count comparable with that of the first population in the other years.

We hypothesize that the unusually high rainfall in June 1982 caused an inflow of pesticides and heavy metals from a golf course adjacent to the first site, and that the contaminants were responsible for the striking changes in reproductive success and meHg tolerance. Residues of chlorinated hydrocarbon insecticides were found in fish of the first, but not of the second, population. The variability in the original population may have permitted a segment of it to withstand the inflow of pollutants, while the susceptible individuals produced nonviable eggs. This may have been the cause of the rapid shift of overall tolerance in the population.

Region 2: NY

Title: DDT Residues in an East Coast Estuary: A Case of Biological Concentration of a Persistent Insecticide

Author(s): G. M. Woodwell, C. F. Wurster, and P. A. Isaacson

Publication date: 1967

Published by: Science, 156:821-824

Number of pages: 4 pp.

Report number(s): (Not applicable)

Available from: American Association for the Advancement of Science
1333 H Street, NW
Washington, DC 20005

Abstract:

DDT residues in the soil of an extensive salt marsh on the south shore of Long Island averaged more than 13 lb/acre (15 kg/ha); the maximum was 32 lb/acre (36 kg/ha). A systematic sampling of various organisms from the vicinity showed concentrations of DDT increasing with trophic level through more than three orders of magnitude from 0.04 ppm in plankton to 75 ppm in a ringbilled gull. Highest concentrations occurred in scavenging and carnivorous fish and birds, although birds had 10 to 100 times more than fish. These concentrations approach those in animals dying from DDT poisoning, which suggests that natural populations in this area are now being affected, possibly limited, many by DDT residues. Similar concentrations have been reported elsewhere in North America.