WATER-QUALITY ASSESSMENT OF THE UPPER SNAKE RIVER BASIN, IDAHO AND WESTERN WYOMING—SUMMARY OF AQUATIC BIOLOGICAL DATA FOR SURFACE WATER THROUGH 1992

By TERRY R. MARET

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Bruce Babbitt, *Secretary*

U.S. GEOLOGICAL SURVEY
Gordon P. Eaton, *Director*

For additional information write to:

District Chief
U.S. Geological Survey
230 Collins Road
Boise, ID 83702-4520

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FOREWORD

The mission of the U.S. Geological Survey (USGS) is to assess the quantity and quality of the earth resources of the Nation and to provide information that will assist resource managers and policymakers at Federal, State, and local levels in making sound decisions. Assessment of water-quality conditions and trends is an important part of this overall mission.

One of the greatest challenges faced by water-resources scientists is acquiring reliable information that will guide the use and protection of the Nation's water resources. That challenge is being addressed by Federal, State, interstate, and local water-resource agencies and by many academic institutions. These organizations are collecting water-quality data for a host of purposes that include: compliance with permits and water-supply standards; development of remediation plans for a specific contamination problem; operational decisions on industrial, wastewater, or water-supply facilities; and research on factors that affect water quality. An additional need for water-quality information is to provide a basis on which regional and national-level policy decisions can be based. Wise decisions must be based on sound information. As a society we need to know whether certain types of water-quality problems are isolated or ubiquitous, whether there are significant differences in conditions among regions, whether the conditions are changing over time, and why these conditions change from place to place and over time. The information can be used to help determine the efficacy of existing water-quality policies and to help analysts determine the need for and likely consequences of new policies.

To address these needs, the Congress appropriated funds in 1986 for the USGS to begin a pilot program in seven project areas to develop and refine the National Water-Quality Assessment (NAWQA) Program. In 1991, the USGS began full implementation of the program. The NAWQA Program builds upon an existing base of water-quality studies of the USGS, as well as those of other Federal, State, and local agencies. The objectives of the NAWQA Program are to:

•Describe current water-quality conditions for a large part of the Nation's freshwater streams, rivers, and aquifers.

•Describe how water quality is changing over time.

•Improve understanding of the primary natural and human factors that affect water-quality conditions.

This information will help support the development and evaluation of management, regulatory, and monitoring decisions by other Federal, State, and local agencies to protect, use, and enhance water resources.

The goals of the NAWQA Program are being achieved through ongoing and proposed investigations of 60 of the Nation's most important river basins and aquifer systems, which are referred to as study units. These study units are distributed throughout the Nation and cover a diversity of hydrogeologic settings. More than two-thirds of the Nation's freshwater use occurs within the 60 study units and more than two-thirds of the people served by public water-supply systems live within their boundaries.

National synthesis of data analysis, based on aggregation of comparable information obtained from the study units, is a major component of the program. This effort focuses on selected water-quality topics using nationally consistent information. Comparative studies will explain differences and similarities in observed water-quality conditions among study areas and will identify changes and trends and their causes. The first topics addressed by the national synthesis are pesticides, nutrients, volatile organic compounds, and aquatic biology. Discussions on these and other water-quality topics will be published in periodic summaries of the quality of the Nation's ground and surface water as the information becomes available.

This report is an element of the comprehensive body of information developed as part of the NAWQA Program. The program depends heavily on the advice, cooperation, and information from many Federal, State, interstate, Tribal, and local agencies and the public. The assistance and suggestions of all are greatly appreciated.

Robert M. Hirsch
Chief Hydrologist

(page v follows)

CONTENTS

FIGURES

TABLES

CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATED WATER-QUALITY UNITS

Multiply	By	To obtain
acre	4,047	square meter
acre-foot (acre-ft)	1,233	cubic meter
acre-foot per year (acre-ft/yr)	1,233	cubic meter per year
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
cubic yard (yd^3)	0.7646	cubic meter
foot (ft)	0.3048	meter
foot per mile (ft/mi)	0.1894	meter per kilometer
inch (in.)	25.4	millimeter
inch per year (in/yr)	2.54	centimeter per year
megawatthour (MWh)	3,600,000,000	joule
mile (mi)	1.609	kilometer
pound (lb)	0.4536	kilogram
square mile (mi^2)	2.590	square kilometer

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

$$°C = 5/9\ (°F - 32)$$

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929—a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

Abbreviated water-quality units used in report:

µg/kg	microgram per kilogram
µg/L	microgram per liter
mg/L	milligram per liter
kg/ha	kilogram per hectare
ppm	parts per million
mm	millimeter
$CaCO_3$	calcium carbonate
µg/g	microgram per gram

Water-Quality Assessment of the Upper Snake River Basin, Idaho and Western Wyoming—Summary of Aquatic Biological Data for Surface Water Through 1992

By Terry R. Maret

Abstract

The 35,800-square-mile upper Snake River Basin in eastern Idaho and western Wyoming was one of 20 areas selected for water-quality study under the National Water-Quality Assessment Program. As part of the initial phase of the study, data were compiled to describe the current (1992) and historical aquatic biological conditions of surface water in the basin. This description of natural and human environmental factors that affect aquatic life provides the framework for evaluating the status and trends of aquatic biological conditions in streams of the basin.

Water resource development and stream alterations, irrigated agriculture, grazing, aquaculture, and species introductions have affected stream biota in the upper Snake River Basin. Cumulative effects of these activities have greatly altered cold-water habitat and aquatic life in the middle Snake River reach (Milner Dam to King Hill). Most of the aquatic Species of Special Concern in the basin, consisting of eight native mollusks and three native fish species, are in this reach of the Snake River. Selected long-term studies, including comprehensive monitoring on Rock Creek, have shown reduced pollutant loadings as a result of implementing best-management practices on cropland; however, aquatic life remains affected by agricultural land use.

Community level biological data are lacking for most of the streams in the basin, especially for large rivers. Aquatic life used to assess water quality of the basin includes primarily macroinvertebrate and fish communities. At least 26 different macroinvertebrate and fish community metrics have been utilized to assess water quality of the basin. Eight species of macroinvertebrates and fish are recognized as Species of Special Concern. The native fish faunas of the basin are composed primarily of cold-water species representing 5 families and 26 species. An additional 13 fish species have been introduced to the basin.

Concentrations of synthetic organic compounds and trace-element contaminants in whole fish collected in the basin during 1970–90 generally did not exceed National Academy of Sciences and National Academy of Engineering concentration guidelines or the 1980–81 geometric mean concentrations from samples collected as part of the U.S. Fish and Wildlife Service National Contaminant Biomonitoring Program. Currently, there are no State fish consumption advisories on any streams in the basin. The organochlorine compounds DDT and PCB's were the most frequently detected fish tissue contaminants. Selected long-term data on DDT, its metabolites, and PCB's indicate decreasing concentrations of these compounds. Arsenic, mercury, and selenium were slightly elevated compared with nationwide baseline concentrations and may indicate bioaccumulation in the food chain. Concentrations of most other trace elements in fish tissue were below levels of concern for the protection of humans and wildlife.

INTRODUCTION

The U.S. Geological Survey (USGS) fully implemented the National Water-Quality Assessment

(NAWQA) Program in 1991. The long-term goals of the program are to describe the status and trends in the quality of a representative part of the Nation's surface- and ground-water resources and to provide a technically sound, scientific understanding of the primary natural and human factors affecting the quality of these resources (Hirsch and others, 1988; Leahy and others, 1990). A nationally consistent, integrated assessment of chemical, physical, and biological data will provide water managers, policymakers, and the public with an improved scientific basis for evaluating effectiveness of water-quality management programs in principal river basins and aquifer systems throughout the Nation.

The biological component of the NAWQA Program consists of ecological surveys that characterize fish, benthic invertebrates, algae communities, and associated riparian and instream habitats. Tissue contaminant studies also are included to assess the occurrence and distribution of environmental contaminants.

The 35,800-mi^2 upper Snake River Basin in eastern Idaho and western Wyoming (fig. 1) was 1 of 20 NAWQA study units selected for assessment under the full-scale implementation plan. As part of the initial phase of the upper Snake River Basin study, data were compiled to describe the current (1992) and historical aquatic biological conditions of surface water in the basin. In addition, qualitative assessments and data summaries were used to describe the primary natural and human environmental factors such as ecoregion, stream size, hydrology, geology, and land use that influence water quality (Gurtz and others, 1992) and affect aquatic life in the basin.

Rationale for Evaluating Aquatic Biological Data

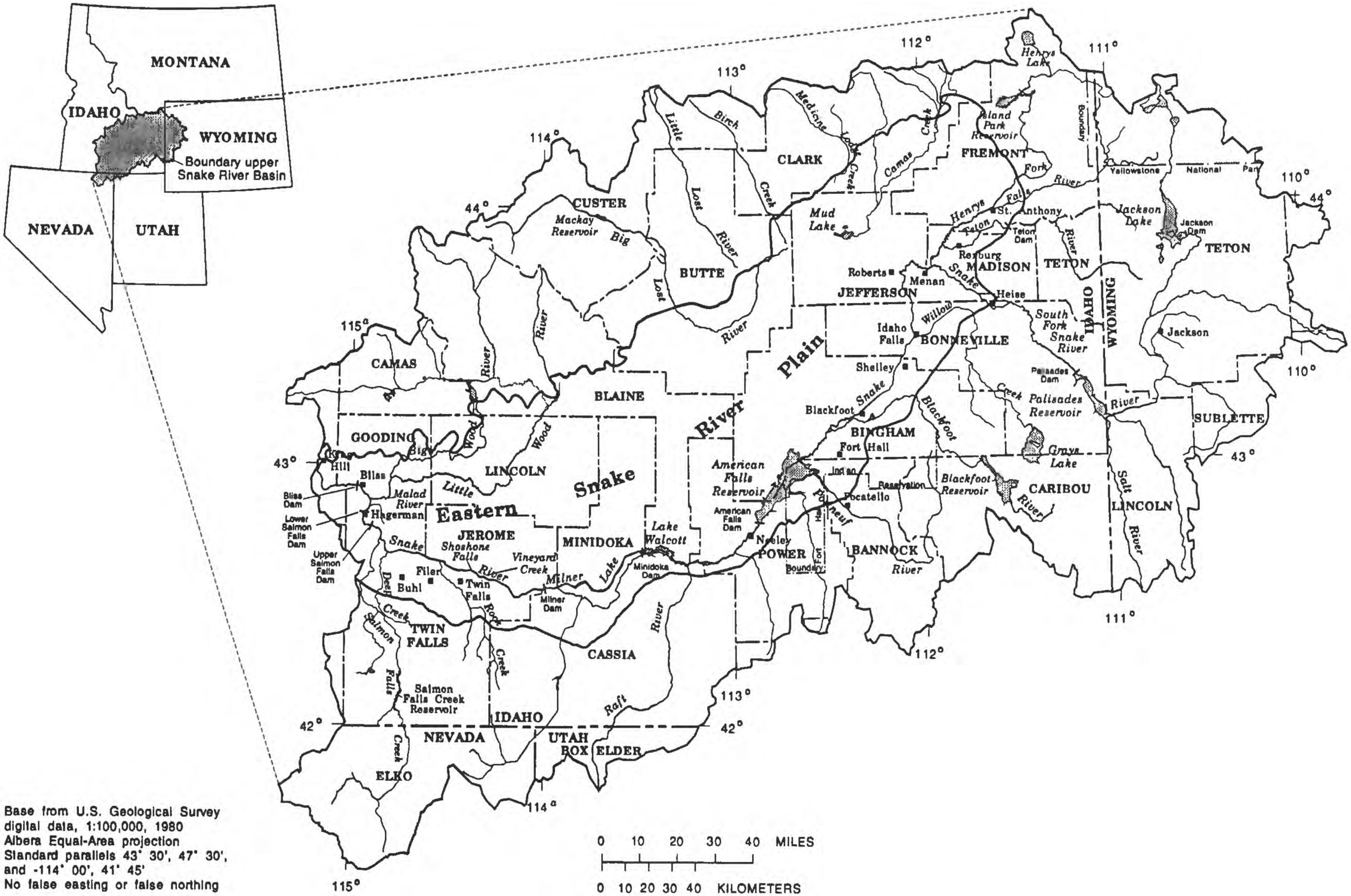
Human activities can alter the physical, chemical, or biological processes of surface water. Such alterations, in turn, can cause changes in the resident aquatic biological communities. Monitoring the health of these communities can complement other physical and chemical water-quality assessment methods and, thus, can provide a more complete evaluation of water-resource conditions. According to Allan and Flecker (1993), protecting or managing ecosystems and associated biological diversity requires development of ways to monitor ecosystem health. Measuring changes in fish, invertebrate, and algae communities can provide an index of water quality and trends that affect beneficial uses of surface-water resources, detect problems that other methods might miss or underestimate, and provide a systematic process for measuring progress of pollution abatement programs (U.S. Environmental Protection Agency, 1990a).

The Clean Water Act of 1972 directed Federal and State agencies to evaluate, restore, and maintain the chemical, physical, and biological integrity of the Nation's water resources. Biological integrity is defined as "the ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition comparable to that of the natural habitats within a region" (Karr and Dudley, 1981).

Development of biological criteria provides a useful tool for assessing stream habitats (Karr, 1991). These criteria are developed on the basis of biological integrity in a stream that has been minimally affected by human activities, or a "reference stream" (Hughes and others, 1986). The Ohio Environmental Protection Agency (1988a) developed biological criteria for fish and aquatic invertebrate communities for various regions and stream types in Ohio on the basis of reference streams. Plafkin and others (1989) published national monitoring protocols for assessing stream degradation on the basis of fish, aquatic macroinvertebrate, and habitat measures. Specific instream biological monitoring protocols have been developed for wadable streams of the Pacific Northwest (Hayslip, 1992). Leonard and Orth (1986) applied and tested an index of biological integrity for fish communities on small, cool-water streams to measure stream degradation.

Because aquatic biological communities integrate the characteristics of their environment, monitoring the biological integrity of these communities can provide an effective approach for evaluating the effects of land uses in a river basin. The Ohio Environmental Protection Agency (1988a) sampled multiple aquatic communities, habitat, and physical and chemical conditions to assess human effects.

Assessment of biological communities also provides data about the occurrence and distribution of contaminants in aquatic systems. Contaminants may be more concentrated in the tissue of an organism than in surrounding water or sediment (U.S. Environmental Protection Agency, 1992). Biomagnification of contaminants in tissue may result in concentrations that are high enough to be of human health or ecological concern. Tissue analyses provide a time-averaged assess-



Base from U.S. Geological Survey digital data, 1:100,000, 1980
Albers Equal-Area projection
Standard parallels 43° 30', 47° 30', and -114° 00', 41° 45'
No false easting or false northing

Figure 1. Location of the upper Snake River Basin.

ment of contaminants, as well as a direct measure of the bioavailability of potential toxicants.

Purpose and Scope

This retrospective report summarizes information on aquatic biology and associated habitats of streams in the upper Snake River Basin. Specifically, the purposes of this report are to:

1. Identify, where possible, the major land use and aquatic habitat features that affect the distribution and abundance of aquatic organisms;

2. Describe the status and trends of biological communities on the basis of current and historical data; and

3. Summarize and evaluate the information that has been collected on organic and inorganic residues in fish tissue.

The summary of aquatic biological data will be used to characterize factors affecting the aquatic conditions in the basin and also will identify future monitoring needs for assessment of land use effects on aquatic life. Only data for fish and macroinvertebrates are summarized because these groups have been the primary focus of past monitoring and assessment programs by State and Federal agencies. Contaminant data are summarized only for fish tissue because little or no data are available on other aquatic biota in the basin.

Sources of Biological Data

Biological data in the upper Snake River Basin have been collected primarily by Federal, State, and academic organizations. Most of the information reviewed in this report is from studies and reports by the Idaho Department of Health and Welfare, Division of Environmental Quality (IDHW); Wyoming Department of Environmental Quality (WDEQ); Idaho Department of Fish and Game (IDFG); Wyoming Game and Fish Department (WGFD); U.S. Fish and Wildlife Service (USFWS); U.S. Forest Service (USFS); Idaho Conservation Data Center (ICDC); Wyoming Natural Diversity Database (WNDD); Idaho State University (ISU); U.S. Environmental Protection Agency (USEPA); and USGS. The ICDC, formerly the Idaho Natural Heritage Program, collects, stores, analyzes, and distributes information on the status and distribution of rare, threatened, and endangered species of Idaho (Moseley and Groves, 1992).

Notable data bases used for this report are the USEPA STORET information on fish tissue and community composition and the IDFG Idaho Rivers Information System (IRIS) information on fish species occurrences. Geographic Information System (GIS) coverages were generated to show spatial occurrence of selected aquatic species.

Previous studies have provided comprehensive, long-term biological evaluations of Snake River tributaries such as Rock Creek (Clark, 1989; Maret, 1990; Yankey and others, 1991) and Cedar Draw Creek (Clark and Litke, 1991). Robinson and Minshall (1991, 1992) at ISU collected data on fish and macroinvertebrate communities and associated habitat for many small reference streams in the Snake River Basin. The current status of the aquatic biological communities on the middle Snake River (Milner Dam to King Hill) was described by Don Chapman Consultants (1992). Idaho Power Company provided fish collection reports for the middle Snake River and its tributaries from 1983 to 1991. Dey and Minshall (1992) summarized all literature on the aquatic biology of the middle Snake River. Baxter and Simon (1970) and Simpson and Wallace (1982) presented information on the ecology and distribution of fish in the basin. Behnke (1992) also provided useful insights on the taxonomy and current status of native trout species in the basin.

Because of the diversity of data reviewed, consolidation of the data for summary or comparison was difficult. Due to the lack of documentation on quality assurance and methods, the data were screened only for obvious errors and assessed qualitatively. Because the occurrences of aquatic taxa are more valuable than any single interpretation, the data presented summarize the distribution of various important communities in the basin.

Acknowledgments

Appreciation is extended to Stan Allen and John Heimer, IDFG, Boise, for providing fishery information. Inez Hopkins was very helpful in locating IDFG aquatic studies. George Stephens, ICDC, Boise, and Robin Jones of the WNDD, Laramie, provided valuable information on aquatic Species of Special Concern. John Kiefling, WGFD, Jackson, provided information on fishery studies in western Wyoming. Jack

Griffith, G. Wayne Minshall, and Christopher Robinson, ISU, Pocatello, provided research reports on streams of the basin. Doug Taki, Shoshone-Bannock Tribes, Fort Hall, shared information on reservation studies. Tim Litke, IDHW, Twin Falls, provided useful insight and agency reports on water-quality assessment studies. Christopher Randolph, Idaho Power Company, Boise, provided data on fish collected from the middle Snake River.

ENVIRONMENTAL SETTING

The Snake River extends about 450 river miles through the upper Snake River Basin from its headwaters near the southern boundary of Yellowstone National Park in northwestern Wyoming to King Hill in south-central Idaho (fig. 1). Twenty-four major subbasins are tributary to the Snake River (U.S. Geological Survey, 1974). Streamflow from six of the northern tributaries evaporates or seeps into the ground-water system before reaching the Snake River. Prominent geomorphic features of the study area include the relatively flat eastern Snake River Plain and the deeply incised Snake River canyon between Milner Dam and Hagerman. Large quantities of ground water discharging as springs from the north canyon walls create numerous cold-water habitats. Water in the basin is high in alkalinity (greater than 150 mg/L as $CaCO_3$), contains large concentrations of various ions, and generally is productive for aquatic life (Thurow and others, 1988).

On the basis of 1:100,000-scale digital line graphs, the basin contains 8,461 mi of streams—6,674 (about 79 percent) in Idaho and 1,787 (about 21 percent) in Wyoming (M.A. Maupin, U.S. Geological Survey, oral commun., 1993). The Utah and Nevada parts of the basin contain less than 1 percent of the total stream miles. Most streams in the basin have cold-water aquatic life as a designated use and are suitable for protection and maintenance of viable communities of aquatic organisms whose optimal growing temperature is below 18°C (Idaho Department of Health and Welfare, 1990).

Flow in the Snake River is highly regulated by dams and diversions, primarily for agricultural use and hydroelectric-power generation. On the main stem of the Snake River, five reservoirs have a combined storage capacity of more than 4 million acre-ft (fig. 1). The largest of these reservoirs, American Falls, has a storage capacity of 1.7 million acre-ft (Kjelstrom, 1992). Numerous smaller reservoirs exist on Snake River tributaries. Streamflow in most major tributaries to the Snake River upstream from Milner Dam is altered by one or more storage reservoirs. Eleven hydroelectric-power facilities in the study unit have a combined generating capacity of 487 MWh (W.H. Low, U.S. Geological Survey, written commun., 1992).

At Milner Dam on the Snake River, nearly all streamflow is diverted for irrigation (Kjelstrom, 1992). Kjelstrom (1986) estimated the mean annual flow of water in the Snake River near King Hill was about 7.6 million acre-ft from 1934 to 1980. During this same period, the mean annual flow at King Hill would have been an additional 4 million acre-ft without irrigation development.

Altitude ranges from about 2,500 ft above sea level at King Hill to 13,770 ft in the mountains of Wyoming. Areas north and northwest of the eastern Snake River Plain are characterized by high mountains and deep intermontane valleys composed of volcanic and sedimentary rocks. The area south of the Snake River in Idaho is characterized by wide valleys about 4,500 ft in altitude and steep, block-faulted mountains more than 9,000 ft in altitude. The predominant feature in the interior of the basin is the eastern Snake River Plain, characterized by large areas of basalt, commonly with little or no vegetation.

Climate on the eastern Snake River Plain and in the valleys is semiarid, and annual precipitation is typically about 10 in. Climate in the mountains is semihumid, and annual precipitation is usually more than 15 in. Snowmelt and runoff from April through July represent the main source of surface water and ground water in the study area. Streamflow generally decreases throughout the summer and winter. January and July are typically the coldest and warmest months, respectively. The average growing season ranges from 120 to 160 days.

Land use in the study area (fig. 2) is about 50 percent rangeland; 23 percent is forest land; 21 percent is agricultural land; and 6 percent is barren basalt, urban areas, water bodies, and wetlands (Maupin, 1995). Most of the irrigated agriculture in the basin is near the Snake River and mouths of tributary drainage basins. Located along the Snake River between Twin Falls and Hagerman are the Nation's largest commercial trout farms, which produce more than 80 percent of the Nation's supply (Brockway and Robinson, 1992). Thir-

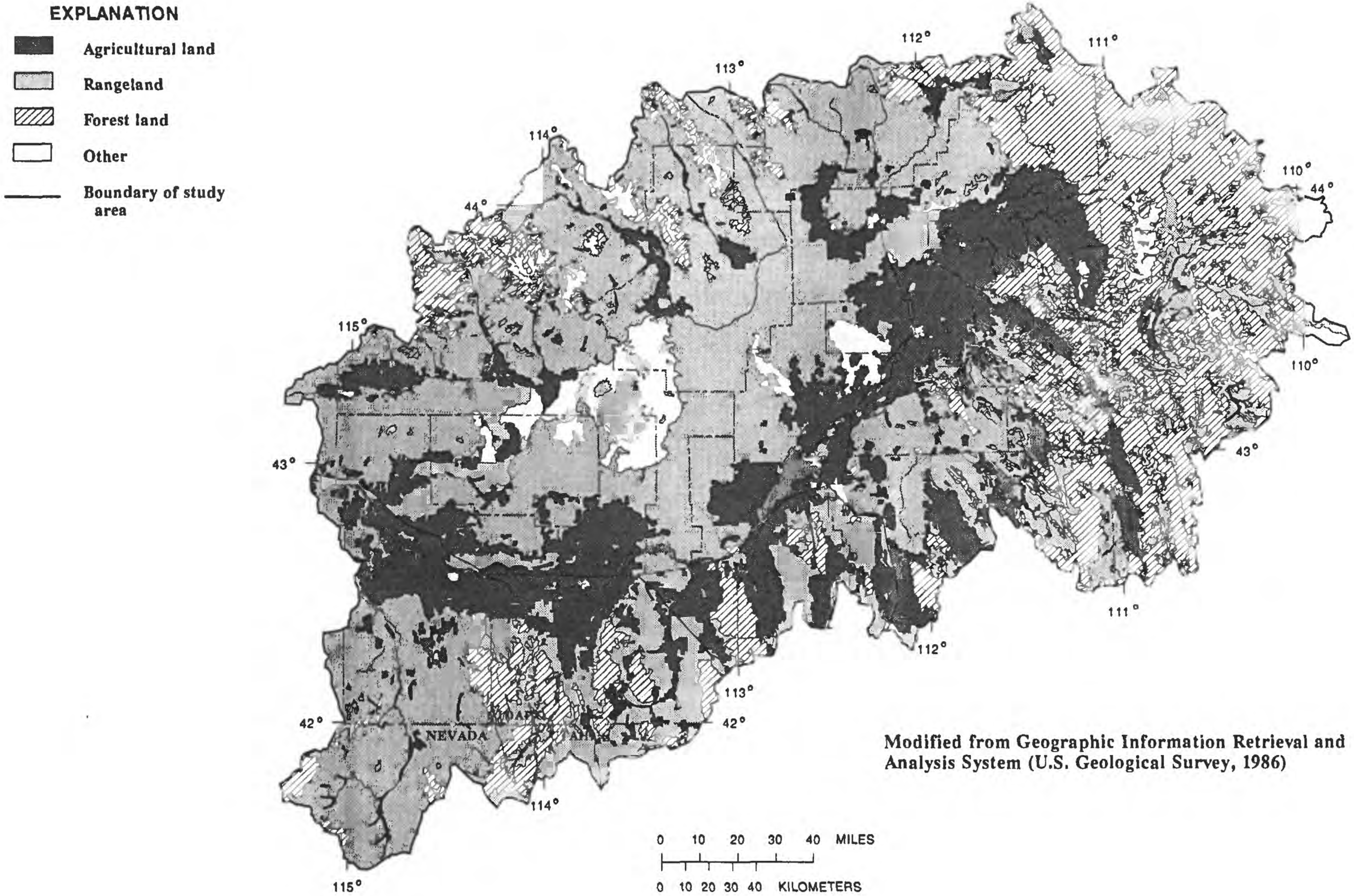


Figure 2. Major land uses in the upper Snake River Basin.

teen municipal, 3 industrial, and 12 aquacultural facilities are permitted under the National Pollutant Discharge Elimination System (NPDES) to discharge into the Snake River and its tributaries (Maupin, 1995). The population of the study area was 435,939 in 1990 (Idaho Department of Commerce, 1992). The largest urban areas are Idaho Falls, Pocatello, and Twin Falls.

Shoshone Falls near Twin Falls on the Snake River has greatly influenced the distribution of fish in the basin. This natural barrier has prevented any fish species from extending its range upstream (Simpson and Wallace, 1982). Shoshone Falls is the farthest extent in the Snake River of anadromous salmon and steelhead migrations from the Pacific Ocean.

Ecoregions

Ecoregions often can be more useful for assessing the health of aquatic systems than hydrologic units, drainage basins, or political boundaries (Omernik and Griffith, 1991). Ecoregions are areas of similar land use, potential vegetation, soils, and land surface forms and have been identified in the Pacific Northwest States (Omernik and Gallant, 1986). Ecoregions can be used to organize water resource information on the basis of regional patterns of ecosystem quality. Hughes and Larsen (1988) reported that statewide studies have shown relations between biological and environmental variables and ecoregion patterns. These studies demonstrated use of ecoregions in stratifying spatial water-quality data to describe ecosystem potential and expected biological communities. In addition, biological data collected from minimally affected reference sites in ecoregions can provide attainable goals and help develop criteria for protection of stream biota (U.S. Environmental Protection Agency, 1990a). Whittier and others (1988) statistically summarized physical habitat, water quality, and fish, macroinvertebrate, and periphyton data in Oregon and identified similarities in streams within ecoregions.

Because of differences in environmental conditions, the structure and function of biological conditions vary in geographic regions and stream-specific habitats. Recognition of this spatial diversity allows for larger homogeneous areas to be examined by stratifying ecological factors.

Six ecoregions in the upper Snake River Basin were identified by Omernik and Gallant (1986). The Snake River Basin/High Desert, Middle Rockies, Northern Basin and Range, and Northern Rockies ecoregions compose the greatest percentage of surface area in the basin (fig. 3). The Snake River Basin/High Desert is the largest and composes half of the basin, the Middle Rockies composes about a quarter of the basin, and the Northern Basin and Range and Northern Rockies compose most of the remainder. The Wyoming Basin and the Montana Valley and Foothill Prairies ecoregions compose less than 1 percent of the basin. The Northern Basin and Range and the Snake River Basin/High Desert ecoregions are characterized by desert shrublands and have similar soil types and land uses (table 1). The Northern Rockies and Middle Rockies ecoregions have similar predominant landforms and land uses but differ primarily in vegetation and soil types. The two most distinct ecoregions, the Snake River Basin/High Desert and Northern Rockies, are discussed in more detail in the following sections.

Robinson and Minshall (1992) characterized the aquatic faunas of small streams in the Snake River Basin and Northern Basin and Range ecoregions in Idaho (fig. 3). Contrary to previous ecoregion investigations, they found that the macroinvertebrate and fish communities were similar in these two ecoregions. They also identified specific community attributes, or "metrics" that can be used to evaluate stream conditions. In addition, community metrics can be developed for ecoregions using minimally affected reference sites (Hughes and others, 1986). Several streams in Idaho have been identified (Rabe and Savage, 1977) as candidates for aquatic research. These streams were selected on the basis of agency interviews and inventories and could serve as indicators, or "benchmarks," of least-affected aquatic ecosystems.

SNAKE RIVER BASIN/HIGH DESERT

The Snake River Basin/High Desert ecoregion consists of basin and range topography and smooth to deeply dissected lava plains. Altitudes range from 2,500 to 5,000 ft. Average annual precipitation is between 8 and 12 in. on the plains and 25 in. on the mountain slopes. The area is drained primarily by intermittent and ephemeral streams. Most of the perennial streams in this ecoregion are large rivers that originate in adjacent, more humid areas. Sagebrush steppe and wheatgrass are the predominant vegetation. Dense stands of sedges and forbs line the riparian zones along

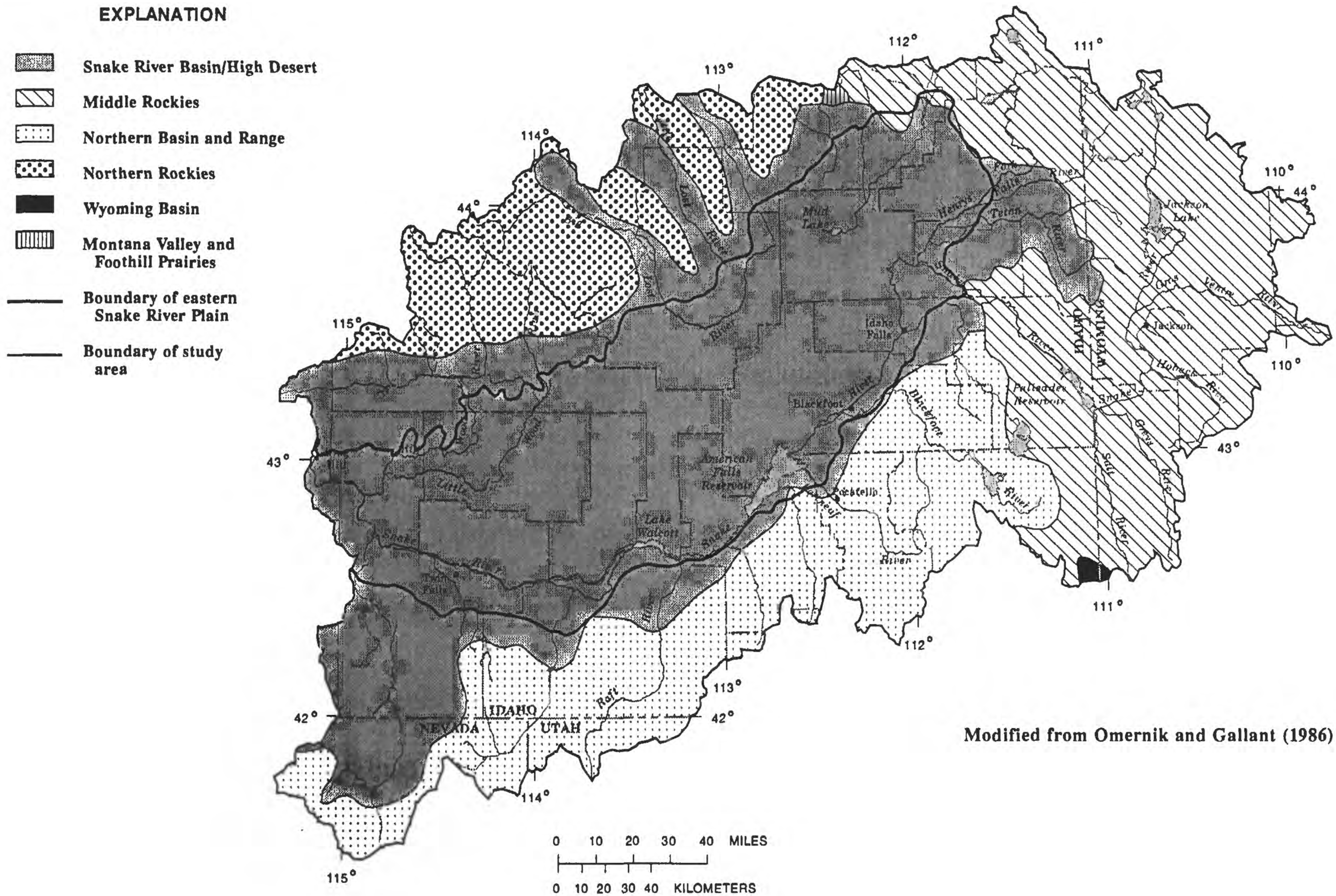


Figure 3. Ecoregions in the upper Snake River Basin.

perennial streams. Woody vegetation consists of alder, willows, cottonwoods, rose, and mock orange. Soils are predominantly Aridisols and aridic Mollisols. Most of the ecoregion is used for rangeland grazing; some areas in basins or that border large streams are irrigated for pasture and production of potatoes, corn, alfalfa, sugar beets, and small grains. Where access by livestock is concentrated, loss or reduction of streamside vegetation can be severe, causing streambank erosion and sedimentation. Water withdrawals for irrigation from canals that interconnect with large rivers often result in dry channels downstream from diversions.

NORTHERN ROCKIES

The Northern Rockies ecoregion includes part of the Rocky Mountains. Altitudes range from 6,000 to 12,000 ft. Because of differences in altitude and exposure, average annual precipitation ranges from 20 in. to greater than 60 in. Perennial streams are common. Coniferous stands of western white pine, lodgepole pine, western red cedar, western hemlock, western larch, Douglas-fir, subalpine fir, Engelmann spruce, and ponderosa pine are the predominant forest and woodland vegetation. Prairie vegetation consists of wheatgrass, fescue, and needlegrass. Mountain soils are derived from acidic rock types under a frigid or cryic soil temperature regime. Dominant soil types are eastern interior mountain soils such as Inceptisols. Logging supports the major economy, but wildlife habitat, recreation, and mining are also important land uses. Logging and related road construction contribute to hillslope and streambank erosion, resulting in large, woody debris in stream channels and increased stream sedimentation. Significant stream disturbance results from placer, shaft, and open-pit metal mining. Mine

Table 1. Characteristics of ecoregions in the upper Snake River Basin

[Modified from Omernik and Gallant (1986); —, no appropriate pattern was discernible from the component map for this characteristic; <, less than]

Ecoregion	Percentage of surface area	Land surface form	Potential natural vegetation	Land use	Soils
Snake River Basin/ High Desert	50	Tablelands with moderate to high relief; plains with hills or low mountains.	Sagebrush steppe (sagebrush, wheatgrass, saltbush, and greasewood).	Desert shrubland grazed; some irrigated agriculture.	Aridisols, aridic Mollisols.
Middle Rockies	23	High mountains.	Douglas-fir, western spruce and fir, alpine meadows (bentgrass, sedge, fescue, and bluegrass).	Grazed and ungrazed forest and woodland.	Alfisols.
Northern Basin and Range	18	Plains with low to high mountains; open high mountains.	Great Basin sagebrush, saltbush, and greasewood.	Desert shrubland grazed.	Aridisols.
Northern Rockies	9	High mountains.	Cedar, hemlock, pine, western spruce, fir, grand fir, and Douglas-fir.	Forest and woodland mostly ungrazed.	Eastern interior mountain soils with acidic rock types; Inceptisols.
Wyoming Basin	<1	Plains with hills or low mountains.	Sagebrush steppe (sagebrush, wheatgrass, and needlegrass). Shrub steppe (saltbush, greasewood, juniper and pinyon woodland).	Desert shrubland grazed; some irrigated agriculture.	Argids, Orthents.
Montana Valley and Foothill Prairies	<1	—	Foothill prairies (wheatgrass, fescue, and needlegrass).	Subhumid grassland and semiarid grazing land; some irrigated land.	Dark-colored soils of semiarid regions.

tailings in or near drainages and mining activities that disturb or remove stream substrate alter the physical and chemical nature of streams and affect habitat quality and quantity of aquatic life.

Large River Habitat

The main-stem Snake River, including the South Fork and Henrys Fork, is the predominant hydrologic feature in the basin. This large river habitat integrates the land uses and ecoregions throughout the basin. The river upstream from Jackson Dam is classified as Class I (high quality) (Wyoming Department of Environmental Quality, 1988). The Snake River between Jackson Dam and Jackson, Wyo., supports cold-water biota but is affected by siltation, dam construction, stream channelization, and streamflow regulation (Wyoming Department of Environmental Quality, 1988). Five main-stem reservoirs built for irrigation water storage and hydroelectric-power generation affect aquatic habitat along the main-stem Snake River.

The South Fork Snake River below Palisades Reservoir is a unique riparian ecosystem because it contains one of the largest continuous cottonwood stands in the State (Idaho Department of Health and Welfare, 1991). This river reach is also a popular recreation area and fishery for cutthroat, *Oncorhynchus clarki*, and brown trout, *Salmo trutta* (Griswold, 1991). The Henrys Fork, regarded as one of the best large-river trout fisheries in the country, enters the Snake River near Idaho Falls.

Water-quality conditions from Palisades Dam to Heise and from Heise to the confluence of the Henrys Fork are rated good (Idaho Department of Health and Welfare, 1989). Tributaries to the Henrys Fork only partially support cold-water biota and salmonid (trout) spawning. Water-quality conditions downstream from the confluence of the Henrys Fork to King Hill are rated fair. Aquatic biota are affected by sediment, organic enrichment, bacteria, nutrients, pesticides, and water temperature increases. Water quality in many tributaries to this reach of the Snake River is rated fair or poor. Beneficial uses in the middle Snake River are either "not supporting" or "potentially at risk" because of the cumulative effects of point and nonpoint sources of pollution. Irrigated agriculture, fish farming, grazing, feedlots, and streamflow regulations affect water-quality conditions in these reaches.

Excessive plant growth in the middle Snake River has become a predominant feature of the aquatic habitat. Extreme dissolved-oxygen (DO) fluctuations (1.0 – 12.0 mg/L) have been measured (Hill, 1992b). Eutrophic conditions attributed to nutrient and sediment inputs and low streamflow caused by drought during the last 5 years have increased the macrophyte and algae growth. Much of this reach of the Snake River now has reduced habitat for fish and invertebrates; many of the deep pools and depositional areas are anoxic because of stratification and oxygen demand from excessive plant decay.

Few researchers have developed protocols to collect data on biological communities in large rivers. The Ohio Environmental Protection Agency (1988a, 1988b, 1989) derived specific biological criteria for large rivers on the basis of characteristic aquatic faunal habitats. Bain (1992) attributed the lack of studies on large rivers to difficulties in sampling deep-flowing waters, large diversity in communities, temporal variability of environmental conditions, and the large scale of physical and biological interrelations. Hughes and Gammon (1987) sampled fish communities on the main-stem Willamette River in Oregon to evaluate changes in water quality and biotic integrity. They found that fish species patterns corresponded better with major physical habitat types of this river than with stream order.

Habitat Variables

In the Pacific Northwest, fishery biologists have focused on research and management activities that affect the habitat of salmonid species because of their sportfishery quality. Most aquatic habitat studies in the upper Snake River Basin have been conducted on salmonid fisheries. Marcus and others (1990) completed a comprehensive review and bibliography of salmonid-habitat relations for the Western United States. Because of the regional and site-specific applications of habitat assessments conducted by various government agencies, standardized methods and protocols are lacking. Standard habitat assessment procedures are needed to better identify problems, develop standards and criteria for stream protection, and help prioritize management efforts among agencies.

Frissell and others (1986) concluded that the structure and dynamics of stream habitat and associated biota are determined by the surrounding watershed and stream size. Hynes (1970) showed that stream communities are largely dependent on the quality and quantity of chemical and physical properties of the stream environment. For example, water-quality characteristics such as pH, water temperature, turbidity, DO, and nutrient concentrations determine the abundance and diversity of aquatic life. A conceptual view of habitat and water-quality variables is necessary to interpret biological patterns. Vannote and others (1980) discussed the river continuum concept and how the gradient of physical factors formed by a watershed drainage network can change the community structure and function along the length of a river. Kuehne (1962) and Sheldon (1968) described how fish distribution patterns and diversity can vary by stream size. Fausch and others (1984) used stream size to calibrate scoring criteria for an index of biotic integrity for fish species.

Measuring factors that affect aquatic life is essential for instream and riparian habitat monitoring. Protocols specific to measuring stream habitat variables in Idaho have been developed. These protocols include monitoring intragravel DO and amount of fine sediment as they relate to salmonid embryo survival (Burton and others, 1990); cobble embeddedness (Burton and Harvey, 1990); thalweg profile, pool and riffle quality, and residual pool index (Burton, 1991); and evaluation of stream riparian vegetation on Idaho rangeland (Cowley, 1992). The Oregon Department of Environmental Quality developed protocols for monitoring nonpoint source pollution using macroinvertebrates and their habitat (Mike Mulvey and others, Oregon Department of Environmental Quality, written commun., 1992). W.H. Clark and T.R. Maret (Idaho Department of Health and Welfare, written commun., 1991) and K.W. King (Wyoming Department of Environmental Quality, written commun., 1993) described regionally specific rapid bioassessment protocols used by these agencies to assess habitat quality and associated macroinvertebrate communities in streams. Peterson (1992) developed a riparian, channel, and environmental inventory using 16 physical and biological conditions as an evaluation tool for small streams affected by agricultural land use.

Armour and Platts (1983) and Platts and others (1983; 1987) described protocols developed by the USFS for assessing cold-water streams in the Pacific Northwest. Hamilton and Bergersen (1984) developed methods to estimate aquatic habitat variables to determine habitat suitability index models used by the USFWS. Hankin and Reeves (1988) used a basinwide approach for monitoring habitat structure and diversity as they relate to fish abundance. Binns and Eiserman (1979) developed a habitat quality index for cold-water streams to estimate biomass of trout. Habitat variables used to calculate the index included late summer flow, annual streamflow variation, water velocity, maximum temperature, nitrate-nitrogen concentration, canopy cover, eroding banks, stream substrate type, and stream width. The USEPA developed qualitative habitat assessment methods as part of their rapid bioassessment protocols (Plafkin and others, 1989). Maret and Jensen (1991) identified stream attributes necessary for determining beneficial use designation according to Idaho's water-quality standards. MacDonald and others (1991) developed an extensive guide for evaluating effects of forestry activities on streams in the Pacific Northwest and Alaska.

Stream classification based on river morphological characteristics is helpful in predicting stream behavior, extrapolating data from one stream to another of similar character, and providing a consistent and reproducible frame of reference. Rosgen (1989) developed a classification system for streams in the Western United States using gradient, sinuosity, width/depth ratio, channel material, entrenchment, and soil/landform features. Frissell and others (1986) used stream classification to establish monitoring sites for assessment of basinwide, cumulative effects of human activities on streams and biota.

Burton and others (1991) concluded that the two major stream types in Idaho are stream and riparian systems dominated by forest overstory (forest mountain streams) and systems dominated by grass and shrub riparian vegetation (rangeland streams). Forest mountain streams are primarily in mountain settings and generally have gradients of more than 1.5 percent. Rangeland streams are in the intermontane valleys, mountain meadows, and plains, and generally have gradients of less than 1.5 percent. Robinson and Minshall (1991) identified three distinct stream types including spring brook, upland (high gradient), and lowland (low gradient) reference streams in the Snake River Basin/High Desert ecoregion.

Kozel and Hubert (1989) determined that salmonid production in forest mountain streams is limited primarily by habitat structure. Physical habitat diversity is vital to fish abundance. For example, resting areas in steep-gradient streams are lacking. Other physical habitat variables that affect fish abundance include canopy cover, pool quantity and quality, runs and glides, and amount of woody debris and fine sediment. Wilzbach (1989) found that canopy closure also can restrict light penetration and thus inhibit primary production.

Chapman (1988) summarized the effects of nonpoint source sediment on salmonid production in Western United States streams. He concluded that salmonid survival to emergence tends to decrease as the amount of fine sediment increases in the incubation environment. Maret and others (1993) described field monitoring techniques for assessing fine sediment and intragravel DO in salmonid spawning habitat in Rock Creek near Twin Falls. The intragravel environment and associated DO required for developing trout embryos were determined to be important factors influencing trout abundance.

Light and resting areas for fish generally are not lacking in riparian rangeland streams; however, streams can become thermally limited to aquatic biota because elimination of riparian vegetation can amplify summer water temperatures (Beschta and others, 1987). Platts and Nelson (1989) showed that increased water temperatures result in a reduction of cold-water fish populations. Platts (1990) studied riparian areas in the arid Western United States and identified habitat variables for assessing the effects of livestock grazing on aquatic biota. Chaney and others (1991) also studied the effects of livestock grazing on riparian areas and stream habitats in the Western United States. They concluded that proper grazing strategies can restore designated beneficial uses of streams and that monitoring instream conditions and riparian areas is essential to the success of management objectives.

LAND USE AND WATER-QUALITY ISSUES

Designated beneficial uses of streams are agriculture, industry, public water supply, recreation, and propagation of fish and wildlife. Water-quality criteria have been developed to protect these beneficial uses from impairment. Surface water is impaired when a pollutant affects a beneficial use so that the use is no longer fully supported (Idaho Department of Health and Welfare, 1989). Most of the streams in the basin have stringent criteria for cold-water biota and salmonid spawning designated uses (Wyoming Department of Environmental Quality, 1988; Idaho Department of Health and Welfare, 1989). Biological monitoring programs have been developed to assess land use effects on streams and characterize impairment of these designated uses. Clark (1990) identified parameters for monitoring beneficial uses of Idaho streams.

The WDEQ (1988) water-quality assessment report lists cold-water fisheries as the only beneficial use that is impaired in the Wyoming part of the basin. This impairment was attributed primarily to increased sediment and habitat alterations. Primary causes of nonpoint source pollution problems in higher altitude areas is sediment due to road construction and recreational vehicles. At lower altitudes, irrigated agriculture, riparian grazing, and road construction affect water quality. Levee construction on the Snake River near Jackson has contributed significantly to channel alterations and sedimentation.

The WDEQ (1992) water-quality assessment report designated beneficial uses for 1,692 river miles. Of this total, 302 miles, or 18 percent, were assessed for use support in the Wyoming part of the basin. About 13 miles, or 4 percent, of these assessed stream segments did not support all designated uses, and about 233 miles, or 77 percent, were classified as partially supporting or threatened for at least one beneficial use. Cold-water fishery was the predominant beneficial use affected. The major types of physical and chemical alterations listed and river miles affected included habitat modification (50 miles), increased sediment (42 miles), and elevated concentrations of trace elements (13 miles). Primary causes of impairment were hydrologic modification, mining, logging, grazing, and land development.

IDHW (1989) reported impairment of one or more beneficial uses in 37 percent of about 5,732 miles assessed in the basin. Beneficial uses affected were cold-water biota, salmonid spawning, and water-contact recreation. Agricultural activities, hydrologic modifications, logging, road construction, and mining were listed as the major nonpoint sources affecting the beneficial uses of the assessed areas. About 31 percent of the river miles did not fully support all designated uses due to hydrologic and habitat modifications. Only about 4 percent of the river miles were impaired by point sources of pollution. Pollutants of concern were nutrients, sediment, bacteria, and organic wastes.

Water quality of the Snake River upstream from Henrys Fork is rated good, but water quality downstream from Henrys Fork to Milner Dam is rated fair (Idaho Department of Health and Welfare, 1989). Three tributaries to the Snake River—Rock Creek, Salmon Falls Creek, and Malad River—are rated fair or poor (Idaho Department of Health and Welfare, 1989). Water quality of the middle Snake River is affected by irrigation drainage, fish-farm effluent, municipal effluent, hydrologic modification, and dams (Brockway and Robinson, 1992). Sediment, organic waste, bacteria, nutrients, pesticides, and increased water temperature were the major pollutants identified. The middle Snake River is listed as "water-quality limited" because nuisance weed growth exceeds water-quality criteria (Idaho Department of Health and Welfare, written commun., 1991). The dominant aquatic plant species in this reach are the macrophytes *Ceratophyllum* sp., *Potamogeton* sp., *Elodea* sp., and filamentous algae *Cladophora* sp. (Hill, 1992b; MacMillan, 1992).

Water Resource Development and Stream Alterations

Water transfer from one river basin to irrigate crops in another basin is common practice. Ecological consequences of interbasin transfer of water include changes in streamflow, introduction of exotic species, alteration of habitat, and changes in water quality (Meador, 1992). Construction of dams, diversions, reservoirs, and canals, and diversions of large volumes of surface water for irrigation have changed the flow characteristics of the Snake River and many of its tributaries. In 1980, about 8.8 million acre-ft of water was diverted from the Snake River and its tributaries by canals and pumps in the upper Snake River Basin (Goodell, 1988). Irrigation projects have resulted in about 5,700 mi of canals and about 1,300 mi of drains in the basin (U.S. Water and Power Resources Service, 1981).

Gilbert and Evermann (1895) reported that chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*Oncorhynchus mykiss*), an anadromous rainbow trout, were found in the Snake River and tributaries as far as Shoshone Falls near Twin Falls. Construction of reservoirs and dams has affected fish distributions in the basin. Since the first hydroelectric dams were constructed on the Snake River in the early 1900's, anadromous fish have been excluded from the upper Snake River Basin. Thurow and others (1988) discussed the effects of dams and reservoirs on the distribution of Yellowstone cutthroat trout (*Oncorhynchus clarki bouveri*) in the basin. These structures have isolated migratory cutthroat trout in the Henrys Fork and Teton, South Fork Snake, Blackfoot, Portneuf, and main-stem Snake Rivers. The Teton Dam failure near St. Anthony in 1976 caused an estimated 40 to 80 percent habitat-related loss of cutthroat trout production in the Teton River and Henrys Fork (Thurow and others, 1988). Surface-water impoundments also affect riverine habitat for species adapted to flowing water but provide new habitat for fish suited to more lentic conditions.

Channel relocation, diking, channel clearance, and riprapping associated with flood control, flood-plain development, and road construction since the 1940's have extensively altered trout habitat in the Wood River (Big Wood and Little Wood) drainage (Thurow, 1987). Irizarry (1969) reported that, once, natural reaches of the Big Wood River supported 10 times more game fish populations than do the present altered reaches. In addition, R.F. Thurow (Idaho Department of Fish and Game, written commun., 1988) reported extensive fish losses as a result of canal diversions and dewatering of the Big Wood River. Similar losses to cutthroat trout fisheries were reported as a result of irrigation diversion in reaches of the Henrys Fork, Teton River, Willow Creek, and Blackfoot, Portneuf, Raft, and main-stem Snake Rivers (Thurow and others, 1988). Irrigation canal failures and subsequent diversions into streams resulted in a 100-year flood in Rock Creek near Twin Falls in 1981 (Sterling, 1983). Failure of a hydroelectric-power facility diversion canal under construction reportedly contributed about 20,000 yd^3 of sediment to the Falls River and Henrys Fork (R.C. Martin, Idaho Department of Fish and Game, oral commun., 1992). The upper Big Lost River Basin (upstream from Mackay Reservoir) is dewatered annually for irrigation and thus has been subjected to long-term stream alteration (Idaho Department of Fish and Game, 1991). The lower 55 mi of the Big Lost River has been modified extensively by irrigation diversions and channelization (U.S. Army Corps of Engineers, 1991).

Irrigated Agriculture

Monitoring by the IDHW, as part of the State Agricultural Pollution Abatement Program, has assessed the effectiveness of best-management practices (BMP's) on water quality. Generally, only physical and chemical data have been collected for these studies. Some biological data have been collected to evaluate the effects of irrigated agriculture on Cedar Draw Creek (Clark and Litke, 1991), Billingsley Creek (Litke, 1986), Vineyard Creek (Litke, 1989), and Rock Creek (Yankey and others, 1991).

The U.S. Department of Agriculture Rural Clean Water Program (RCWP) on Rock Creek near Twin Falls, an assessment of BMP's on irrigated cropland, has identified several agricultural pollutants affecting aquatic life in Rock Creek. The IDHW monitoring studies done between 1981 and 1991 showed that sediment, nutrients, and pesticides have impaired instream aquatic life. Irrigation-return flows and streambank erosion are primary sources of sediment. Streambank erosion contributes more sediment to Rock Creek than irrigation-return flows (Maret, 1990). Grazing and increased streamflows for irrigation are identified as the primary causes of the streambank erosion. Chandler and Maret (1992) reported statistically significant reductions in pollutant loadings and concentrations in lower Rock Creek as a result of BMP's.

Clark (1989) reported fish kills in the Rock Creek Basin near Twin Falls in 1985 and 1987. The suspected cause was an algicide used to control aquatic plant growth in irrigation canals. Litke (1988) reported that chemicals often were used in canals and laterals in the Deep Creek watershed to control plant growth. Mechanical dislodging of plants contributes considerable quantities of organic matter, nutrients, and sediment to downstream waters.

Yankey and others (1991) reported decreases in sediment and nutrient concentrations as a result of BMP's in the Rock Creek Basin; however, the designated salmonid-spawning beneficial use in lower Rock Creek was not supported. They stated that Rock Creek may attain full support status for all instream uses if sediment and nutrient concentrations continue to decrease.

Fishery studies of the Blackfoot, Portneuf, and main-stem Snake Rivers within or adjacent to Fort Hall Indian Reservation (fig. 1) attributed low trout populations to increased water temperatures caused by irrigation-return flows (Crist and Holden, 1986). Instream flow studies (Holden and others, 1987) indicated that further water withdrawals for irrigation on the reservation would contribute to loss of the trout habitat.

Livestock Grazing

The effects of livestock grazing on private and public lands in the basin are widespread. Grazing can affect water quality by increasing sediment loads resulting from removal of riparian and upland vegetation (MacDonald and others, 1991). Degradation of stream habitat by grazing includes channel aggradation and stream widening, resulting in increased summer water temperatures. Platts and Martin (1978) found that reaches of Willow Creek and the Blackfoot River (fig. 1) altered by livestock grazing displayed unstable streambanks and silt substrate. Animal waste also can impair water quality through bacterial contamination and increased nutrient concentrations. Thurow and others (1988) discussed the effects of grazing on cutthroat trout populations in many of the Snake River tributaries. Chaney and others (1991) documented improvements in riparian habitat along the Henrys Fork and tributaries to Henrys Lake as a result of livestock management practices.

Burton and others (1991) outlined the effects of livestock grazing on water column chemistry, streambank erosion, and channel and riparian vegetation. Characteristics used to assess the effects of livestock grazing on each of these categories were water temperature, nutrient concentration, macroinvertebrate indicators, low-flow and bankfull discharge, streambank stability, undercut banks, overhanging bank vegetation, pool quality and quantity, stream substrate embeddedness or percentage of fine sediment, vegetation composition, woody regeneration, forage stubble height, and soil compaction.

Aquaculture

Aquacultural (fish farming) effluent can affect water quality and biota in receiving water. Water discharging from trout and salmon hatcheries increases concentrations of suspended solids, organic nitrogen, ammonia, and total phosphorus, and also increases pH, water temperature, and chemical oxygen demand (Kendra, 1991). Kendra also found that benthic macroinvertebrate communities moderately respond to organically enriched hatchery discharges by replacing sensitive taxa with more tolerant forms. Discharge of other chemicals to treat disease, parasites, and algae also may be harmful to aquatic life in receiving water (Kendra, 1989).

About 140 aquacultural facilities along the Snake River between Twin Falls and Hagerman (fig. 1) are permitted under the NPDES (Maupin, 1995). These permits are issued primarily on the basis of best available treatment technology rather than on instream water-quality conditions (Brockway and Robinson, 1992). The cumulative instream effects of aquacultural effluents and return flows from irrigated agriculture in this reach of the Snake River have been nuisance aquatic weed growth and impaired designated beneficial uses (Idaho Department of Health and Welfare, written commun., 1991). Nutrients (nitrate and phosphorus) and sediment were listed as primary pollutants of concern in this river reach.

Litke (1986) assessed the effects of aquaculture and other land use practices on the water quality of Billingsley Creek, a tributary of the Snake River near Hagerman. He found that water-quality degradation was the most severe downstream from major hatchery facilities where inorganic nitrogen and total phosphorus were elevated and DO concentrations were reduced. The benthic community associated with these conditions was composed primarily of pollution-tolerant midges (Chironomidae) and snails (Gastropoda).

Introduced Species

Aquatic species introduced into streams by anglers, fish hatcheries, or government agencies are relatively common in the Western United States. Altered aquatic habitats are particularly vulnerable to invasion by introduced species (Moyle, 1986). About 25 and 42 percent of the fish species in Wyoming and Idaho, respectively, were introduced (Baxter and Simon, 1970; Simpson and Wallace, 1982). Bowler (1991) and Frest (1992) noted the rapid spread of introduced mollusk fauna as a result of water-quality degradation in the middle Snake River. The New Zealand mud snail (*Potamopyrgus antipodarum*) was introduced in the last decade and has built enormous populations throughout this reach (T.J. Frest and others, Deixis Consultants, written commun., 1992). Introduction of nonnative salmonids has threatened native populations of Yellowstone cutthroat trout in this basin (Thurow and others, 1988). Notable examples are the displacement of the Yellowstone cutthroat with rainbow trout (*Oncorhynchus mykiss*) in the Henrys Fork and Teton, lower Blackfoot, and Portneuf Rivers. Introductions of nonnative salmonids also can lead to hybridization and can threaten preservation of the various subspecies of cutthroat trout (Behnke, 1992). In 1982, the Idaho Power Company (C. Randolph, written commun., 1992) collected *Tilapia* sp., a tropical fish species commercially grown in hatcheries, along the middle Snake River near Buhl. Their data also show that the trout populations are composed primarily of hatchery rather than wild fish. The biological consequences of these introductions are not known; however, interspecific competition with native species and introductions of harmful diseases or pathogens to the aquatic environment are possible (Moyle, 1986).

STATUS AND TRENDS IN AQUATIC LIFE

Most rivers and streams in North America are no longer in a natural or pristine state and, in most cases, loss of natural riverine conditions has led to decreased quality or loss of aquatic habitat (Heede and Rinne, 1990). Increased sediment, nutrients, and organic and inorganic constituents can result in elimination of habitat, reduction of food supplies, or acute or chronic toxicity. Numerous human factors have affected aquatic life in streams of the upper Snake River Basin.

Macroinvertebrate and fish communities have been used most frequently to assess the status and trends of aquatic life in streams in the basin. The sections that follow describe studies in which these groups of organisms have been used to assess stream conditions.

Macroinvertebrates

Macroinvertebrates inhabit most streams and are visible to the unaided eye (retained on a U.S. Standard No. 30 sieve with a 0.595-mm opening) (Klemm and others, 1990). They are a key stream component in processing organic material and in nutrient cycling and are an important food source for fish and other aquatic organisms. These organisms are easy to collect, relatively sessile, and have specific environmental requirements to complete their life cycle. Macroinvertebrate communities are excellent indicators of long-term environmental changes such as siltation (Lenat and others, 1979) and slug-load pollutants of short duration (Prophet and Edwards, 1973). They are also indicators of point and nonpoint source water pollution. Macroinvertebrates integrate the effects of upstream land and water uses in a watershed over the long term (months to years) because most of their life cycle is spent in the water.

A typical stream macroinvertebrate community is composed primarily of insects, annelids, flatworms, turbellarians, crustaceans, and mollusks. In Idaho, healthy streams typically are composed of a diverse macroinvertebrate community. The insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies), collectively called EPT, are usually the most dominant taxa numerically (Andrews and Minshall, 1979). The macroinvertebrate communities throughout the upper Snake River Basin are characteristic of cold-water habitats. Reduction in abundance and diversity of these communities can indicate environmental degradation.

Specific macroinvertebrate taxa are also indicative of various types of substrate and habitats in streams. Taxa indicative of erosional habitats (high velocity and coarse substrate) are riffle beetles (*Psephenus*), caddisflies (Hydropsychidae), blackflies (Simuliidae), and stoneflies (Perlidae). Taxa indicative of depositional habitats (low velocity and fine-grained substrates) are mayflies (*Hexagenia* and *Caenis*), scuds (Amphipoda), and caddisflies (Leptoceridae and Limnephilidae).

Macroinvertebrates in the basin were used to assess primarily the environmental perturbations in specific localities (fig. 4, table 2). These collections are not directly comparable because of differences in collection methods, time of sampling, number of samples, and level of identification. However, the occurrence information serves as a baseline of faunal distribution in the basin. Exceptions to site-specific data are the macroinvertebrate taxa in many small reference streams in the Snake River Basin/High Desert and Northern Basin and Range ecoregions (Robinson and Minshall, 1992). These data provide baseline information on the expected faunas in "least-affected" streams of the largest ecoregions in the basin. The frequency of occurrence, mean number, and total number of the 94 macroinvertebrate taxa collected from the 14 reference streams during the summers of 1990–91 are listed in table 3. Midges (Chironomidae) and aquatic worms (Oligochaeta) were found at most sites. Other taxa most frequently collected were EPT's.

Long-term data are lacking to assess trends in macroinvertebrate community health in the basin. The IDHW 1981–91 Rock Creek monitoring program provided the only long-term data on macroinvertebrates. Replicate data were collected seasonally four times per year at six sites using quantitative methods. The purpose of the program was to evaluate stream improvements resulting from BMP's. Two collection sites (11 and 12, fig. 5) represented background conditions and cumulative land use effects from irrigated agriculture, grazing, aquaculture, and water diversions. EPT taxa collected over a 10-year period at these two sites on Rock Creek were compared (fig. 6) to the EPT ecoregion median (Robinson and Minshall, 1992) for similar reference streams. Site 12, downstream from an area of intensive agricultural land use (about 26 percent of the total land area in the watershed) near the mouth of Rock Creek (fig. 5) had a lower median EPT than the upstream site (11) for August samples when irrigation-return flow effects were greatest. Site 12 had an EPT median of 7 compared with EPT medians of 12 and 16 at site 11 and the ecoregion reference stream, respectively. The low median EPT at site 12 suggests that upstream land use may be affecting macroinvertebrate community health in Rock Creek.

During 1981 to 1988, Maret (1990) noted that from headwaters to lower reaches, the macroinvertebrate community changed from "clean water" organisms that include the caddisflies (*Hesperoperla, Helicopsyche borealis, Wormaldia,* and *Glossosoma montana*), mayfly (*Epeorus*), and stonefly (*Pteronarcys californica*) to facultative taxa including the caddisfly (*Hydropsyche*) and the mayflies (*Tricorythodes minutus* and *Baetis tricaudatus*). Significant reductions in sediment and associated nutrients in lower Rock Creek were noted as a result of BMP's between 1981 and 1990, but the macroinvertebrate communities did not show any notable improvement during this period (Yankey and others, 1991).

More than 40 percent of the macroinvertebrates collected in 1991 from low-gradient riffle habitats in the Snake River from Shoshone Falls downstream to Hagerman were midges (Chironomidae) (Hill, 1992c). Less than 3 percent of the total community were made up of Trichoptera and Plecoptera. In addition, the low number of Plecoptera is indicative of water-quality problems (high nutrients, low DO, and increased sedimentation). Falter and others (1976) earlier reported that Trichoptera were the dominant taxa upstream and downstream from this reach of the Snake River. These qualitative changes in the macroinvertebrate fauna reflect the drought conditions (low streamflows) and degraded water quality.

Numerous other macroinvertebrate studies have been conducted in the upper Snake River Basin including Portneuf River (Minshall and Andrews, 1973); Malad River (S.B. Bauer, Idaho Department of Health and Welfare, written commun., 1980); Blackfoot River

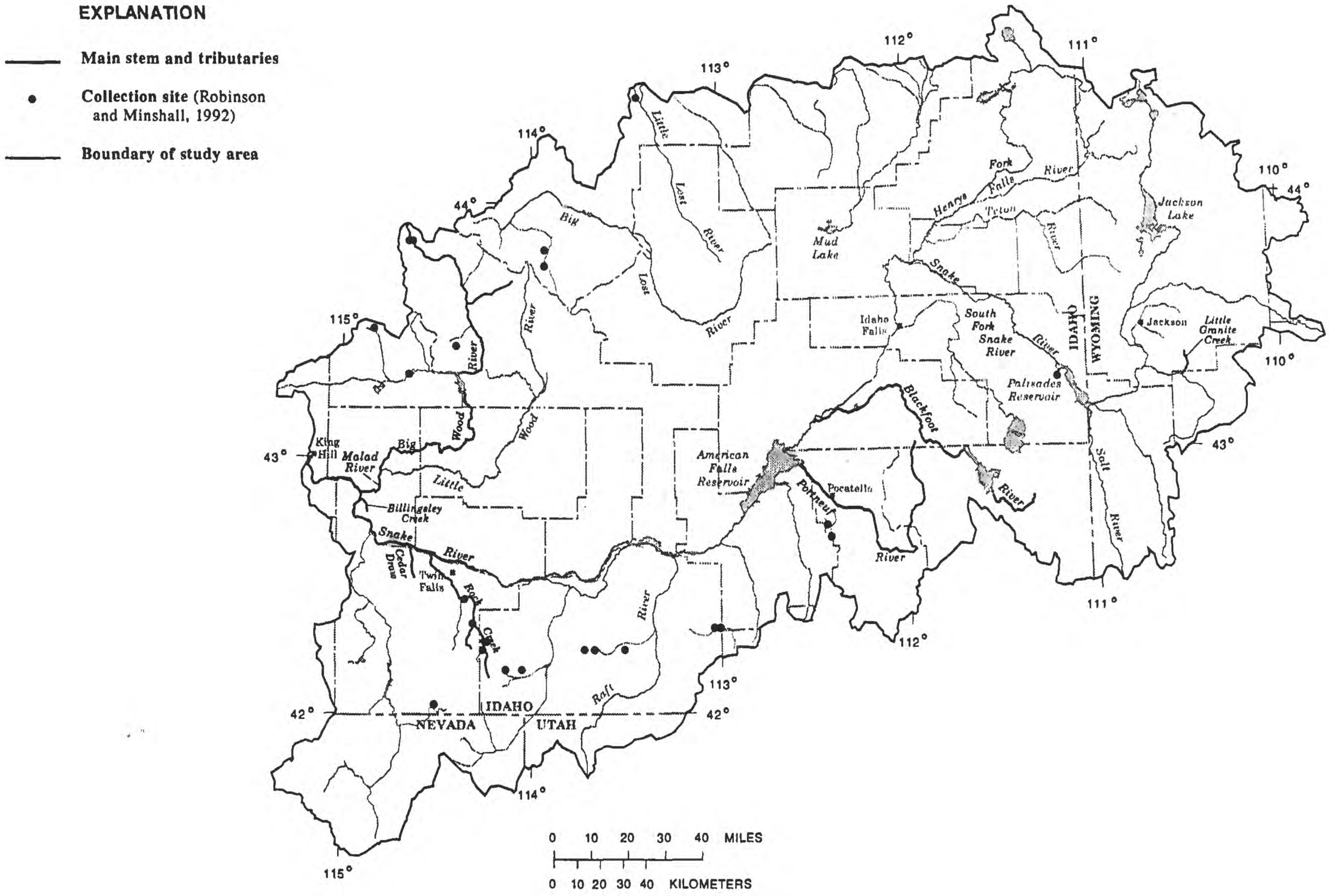


Figure 4. Macroinvertebrate collection sites in the upper Snake River Basin, 1973–92.

Table 2. Macroinvertebrate taxa identified in selected drainages in the upper Snake River Basin, 1973–93

[Sources of information: Minshall and Andrews (1973); Platts and Rountree (1974); S.B. Bauer, Idaho Department of Health and Welfare, written commun. (1980); Platts and Andrews (1980); F.A. Mangum, U.S. Forest Service, written commun. (1984); U.S. Geological Survey (1985); Litke (1986); Maret (1990); U.S. Fish and Wildlife Service (1990); Clark and Litke (1991); Frest (1992); Hill (1992d); Robinson and Minshall (1992); Frest and Johannes (1993a, 1993b); and U.S. Environmental Protection Agency STORET data base. Scientific names were standardized using reports by Pennak (1978) and Merritt and Cummins (1984). LE, federally listed as endangered (C.H. Lobdell, U.S. Fish and Wildlife Service, written commun., 1993); LT, federally listed as threatened (C.H. Lobdell, U.S. Fish and Wildlife Service, writtten commun., 1993); SC, Species of Special Concern (Moseley and Groves, 1992). Locations of collection sites shown in figure 4. Occurrence: 1, Rock Creek; 2, Headwater streams (Robinson and Minshall, 1992); 3, Snake River (downstream from Shoshone Falls to King Hill); 4, Cedar Draw Creek; 5, Billingsley Creek; 6, Malad and Big Wood Rivers; 7, Portneuf River; 8, Blackfoot River; 9, Little Granite Creek]

Taxon (occurrence)
Platyhelminthes
Turbellaria (Flatworms) (1)
Planariidae (2,3,4,5,6,8)
Dugesia sp. (1)
D. dorotocephala (7)
Polycelis coronata (9)
Nematoda (1,2,4,5,7,8)
Nematomorpha (6)
Annelida (Worms)
Hirudinea (1,3,4,5,6,7,8)
Oligochaeta (2,3,6,8)
Lumbriculidae (8)
Naididae (1)
Tubificidae (1,2,4,5,7,8,9)
Arthropoda
Crustacea
Amphipoda (Scuds)
Gammarus sp. (4)
G. lacustris (1,7,8)
Hyalella sp. (3)
H. azteca (1,2,3,4,5,6,7,8)
Decapoda (Crayfish)
Pacifastacus sp. (1,5)
Isopoda (Sow bugs)
Ascellus sp. (5)
Caecidotea communis (1)
Ostracoda (Seed shrimp) (1,4)
Arachnoidea
Hydracarina (Water mites) (1,2,4,6,8)
Lebertia sp. (9)
Mideopsis sp. (9)
Sperchon sp. (9)
Insecta
Coleoptera (Beetles)
Carabidae (2)
Dryopidae
Helichus sp. (1)
Dytiscidae (2)
Haliplus sp. (7,8)
Laccophilus sp. (7)
Oreodytes sp. (6)
Elmidae (6,8)
Cleptelmis sp. (2,8)
Dubiraphia sp. (2,3,7)
Gonielmis sp. (2)
Heterlimnius sp. (2,8)
H. corpulentus (9)
Lara sp. (2)
Microcylloepus sp. (1,6)
Narpus sp. (2,3,9)
Optioservus sp. (1,4,5,8)
O. quadrimaculatus (7,9)
Rhizelmis sp. (2)
Zaitzevia sp. (1,3,6,8)
Haliplidae
Agabus sp. (8)
Brychius sp. (1)
Hydraenidae
Hydraena sp. (8)
Hydrophilidae (6)
Ametor scabrosus (8)
Psephenidae (2)
Psephenus falli (1)
Diptera (True flies)
Ceratopogonidae (2,5,7,8)
Bezzia sp. (1)
Chironomidae (1,2,3,4,5,6,7,8)
Chironomus sp. (3)
Conchapelopia sp. (1)
Cricotopus sp. (9)
Diamesia sp. (9)
Dicrotendipes sp. (3)
Glyptotendipes sp. (3)
Microspectra sp. (9)
Orthocladius sp. (1,9)
Pagastia sp. (9)
Parametriocnemus sp. (9)
Paratanytarsus sp. (9)
Phaenospectra sp. (9)
Polypedilum sp. (1)
Rheotanytarsus sp. (1)
Thienemanniella sp. (9)
Dixidae (8)
Empididae (2,5,8)
Chelifera sp. (1,2,9)
Clinocera sp. (9)
Hemerodromia sp. (1,2,9)
Ephydridae (8)
Pelecorhynchidae
Glutops sp. (2)
Psychodidae
Pericoma sp. (1,8,9)
Ptychopteridae
Ptychoptera sp. (8)
Rhagionidae
Atherix sp. (8)
A. pachypus (9)
A. variegata (2,7,8)
Simuliidae (3,8)
Prosimulium sp. (2)
Simulium sp. (1,2,4,5,6,7,8,9)
S. bivittatum (1)
S. vittatum (1)
Stratiomyidae (2,5,8)
Euparyphus sp. (1)
Odontyomyia sp. (2)
Tipulidae (2,3,6)
Antocha sp. (1,2,8,9)
Dicronota sp. (2,9)
Hesperoconopa sp. (9)
Hexatoma sp. (1,2,8,9)
Limnophila sp. (1,2,8)
Pedicia sp. (8)
Tipula sp. (1,5,7,8)
Ephemeroptera (Mayflies)
Baetidae (1,4)
Baetis sp. (3,6,8)
B. bicaudatus (2,6,9)
Baetidae—Continued
B. insignificans (1)
B. intermedius (2)
B. tricaudatus (1,4,5,6,7,9)
Callibaetis nigritus (7)
Ephemerellidae
Caudatella heterocaudata (2)
C. hystrix (6)
Drunella sp. (1)
D. coloradensis (2,6)
D. doddsi (2,6,9)
D. flaviinea (2)
D. grandis (9)
D. spinifera (2,6)
Ephemerella sp. (2,3,8)
E. aurivilli (2,8)
E. coloradensis (2,8)
E. doddsi (2,7,8)
E. grandis (2,7,8)
E. hecuba (8)
E. inermis (1,2,4,5,7,8)
E. infrequens (2,6,9)
E. margarita (8)
E. tibialis (8)
Serratella tibialis (2,6)
Ephemeridae
Hexagenia sp. (3)
Heptageniidae (1,2,3,5)
Cinygmula sp. (1,2,6,7,8,9)
Epeorus sp. (3)
E. albertae (1,2)
E. deceptious (6)
E. grandis (9)
E. iron (2)
E. longimanus (1,2,6,7,9)
Heptagenia sp. (7,8)
H. elegantula (1)
Nixe criddlei (1)
N. simplicioides (1)
Rhithrogena sp. (2,8)
R. hageni (1,6,9)
R. robusta (9)
Stenonema sp. (2,3,6)
Leptophlebiidae
Leptophlebia sp. (8)
Paraleptophlebia sp. (2,8)
P. bicornuta (1)
P. heteronea (1,7)
Polymitarcyidae (1)
Ephoron album (1,7)
Siphlonuridae
Ameletus sp. (2,8)
A. cooki (2)
A. oregonensis (9)
A. similor (2)
A. sparsatus (6,9)
A. velox (2)
Tricorythidae
Caenis sp. (6)
C. simulans (7)

Table 2. Macroinvertebrate taxa identified in selected drainages in the upper Snake River Basin, 1973–93— Continued

Taxon (Occurrence)
Tricorythidae—Continued
Tricorythodes sp. (2)
T. minutus (1,3,4,5,6,7,8)
Hemiptera (True bugs) (3)
Corixidae (2,6,8)
Cenocorixa bifida (1)
Hesperocorixa sp. (7)
Sigara altenata (1)
Gelastocoridae
Gelastocoris sp. (1)
Gerridae
Gerris sp. (8)
G. remigis (1)
Naucoridae (2)
Lepidoptera (Caterpillars) (7)
Pyralidae
Parargyractis sp. (3)
Petrophila sp. (1,3,4)
Megaloptera
Sialis sp.
Odonata (Dragonflies)
Coenagrionidae
Argia sp. (1,2,7)
Enallagma sp. (1,3,6,7)
Ishnura sp. (1,4,5)
Gomphidae (1,6)
Ophiogomphus sp. (1,2,6,7)
Plecoptera (Stoneflies)
Capniidae (9)
Capnia sp. (1,2,6,8)
Paracapnia sp. (2)
Chloroperlidae (1,2,8,9)
Alloperla sp. (2,6,7,8)
Leuctridae (9)
Paraleuctra sp. (8)
Nemouridae
Amphinemura sp. (2)
Malenka sp. (1)
Nemoura sp. (6,8)
Prostoia besametsa (9)
Zapada sp. (2,8)
Z. cinctipes (2,9)
Z. oregonensis (2,9)
Perlidae (3)
Acroneuria californica (6)
A. pacifica (7)
Beloneuria sp. (2)
Calineuria sp. (2)
Hesperoperla sp. (8)
H. pacifica (1,2,8,9)
Perlodidae (3,9)
Arcynopterx parallela (6,7)
Isogenoides sp. (8)
I. zionensis (9)
Isogenus sp. (1)
I. modestus (6)
Isoperla sp. (1,2,8)
I. fulva (7,9)
I. mormona (7)
Kogotus sp. (9)
Megarcys sp. (9)
M. signata (8)
Setvena bradleyi (2)
Skwala sp. (1)
S. parallela (8)
Yugus sp. (2)
Pteronarcyidae
Pteronarcella badia (1,8,9)
Pteronarcys californica (1,2,6,7,8)
Taeniopterygidae
Taenionema sp. (9)
Trichoptera (Caddisflies)
Brachycentridae
Amiocentrus sp. (2)
A. aspilus (1,4)
Brachycentrus sp. (2,3,4,5,6,7,8)
B. americanus (1,9)
B. occidentalis (1)
Micrasema sp. (1,2,5,9)
Oligoplectrum sp. (1)
Glossosomatidae (1,4)
Culoptila cantha (1)
Glossosoma sp. (2,5,6,8)
G. montana (1)
Protoptila coloma (1)
P. tenebrosa (1)
Helicopsychidae
Helicopsyche sp. (2)
H. borealis (1,4,5,7,8)
Hydropsychidae
Arctopsyche grandis (2,6,7,9)
Cheumatopsyche sp. (3,6,7,8)
C. campyla (1)
C. enonis (1)
C. pettiti (1)
Hydropsyche sp. (2,3,4,5,6,7)
H. californica (1)
H. occidentalis (1)
H. oslari (1)
Parapsyche elis (2,6,9)
Hydroptilidae (8)
Agraylea sp. (1)
Hydroptila sp. (1,3,4,5,8)
H. ajax (1)
H. arctia (1)
H. argosa (1)
Leucotrichia sp. (1,4,5)
Neotrichia sp. (3)
N. halia (1)
Ochrotrichia sp. (1,5)
O. stylata (1)
Lepidostomatidae
Lepidostoma sp. (1,7,8)
L. cinereum (1)
Leptoceridae (3,8)
Ceraclea sp. (7,8)
Mystacides sp. (1)
Nectopsyche sp. (2,4,7)
N. gracilis (1)
N. halia (1)
N. lahontanenses (1)
N. stigmatica (1)
Triaenodes sp. (8)
Limnephilidae (2,6)
Clostoeca sp. (2)
Dicosmoecus atripes (9)
D. gilvipes (1)
Ecclisomyia sp. (8)
Grensia sp. (2)
Hesperophylax sp. (1,8)
Limnephilus sp. (1,7,8)
Moselyana sp. (2)
Neophylax sp. (2)
Oligophlebodes sp. (8)
Limnephilidae—Continued
Onocosmoecus unicolor (1)
Psychoglypha sp. (2)
Philopotamidae
Wormaldia sp. (8)
W. gabriella (1)
Polycentropidae
Polycentropus sp. (1,3,6)
P. amereus (3)
Rhyacophilidae
Rhyacophila sp. (2,5,8)
R. acropedes (1,2,6,9)
R. angelita (2,6,9)
R. coloradensis (1,2,9)
R. hyalinata (2,6)
R. tucula (9)
R. vaccua (2)
R. vagrita (2)
R. vespula (2)
Psychomyiidae
Psychomyia sp. (3)
Tinodes sp. (1)
Uenoidae
Neothremma sp. (2,8)
Mollusca
Gastropoda (Snails) (1)
Amnicola sp. (3,7)
Banbury Springs limpet (LE) (3) (undescribed *Lanx* sp.)
Bliss Rapids snail (LT) (3) (no scientific name)
Ferrissia sp. (3,6,8)
Fisherola nuttalli (SC) (3)
Fluminicola sp. (1,2,4,5,8)
F. columbiana (SC) (3)
F. hindsi (3)
Fontelicella sp. (1,2,4,5)
Fossaria sp. (1,3,4,5)
Gyraulus sp. (1,2,3,5,6,7,8)
Lymnaea sp. (1,4,6,7,8)
Parapholyx sp. (3,5)
Physa sp. (1,2,4,5,6,7,8)
P. natricina (LE) (3)
Physella sp. (3)
Planorbella sp. (3)
Potamopyrgus antipodarum (3)
Pyrgulopsis idahoensis (LE) (3)
Radix sp. (3)
Stagnicola hinkleyi (3)
Valvata humeralis (3)
V. sincera (3)
V. utahensis (LE) (3)
Vorticifex sp. (1)
V. effusa (3)
Pelecypoda (Clams) (3,8)
Anodonta californiensis (SC) (1,3)
Corbicula fluminea (3)
Gonidea sp. (1,3)
Margaritifera sp. (1,3)
Pisidium sp. (1,3,4,5,7,8)
P. nitidum (3)
P. punctatum (3)
Sphaerium sp. (1,4,5,6,7)
S. nitidum (3)

(Platts and Andrews, 1980); Little Granite Creek (U.S. Geological Survey, 1985); Billingsley Creek (Litke, 1986); and Cedar Draw Creek (Clark and Litke, 1991). Studies by Frest (1992), Hill (1992b), and Frest and Johannes (1993a and 1993b) provided macroinvertebrate data for the main-stem Snake River. Langenstein and Bowler (1991) described the macroinvertebrate faunas of upper Box Canyon, one of the few remaining unaffected alcove spring habitats along the Snake River between Twin Falls and Hagerman (fig. 1).

Table 3. Occurrence of macroinvertebrate taxa identified in 14 reference streams in the upper Snake River Basin, 1990–91 (Robinson and Minshall, 1992)

[Each sample represents a qualitative riffle-run habitat sample of 3 minutes]

Taxon	Frequency of occurrence	Mean number collected	Total number collected	Taxon	Frequency of occurrence	Mean number collected	Total number collected
Chironomidae	93	34	442	*Hesperoperla pacifica*	14	4	7
Oligochaeta	86	29	342	Carabidae	14	1	2
Alloperla	71	9	93	*Rhyacophila*	14	2	4
Hydracarina	64	12	110	*Rhyacophila vaccua*	14	3	6
Turbellaria	64	7	63	Tipulidae	14	1	2
Drunella doddsi	64	9	81	*Yugus*	14	4	8
Simulium	57	10	77	*Chelifera*	14	2	4
Cinygmula	57	26	209	*Epeorus iron*	14	14	28
Heterlimnius	57	19	155	*Neophylax*	14	3	5
Rhyacophila acropedes	57	7	52	*Ephemerella infrequens*	14	2	3
Brachycentrus	50	10	73	*Psychoglypha*	14	12	23
Hexatoma	50	6	41	*Grensia*	14	4	7
Baetis bicaudatus	50	32	222	*Prosimulium*	14	146	292
Ephemerella inermis	50	14	97	*Optioservus*	7	2	2
Baetis intermedius	43	46	273	*Tricorythodes*	7	2	2
Zapada oregonensis	43	9	56	*Helicopsyche*	7	4	4
Parapsyche elis	43	9	56	*Dicronota*	7	4	4
Capnia	43	10	58	Dytiscidae	7	1	1
Micrasema	43	6	36	Ceratopogonidae	7	1	1
Rhizelmis	36	48	241	Empididae	7	2	2
Pisidium	36	12	61	*Ephemerella aurivilli*	7	5	5
Rhyacophila hyalinata	36	2	12	*Gonielmis*	7	13	13
Antocha	36	3	16	*Baetis tricaudatus*	7	10	10
Serratella tibialis	36	5	18	*Clostoeca*	7	2	2
Nematoda	36	2	12	*Dicosmoecus*	7	2	2
Rhyacophila angelita	36	6	30	*Beloneuria*	7	2	2
Rhyacophila vespula	36	2	8	*Limnophila*	7	1	1
Hyallela azteca	29	23	91	*Setvena bradleyi*	7	7	7
Hemerodromia	29	3	8	*Rhyacophila vagrita*	7	4	4
Epeorus longimanus	29	37	148	*Rhyacophila coloradensis*	7	1	1
Calineuria	29	7	27	*Ameletus similor*	7	6	6
Isoperla	29	3	10	*Ameletus velox*	7	1	1
Drunella coloradensis	29	8	33	*Cleptelmis*	7	1	1
Rhithrogena	29	6	22	*Ephemerella grandis*	7	2	2
Zapada cinctipes	29	10	40	*Lara*	7	1	1
Pteronarcys californica	21	4	12	*Narpus*	7	1	1
Ameletus	21	1	4	*Pericoma*	7	24	24
Ostracoda	21	20	60	*Moselyana*	7	1	1
Paraleptophlebia	21	4	13	*Drunella flavilinea*	7	20	20
Heptageniidae	21	2	7	*Epeorus deceptivus*	7	10	10
Glutops	21	3	8	Gastropoda	7	2	2
Drunella spinifera	21	2	7	*Stenonema*	7	18	18
Neothremma	21	3	9	*Caudatella heterocaudata*	7	1	1
Arctopsyche	21	3	8	*Zapada*	7	1	1
Hydropsyche	14	28	55	*Paracapnia*	7	1	1
Glossosoma	14	7	14	*Amphinemura*	7	6	6
Limnephilidae	14	4	7	Diptera	7	2	2

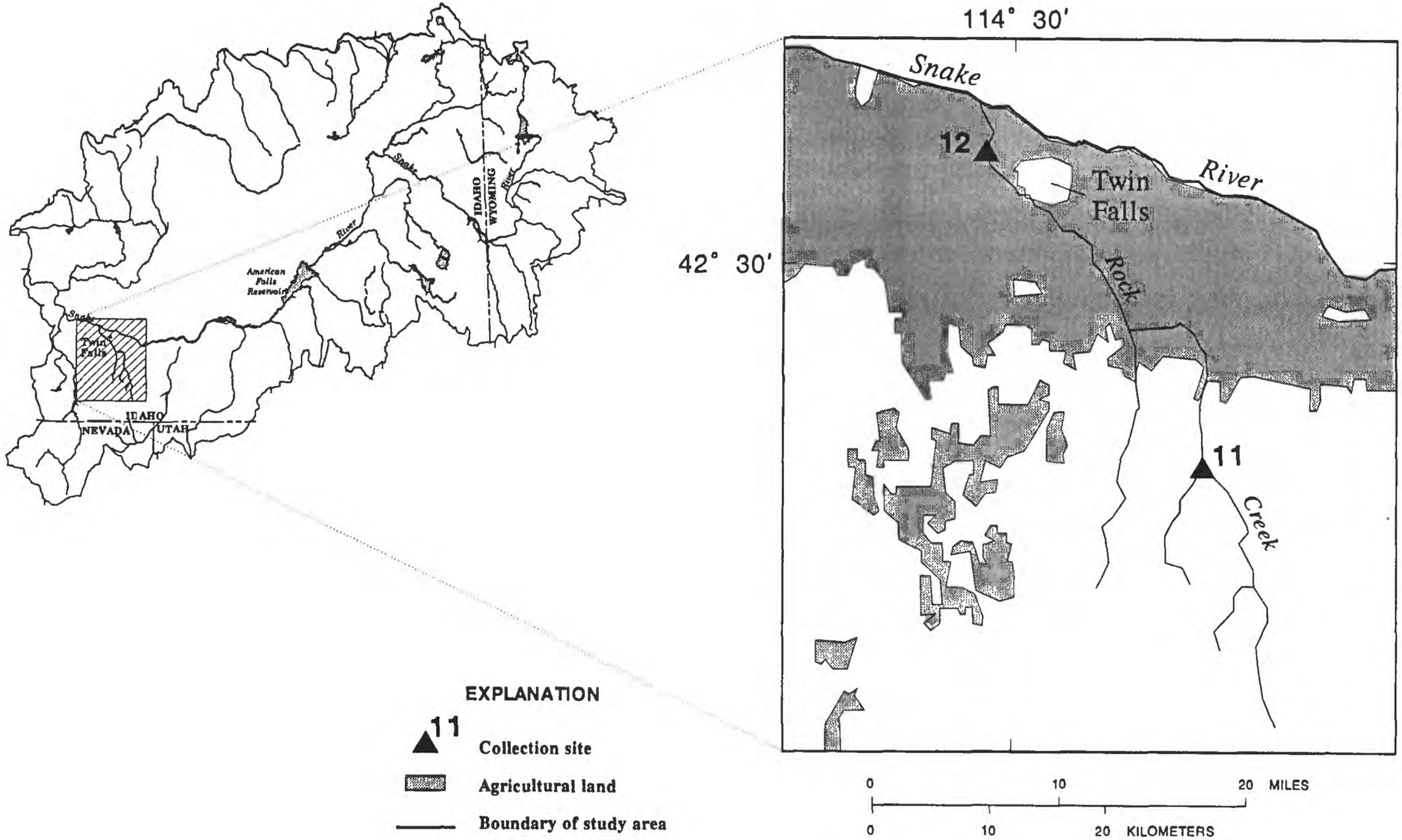


Figure 5. Ephemeroptera, Plecoptera, and Trichoptera taxa collected at Rock Creek sites upstream and downstream from areas of intensive agriculture, 1981–90.

Numerous methods have been used to assess macroinvertebrate data. Community metrics are used to summarize the number of taxa, species diversity indices, trophic composition, and similarity indices. Many of the metrics that have been used to assess cold-water streams in the Snake River Basin in Idaho are summarized in table 4. Robinson and Minshall (1992) found that 7 of 18 macroinvertebrate metrics were useful for distinguishing stream types and ecoregions in Idaho. These metrics include EPT richness, Shannon's diversity index, percentage of EPT, Hilsenhoff's biotic index, Simpson's dominance index, percentage of dominant taxa, and percentage of filterers. They also found that 12 taxa were important in distinguishing among stream types: blackflies (*Simulium*), mayflies (*Baetis* and *Ephemerella*), flatworms (Turbellaria), riffle beetles (Elmidae), caddisflies (*Rhyacophila* and *Clostoeca*), water mites (Hydracarina), snails (*Pisidium*), stoneflies (*Alloperla*), and Tipulidae (*Hexatoma* and *Antocha*). Other taxa, including the mayflies (*Rhithrogena* and *Drunella doddsi*), stoneflies (*Zapada* and *Capnia*), and caddisflies (*Micrasema* and *Rhyacophila acropedes*), were common in the upland (high altitude and gradient) streams sampled. In contrast, alderflies (*Sialis*) and dragonflies (Odonata) were most common in lowland (low altitude and gradient) and impaired sites.

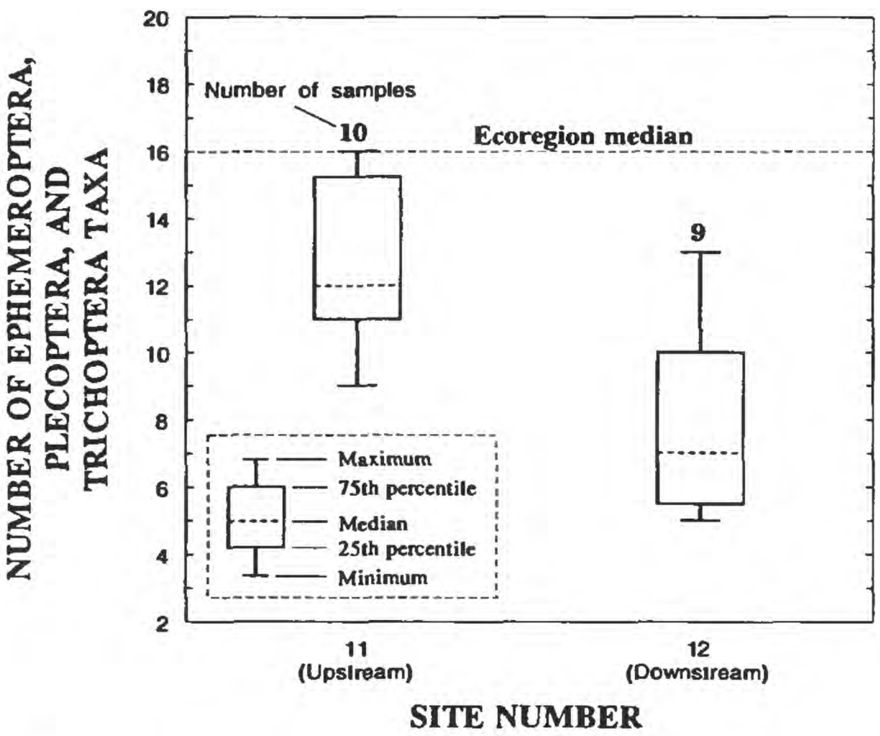


Figure 6. Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa collected at Rock Creek sites upstream and downstream from areas of agricultural land use, August 1981–90. (Taxa numbers are compared to the median EPT taxa collected from 14 reference streams in the Snake River Basin/High Desert ecoregion; data from Robinson and Minshall, 1992; site locations shown in figure 5)

Functional feeding groups and pollution tolerances for macroinvertebrates in the upper Snake River Basin are listed in table A (back of report). The functional feeding categories are based on morphological and behavioral adaptations for food acquisition rather than on actual food ingested (Merritt and Cummins, 1984). Although the categories are only an approximation of food habits due to the complexities of food availability and type eaten during different life stages and season,

Table 4. Macroinvertebrate community metrics used in assessing biotic integrity of cold-water streams in Idaho

[IDHW, Idaho Department of Health and Welfare; •, denotes metric was used in assessing biotic integrity; EPT, Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies)]

Metrics	Fisher (1989)	Clark and Maret (IDHW, written commun., 1991)	Robinson and Minshall (1992)
Community indices			
Shannon's diversity index			•
Simpson's dominance index			•
Biotic condition index			•
Community loss index	•		
Hilsenhoff's biotic index	•	•	•
Total EPT taxa	•	•	•
Total taxa		•	•
Community balance			
EPT abundance	•		
EPT/chironomid taxa	•		•
EPT/chironomids and oligochaeta			•
Percentage of chironomids			•
Percentage of EPT		•	
Percentage of dominant family	•		
Percentage of dominant taxa			•
Percentage of chironomids and oligochaeta			•
Total abundance	•	•	•
Trophic composition			
Density of collectors	•		
Density of predators	•		
Density of scrapers	•		•
Density of shredders	•		
Percentage of filterers		•	•
Percentage of scrapers		•	•
Percentage of shredders		•	•
Percentage of scrapers/filterers-collectors			•
Percentage of shredders/total individuals			•
Comparative index			
Jaccard Coefficient of Similarity		•	

they are helpful in assessing trophic structure of the community. The assigned tolerance values describe the relative tolerance each taxa has to increased sediment, organic matter, and temperature. These tolerance values, in conjunction with species richness, are useful in assessing macroinvertebrate community health and stream quality (Hilsenhoff, 1987; Plafkin and others, 1989).

The IDHW is developing monitoring protocols and a statewide data base of macroinvertebrates using the USEPA national data base STORET/BIOS (W.H. Clark and T.R. Maret, Idaho Department of Health and Welfare, written commun., 1991). The WDEQ also has developed monitoring protocols for streams using macroinvertebrates (K.W. King, Wyoming Department of Environmental Quality, written commun., 1993). These are regional sources of information on taxa pollution tolerance values and trophic class assignments. Clark (1991) summarized the literature pertaining to identification and distributions of aquatic macroinvertebrates for the Western United States with emphasis on Idaho.

SPECIES OF SPECIAL CONCERN

Species of Special Concern, as defined by IDFG, are native species that are low in numbers, limited in distribution, or have suffered significant habitat losses (Moseley and Groves, 1992). Macroinvertebrate Species of Special Concern consist of eight members of the phylum Mollusca (table 2), both gastropods (snails and limpets) and bivalves (clams), which have been surveyed extensively in the middle Snake River and associated spring habitats. Five of these mollusks in the basin currently are recognized by the U.S. Fish and Wildlife Service as federally listed endangered or threatened species. These include the Utah valvata snail (*Valvata utahensis*), Bliss Rapids snail (no scientific name), Snake River Physa snail (*Physa natricina*), Idaho springsnail (*Pyrgulopsis idahoensis*), and Banbury Springs limpet (undescribed *Lanx* sp.) (C.H. Lobdell, U.S. Fish and Wildlife Service, written commun., 1993). The Columbia pebblesnail (*Fluminicola columbiana*), shortface limpet (*Fisherola nuttalli*), and California floater (*Anodonta californiensis*), a bivalve clam, are other Species of Special Concern and are candidate species for Federal listing (Moseley and Groves, 1992). These eight species are dependent on cold, well-oxygenated, unpolluted water for survival (T.J. Frest and others, Deixis Consultants, written commun., 1992).

These endemic species were found in the Snake River and (or) adjacent spring habitats. Distributions of six of these species in the last 10 years are shown in figure 7; data were provided by the ICDC (George Stephens, written commun., 1992). Most of these species were found in the Snake River reach near Hagerman.

Mollusk species decline as a result of the cumulative effects of hydroelectric-power development, irrigation diversions and return flows, municipal point source discharges, runoff from dairies and feedlots, and aquacultural effluents. These human factors result in fragmentation of the remaining free-flowing habitat and degradation of water quality from excessive nutrient and sediment loading. In addition, reduced streamflows resulting from irrigation withdrawals and drought conditions have exacerbated water-quality conditions in the middle Snake River (C.H. Lobdell, U.S. Fish and Wildlife Service, written commun., 1993). The following paragraphs describe the known status and specific habitat requirements of the eight mollusk Species of Special Concern. Data are from the USFWS (C.H. Lobdell, written commun., 1993).

The Utah valvata snail has been found in two locations: downstream from American Falls Reservoir and in spring pools and slow-moving reaches of the Snake River near Hagerman. Frest and Johannes (1993b) found this species downstream from Minidoka Dam in cold ground-water seeps. This species lives in deep pools adjacent to rapids or in perennial flowing water associated with large spring complexes and prefers mud or mud-sand substrate.

The Bliss Rapids snail has been collected from the tailwaters downstream from Lower Salmon Falls and Bliss Dams and from several unpolluted springs near Hagerman. The snail also has been found near Idaho Falls and downstream from American Falls Reservoir. This species prefers stable, cobble- to boulder-sized substrate in flowing water and avoids surfaces with attached plants.

The Snake River Physa snail remains at only a few locations in the Snake River near Hagerman and King Hill. Another population lives near Minidoka Dam. The population of this species is extremely low; fewer than 50 specimens were collected from the middle Snake River. The species lives in swift current in deep habitats or near margins of rapids in the Snake River

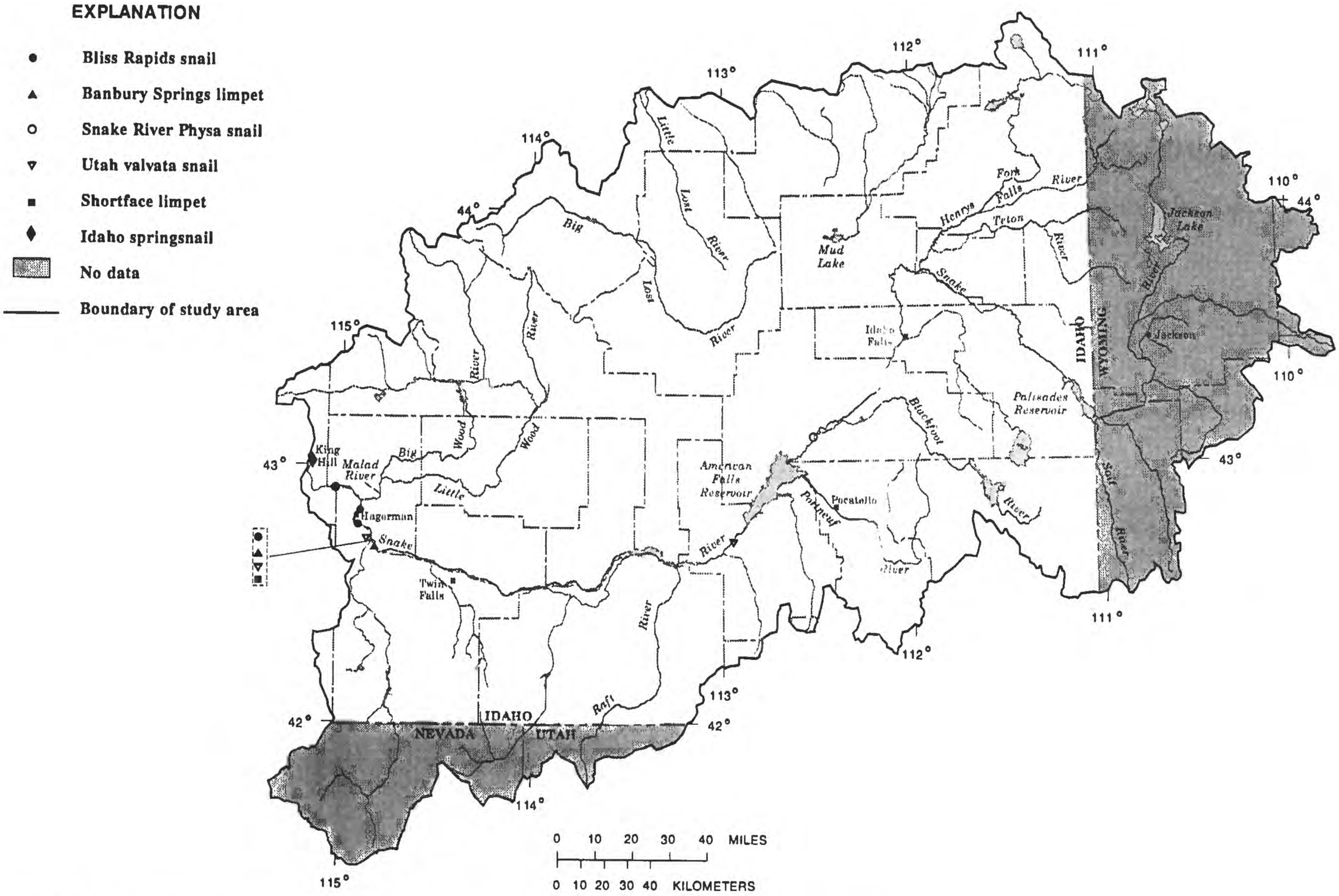


Figure 7. Distributions of macroinvertebrate (Gastropods) Species of Special Concern in the upper Snake River Basin, 1981–91. (From George Stephens, Idaho Conservation Data Center, written commun., 1992)

and prefers the underside of gravel- to boulder-sized substrate.

The Idaho springsnail has been collected at the mouth of Clover Creek near King Hill (George Stephens, Idaho Conservation Data Center, written commun., 1992). A population also has been found near Bliss Dam (T.J. Frest, Deixis Consultants, written commun., 1992). This species lives in permanent flowing waters of the main-stem Snake River. The species prefers mud or sand associated with gravel- to boulder-sized substrate and often is attached to vegetation in riffles.

The obligate cold-spring Banbury Springs limpet has been found only in three unpolluted springs along the Snake River near Hagerman (George Stephens, Idaho Conservation Data Center, written commun., 1992). It prefers relatively swift current and smooth rocks and avoids surfaces with aquatic macrophytes or filamentous algae. This species is particularly susceptible to DO fluctuations because it breathes through its mantle.

The Columbia pebblesnail has been collected at one location in the Snake River near Hagerman (T.J. Frest, Deixis Consultants, written commun., 1992). Specimens also have been reported in the Snake River near Jackson, Wyo. (Frest and Johannes, 1993a).

The distribution of the California floater appears to be declining, but healthy populations still live in the middle Snake River (T.J. Frest, Deixis Consultants, written commun., 1992). Frest and Johannes (1993b) also found this species in the main-stem Snake River downstream from Minidoka Dam. This large clam prefers areas with soft substrate in well-oxygenated water (Frest, 1992).

The shortface limpet has been found in rapids of the main-stem Snake River upstream from upper Salmon Falls Creek Reservoir (George Stephens, Idaho Conservation Data Center, written commun., 1992) and at several sites near Hagerman and between King Hill and Bliss Dam near springs (T.J. Frest, Deixis Consultants, written commun., 1992). It prefers swift current and cobble- or boulder-sized substrate.

Collections at a number of locations on the middle Snake River by Frest (1992) indicated that most of these species no longer live in this reach due to deteriorating water quality. Collections in July 1991 indicated that the shortface limpet and Utah valvata snail are the only Species of Special Concern that remain in the middle Snake River. Frest (1992) also noted that areas of clear water and cobble- and boulder-sized substrate have decreased in the middle Snake River since 1986 and that shallow-water, soft-sediment habitats are now more widespread. Primary causes for these changes are decreases in streamflow and increases in nitrate, phosphate, and sediment concentrations from agricultural and aquacultural sources. Water-quality degradation also has led to a reduction of endemic cold-water mollusk species and an increase in more pollution-tolerant and exotic species such as the abundant New Zealand mud snail (*Potamopyrgus antipodarium*) (Bowler, 1991). Moreover, the snails *Fluminicola hindsi* and *Vorticifex effusa*, characteristic of fast-flowing freshwater habitat, are declining in the middle Snake River reach (T.J. Frest, Deixis Consultants, written commun., 1992).

Surveys by Frest and Johannes (1993a; 1993b) in the middle Snake River reach near Twin Falls and immediately downstream from the Minidoka Dam on the main-stem Snake River provide additional information on the current status of these species. Their surveys did not reveal any living federally listed species near Twin Falls. Live specimens of the Utah valvata snail and one live specimen of the California floater were found near Minidoka Dam. They concluded that mollusk Species of Special Concern and other cold-water-adapted species were rare or absent in both areas.

Fish

The number of fish species and their relative abundances are excellent indicators of water quality and habitat alterations resulting from land use effects. Advantages for using fish communities to assess water quality are that fish are generally easy to identify, life history information is available for most species, many species are widely distributed, many trophic levels are represented, and descriptive analyses of fish communities are relatively easy to understand (Karr and others, 1986). In addition, Idaho water-quality standards designate aquatic biota and salmonid spawning as beneficial uses of most streams in the basin (Idaho Department of Health and Welfare, 1990). Accordingly, water-quality criteria have been promulgated or proposed to protect instream fishery uses in Idaho (Harvey, 1989).

Fish communities of the Snake River have been investigated since the late 1800's. Gilbert and Evermann (1895) and Evermann (1896) described the historical fish distributions in the middle Snake River and tributaries before hydroelectric-power development. They found chinook salmon, steelhead, and white sturgeon (*Acipenser transmontanus*), Pacific lamprey (*Lampetra tridentata*), and cutthroat trout throughout the Snake River downstream from Shoshone Falls. Since the construction of hydroelectric-power facilities on the main-stem Snake River, the chinook salmon, steelhead, and Pacific lamprey (anadromous species) have been eliminated from the basin.

Most fishery surveys have been made by the WGFD and the IDFG to assess sportfishery populations. Sources and species of fish collected in the basin between 1982 and 1992 are summarized in table 5 and figure 8. These data represent species collected in selected river drainages and tributaries, with the exceptions of the middle Snake and South Fork Snake Rivers. The fish fauna is made up predominantly of coldwater species in the families Salmonidae (trout), Cottidae (sculpins), Cyprinidae (minnows), and Catostomidae (suckers). Currently, the native fish faunas of the upper Snake River Basin are represented by 5 families and 26 species (table B, back of report). An additional 13 species (out of 39 total) have been introduced primarily to enhance sportfishery. Sportfishery regulations have been established for all trout species (Salmonidae), white sturgeon, channel catfish (*Ictalurus punctatus*), smallmouth bass (*Micropterus dolomieui*), largemouth bass (*Micropterus salmoides*), yellow perch (*Perca flavescens*), and walleye (*Stizostedion vitreum*).

Hierarchial cluster analysis of species occurrence data is useful for assessing spatial relations among fish communities on the basis of similarities in community composition (Pielou, 1984). Figure 9 is a dendrogram of regional patterns in fish species similarity values for 12 selected drainages (subbasin or stream reach) in the upper Snake River Basin. A cluster analysis was performed using a matrix of Jaccard Coefficients of Community Similarity (*JC*) calculated using multivariate

Table 5. Fish species identified in selected drainages in the upper Snake River Basin, 1982–92

[Sources of information: Simpson and Wallace (1982); Jones and others (1984); Thurow and others (1988); Allen and others (1990); Maret (1990); Moseley and Groves (1990); Hill (1992c); J. Kiefling (Wyoming Department of Game and Fish, written commun., 1992); C. Randolph (Idaho Power Company, written commun., 1992); Robinson and Minshall (1992). Common and scientific names were standardized using a report by Robins and others (1991). SC, Species of Special Concern (Robin Jones, Wyoming Natural Diversity Database, written commun., 1992); (Moseley and Groves, 1992). E, eliminated from study area. Locations of collection sites shown in figure 8. Occurrence: 1, Middle Snake River (downstream from Shoshone Falls to King Hill); 2, South Fork Snake River; 3, Henrys Fork Snake River; 4, Rock Creek; 5, Big Wood River; 6, Portneuf River; 7, Blackfoot River; 8, Teton River; 9, Willow Creek; 10, Big Lost River; 11, Salt River; 12, Snake River headwaters to Yellowstone National Park]

Family Common name	Species	Occurrence
Acipenseridae		
White sturgeon (SC)	*Acipenser transmontanus*	1
Catostomidae		
Bluehead sucker (SC)	*Catostomus discobolus*	2,9
Bridgelip sucker	*Catostomus columbianus*	1,4,5
Largescale sucker	*Catostomus macrocheilus*	1,4,5
Mountain sucker	*Catostomus platyrhynchus*	1,2,3,4,6,7,8,9,11,12
Utah sucker	*Catostomus ardens*	1,2,3,6
Centrarchidae		
Black crappie	*Pomoxis nigromaculatus*	1
Bluegill	*Lepomis macrochirus*	1
Largemouth bass	*Micropterus salmoides*	1,5
Smallmouth bass	*Micropterus dolomieui*	1
Cichlidae		
Tilapia	*Tilapia* sp.	1
Cottidae		
Mottled sculpin	*Cottus bairdi*	1,2,3,4,5,6,7,8,9,11,12
Paiute sculpin	*Cottus beldingi*	2,3,6,7,8,9
Shorthead sculpin	*Cottus confusus*	9,10
Shoshone sculpin (SC)	*Cottus greenei*	1
Torrent sculpin[1]	*Cottus rhotheus*	
Wood River sculpin (SC)	*Cottus leiopomus*	5
Cyprinidae		
Carp	*Cyprinus carpio*	1,4,6,7,9
Chiselmouth	*Acrocheilus alutaceus*	1,4
Hornyhead chub (SC)[2]	*Nocomis biguttatus*	
Cyprinidae—Continued		
Leatherside chub (SC)	*Gila copei*	2,5
Leopard dace	*Rhinichthys falcatus*	1
Longnose dace	*Rhinichthys cataractae*	2,3,4,5,6,7,8,9,12
Northern squawfish	*Ptychocheilus oregonensis*	1
Peamouth	*Mylocheilus caurinus*	1
Redside shiner	*Richardsonius balteatus*	1,2,3,4,5,6,7,8,9,11,12
Speckled dace	*Rhinichthys osculus*	1,2,3,4,5,6,7,8,9,11,12
Utah chub	*Gila atraria*	1,2,3,4,5,6,7,8,9,11,12
Ictaluridae		
Black bullhead	*Ameiurus melas*	1
Brown bullhead	*Ameiurus nebulosus*	1,4
Channel catfish	*Ictalurus punctatus*	1
Percidae		
Walleye	*Stizostedion vitreum*	1
Yellow perch	*Perca flavescens*	1,5
Petromyzonidae		
Pacific lamprey (E)	*Lampetra tridentata*	1
Salmonidae		
Brook trout	*Salvelinus fontinalis*	3,4,5,6,7,8,9,10,11
Brown trout	*Salmo trutta*	1,2,3,4,5,6,9,11
Bull trout (SC)	*Salvelinus confluentus*	10
Chinook salmon (E)	*Oncorhynchus tshawytscha*	1
Cutthroat trout (SC)	*Oncorhynchus clarki* sp.	1,2,3,5,6,7,8,9,11,12
Mountain whitefish	*Prosopium williamsoni*	1,2,3,5,8,10,11,12
Rainbow trout	*Oncorhynchus mykiss* sp.	1,3,4,5,6,7,8,9,10,11

[1]Collected from Lake Fork and Station Fork Creeks, Cassia County, Idaho (Robinson and Minshall, 1992).

[2]Collected from the Buffalo Fork Basin of the Snake River, Teton County, Wyoming (Robin Jones, Wyoming Natural Diversity Database, written commun., 1992).

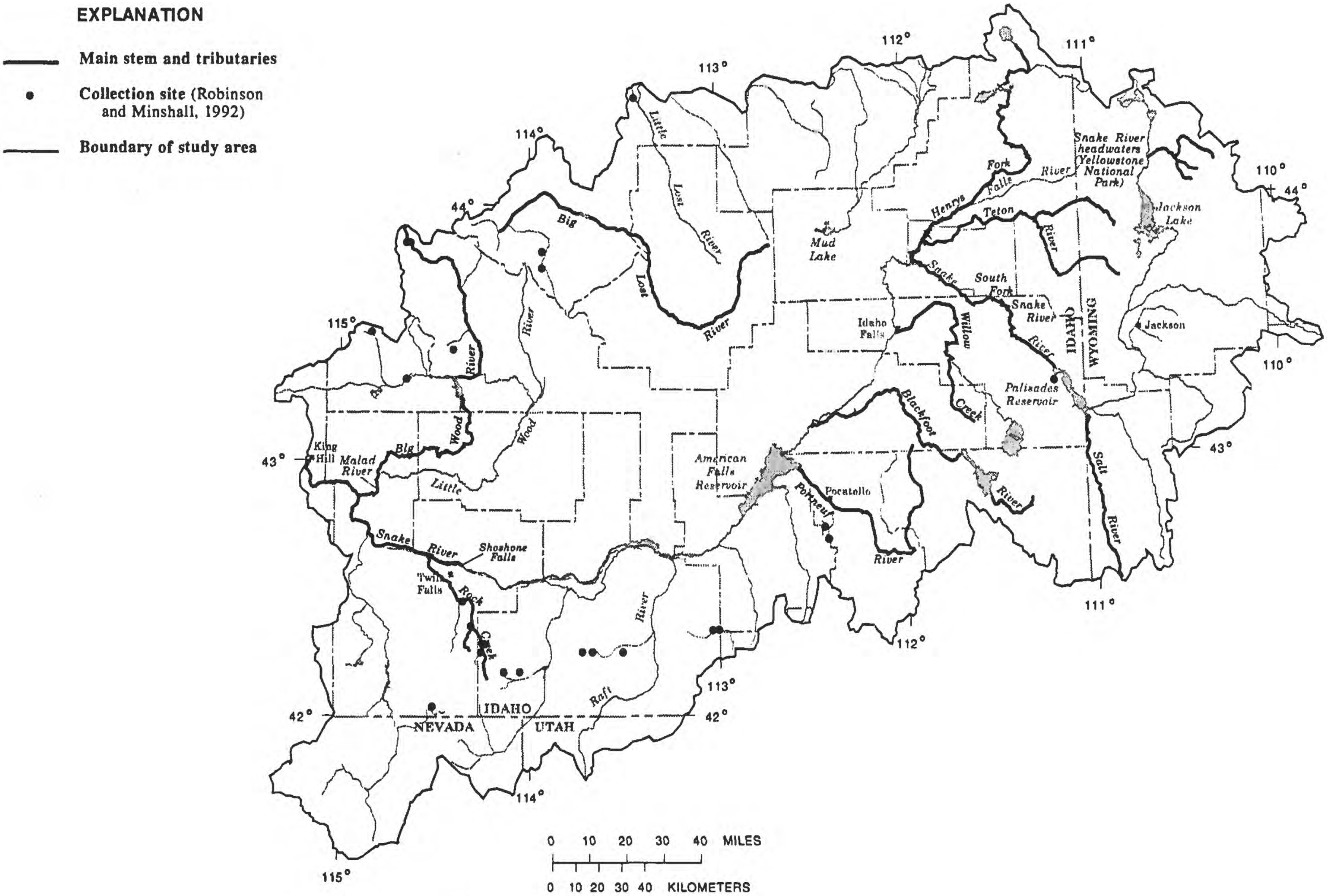


Figure 8. Fish collection sites in the upper Snake River Basin, 1982–92.

statistical procedures from occurrence data in table 5 (W.L. Warren, University College of Wales, written commun., 1990). The formula (Plafkin and others, 1989) to calculate *JC* is:

$$JC = \frac{A}{A + B + C}$$

where

A = number of taxa common to both samples,

B = number of taxa present in sample *B* but not *A*, and

C = number of taxa present in sample *A* but not B.

A matrix of cophenetic values was constructed to determine the degree of distortion caused by averaging members of clusters and treating them as a single new object in the dendrogram. A correlation coefficient of 0.97 ($p < 0.01$) calculated between the dendrogram and cophenetic matrix values indicated an excellent fit (little distortion) of the dendrogram to the data.

Three distinct groupings of sites were identified by the cluster analysis (fig. 9). These include drainages 2 and 12; drainages 3, 8, 11, 6, 9, and 7; and drainages 4 and 5. The South Fork Snake River (drainage 2) and upper Snake River in Wyoming (drainage 12) are high-quality cutthroat trout fisheries. The grouping of the Henrys Fork, Teton River, Salt River, Portneuf River, Willow Creek, and Blackfoot River (drainages 3, 8, 11, 6, 9, and 7, respectively) is indicative of cutthroat trout fisheries affected by habitat degradation, excessive harvesting, and introduction of nonnative species (fig. 8) upstream from Shoshone Falls (Thurow and others, 1988). Rock Creek and Big Wood River (drainages 4 and 5, respectively) are predominantly rainbow and brown trout fisheries affected by agricultural activities and related habitat degradation downstream from Shoshone Falls (Thurow, 1987; Yankey and others, 1991).

Fish communities in the middle Snake River (drainage 1) and the Big Lost River (drainage 10) were the most dissimilar to those in other drainages. The middle Snake River contains at least 29 fish

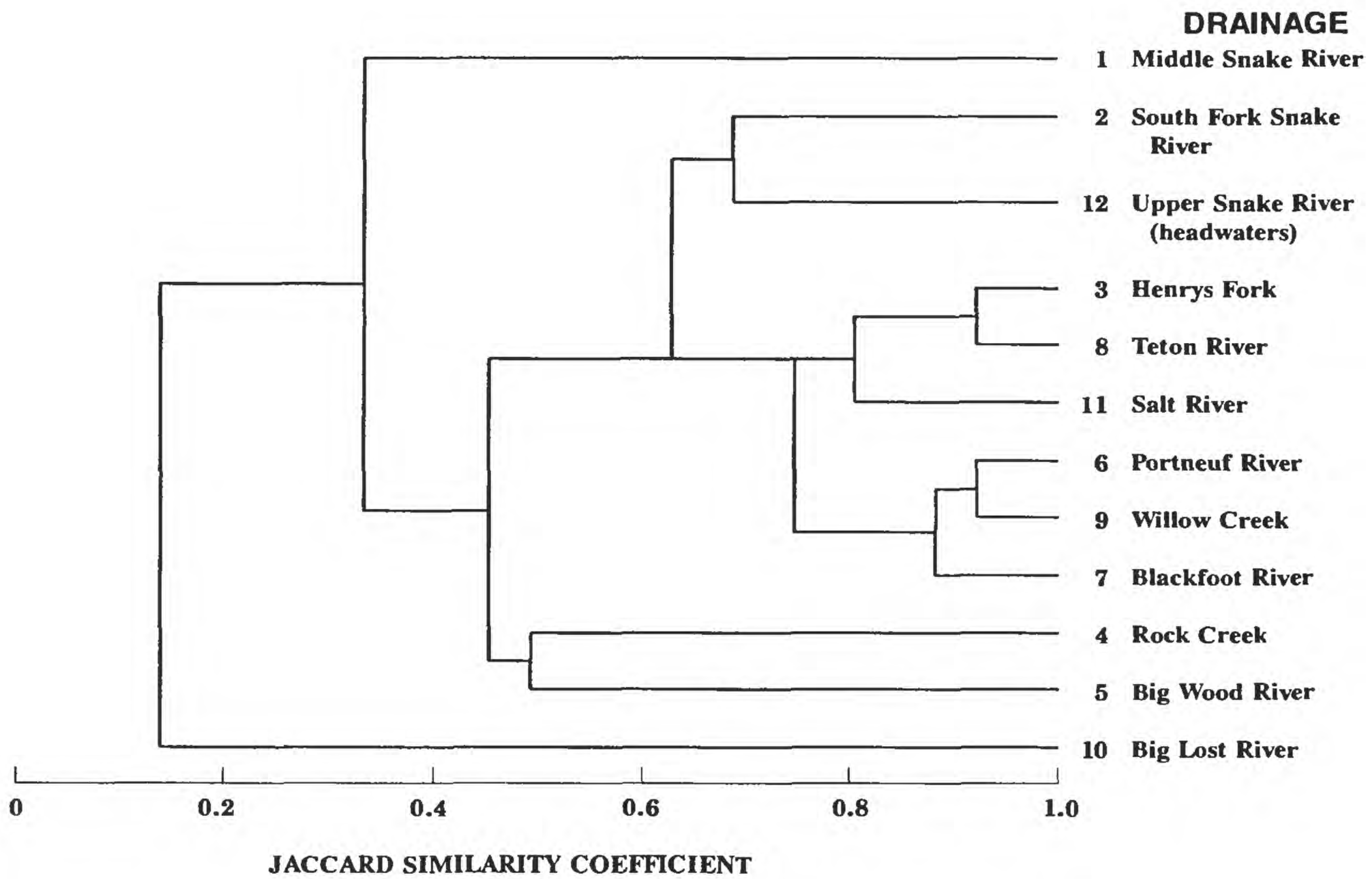


Figure 9. Dendrogram showing relative similarities in fish species in 12 drainages in the upper Snake River Basin. (Locations of drainages shown in figure 8)

species (table 5). Many of these species such as catfish (Ictaluridae) and sunfish (Centrarchidae) are introduced and are adapted to warm-water habitats. The Big Lost River contains only five species, the lowest number among all drainages (table 5). The isolated location of this river drainage may be a partial explanation for the low number of fish species.

Shoshone Falls, a large waterfall on the Snake River upstream from the city of Twin Falls, prevents migration of fish upstream and may explain, in part, similarities in fish faunas (fig. 9). In addition, native species living only in the Snake River and its tributaries downstream from the falls include the bridgelip sucker (*Catostomus columbianus*), largescale sucker (*Catostomus macrocheilus*), chiselmouth (*Acrocheilus alutaceus*), leopard dace (*Rhinichthys falcatus*), northern squawfish (*Ptychocheilus oregonensis*), peamouth (*Mylocheilus caurinus*), white sturgeon, Wood River sculpin (*Cottus leiopomus*), and Shoshone sculpin (*Cottus greenei*).

Typical headwater streams in the basin have sparse fish faunas, few species, and low abundances. Robinson and Minshall (1992) found only eight species of fish in their sampling of small reference streams in the basin (table 6). Trout and sculpin typically made up entire collections from some of the headwater streams sampled in the basin. In addition, fish abundances were low as illustrated by mean numbers of fish (2–13 individuals per species) collected by electrofishing 328-ft reaches of each stream (table 6).

The distribution of selected Idaho fish species (figs. 10–13) is based on the Idaho Rivers Information System data base (Allen and others, 1990), which contains information on fish collections over the last 10 years (S.T. Allen, Idaho Department of Fish and Game, oral commun., 1992). The distribution of the six trout species indicates the extent of cold-water habitats in the basin. Brook trout (*Salvelinus fontinalis*), rainbow trout, brown trout, and cutthroat trout generally are found throughout the study area in Idaho (figs. 10 and 11). Bull trout (*Salvelinus confluentus*) and redband trout (*Oncorhynchus mykiss gibbsi*) have more restricted distributions.

Fish community metrics used to assess biotic integrity in Idaho cold-water streams are summarized in table 7. Twenty-six fish metrics, including species richness and composition, trophic composition, abundance, condition, age structure, and comparative index, have been tested in Idaho streams. Most of these metrics are associated with salmonid fishery attributes. The IDHW has developed monitoring protocols that include fish community assessment to measure stream conditions (Chandler and others, 1993).

Robinson and Minshall (1992) found that 6 of the 20 metrics they tested (table 7) were important in distinguishing stream types and ecoregions. These metrics included the number of salmonid species, number of tolerant species, percentage of salmonids, salmonid biomass, abundance of pollution-tolerant species, and salmonid condition index. Generally, the data indicated a shift from relatively intolerant salmonid fishery in upland streams to a tolerant nonsalmonid fishery in affected streams. Robinson and Minshall (1992) also found that the number of tolerant species and tolerant fish abundance were greater in the Snake River Basin/High Desert ecoregion than in the Northern Basin and Range ecoregion (fig. 3). They suggested that streams in the Snake River Basin/High Desert were more heavily affected than streams in the Northern Basin and Range.

The origin, trophic group, and relative tolerance to organic enrichment, sediment, and warm-water pollution for fish in the basin are listed in table B. Although the assigned categories are subjective, researchers have found that these descriptors of fish communities can be used to assess stream degradation and biotic integrity (Karr, 1991). As additional information becomes available for a given species, these values will require adjustment to refine the use of fish communities as environmental indicators.

As part of the Rock Creek RCWP, data were collected to assess long-term trends in fish communities affected by irrigated agriculture. Two IDHW monitoring sites in the Rock Creek RCWP area are shown in

Table 6. Occurrence of fish species identified in 14 reference streams in the upper Snake River Basin, 1990–91

[Data from Robinson and Minshall (1992)]

Species	Frequency of occurrence	Mean number collected	Total number collected
Brook trout	53	8	64
Rainbow trout	40	13	79
Mottled sculpin	40	6	38
Cutthroat trout	13	2	4
Torrent sculpin	13	4	7
Brown trout	7	4	4
Redside shiner	7	5	5
Speckled dace	7	11	11

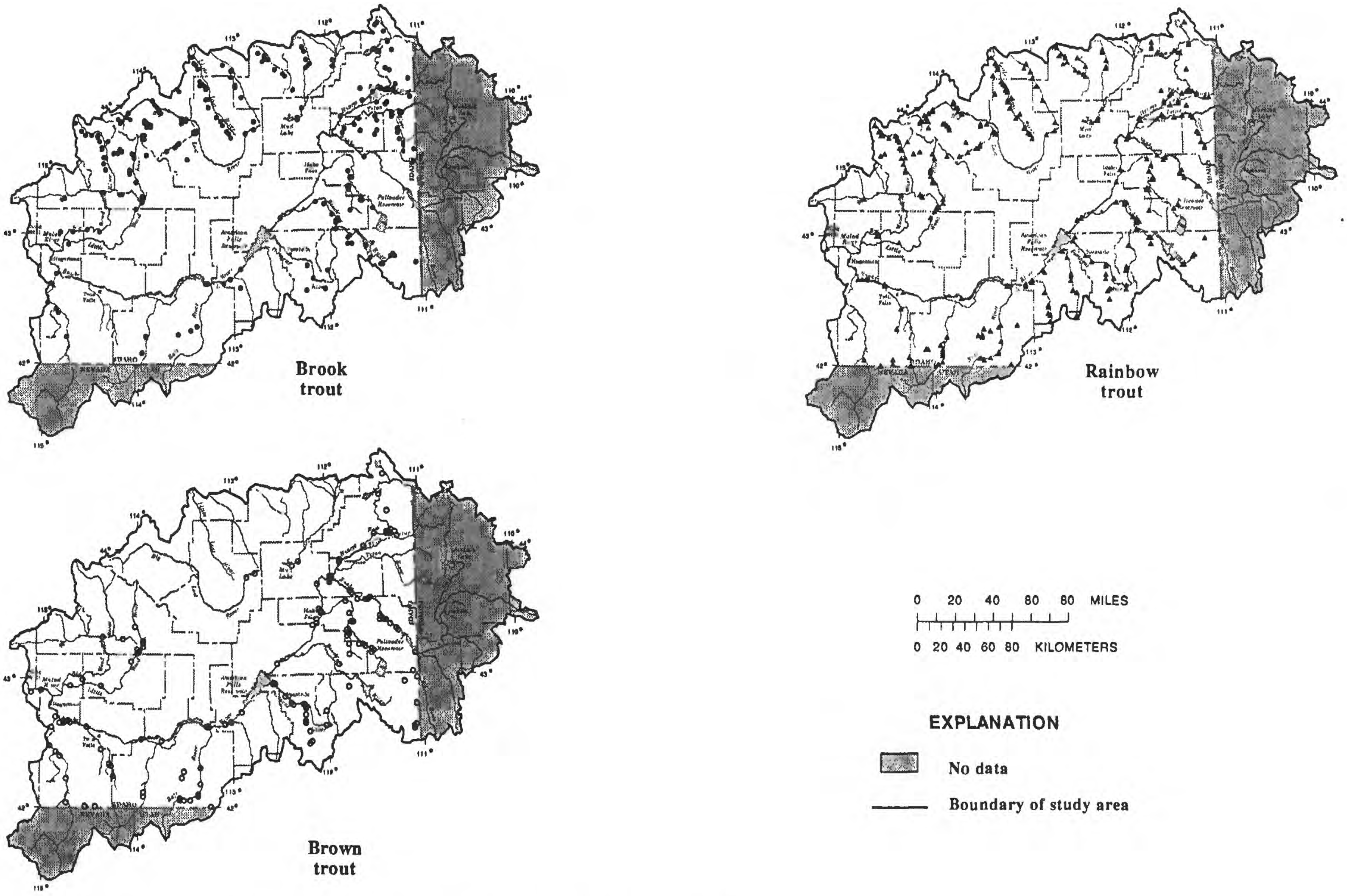


Figure 10. Distributions of trout species in the upper Snake River Basin, 1980–90. (From Allen and others, 1990)

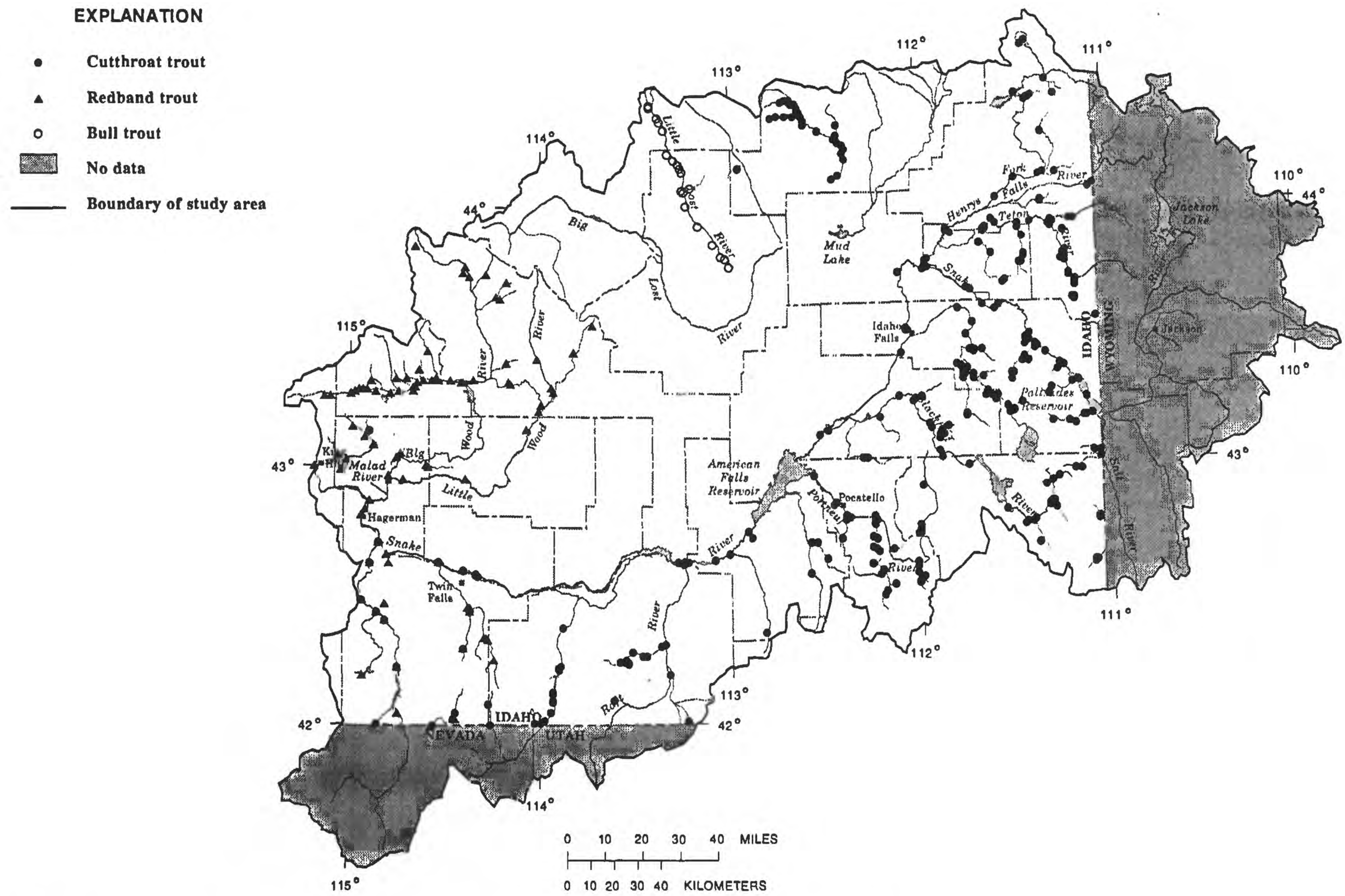


Figure 11. Distributions of native trout Species of Special Concern in the upper Snake River Basin, 1980–90. (From Allen and others, 1990)

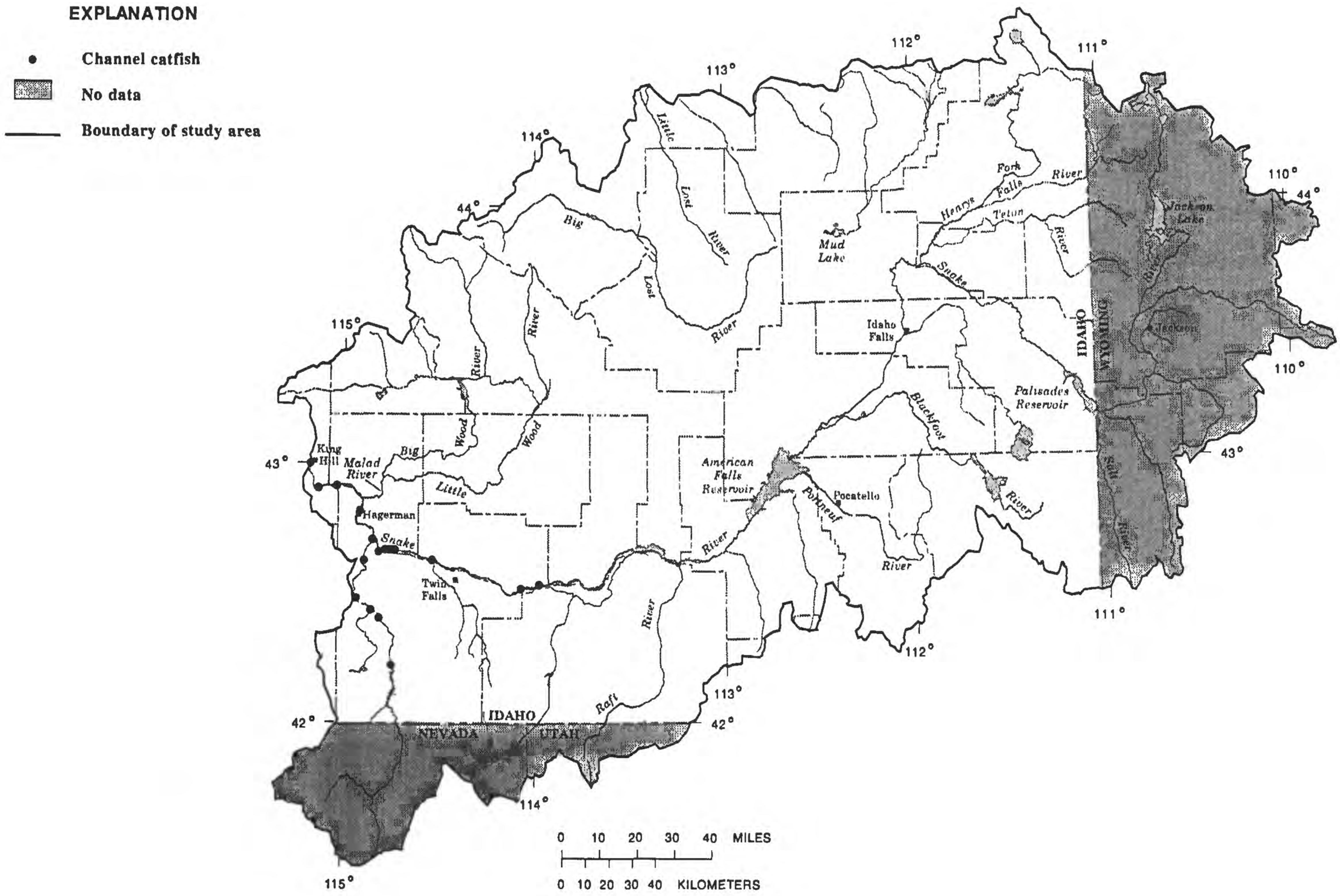


Figure 12. Distributions of channel catfish in the upper Snake River Basin, 1980–90. (From Allen and others, 1990)

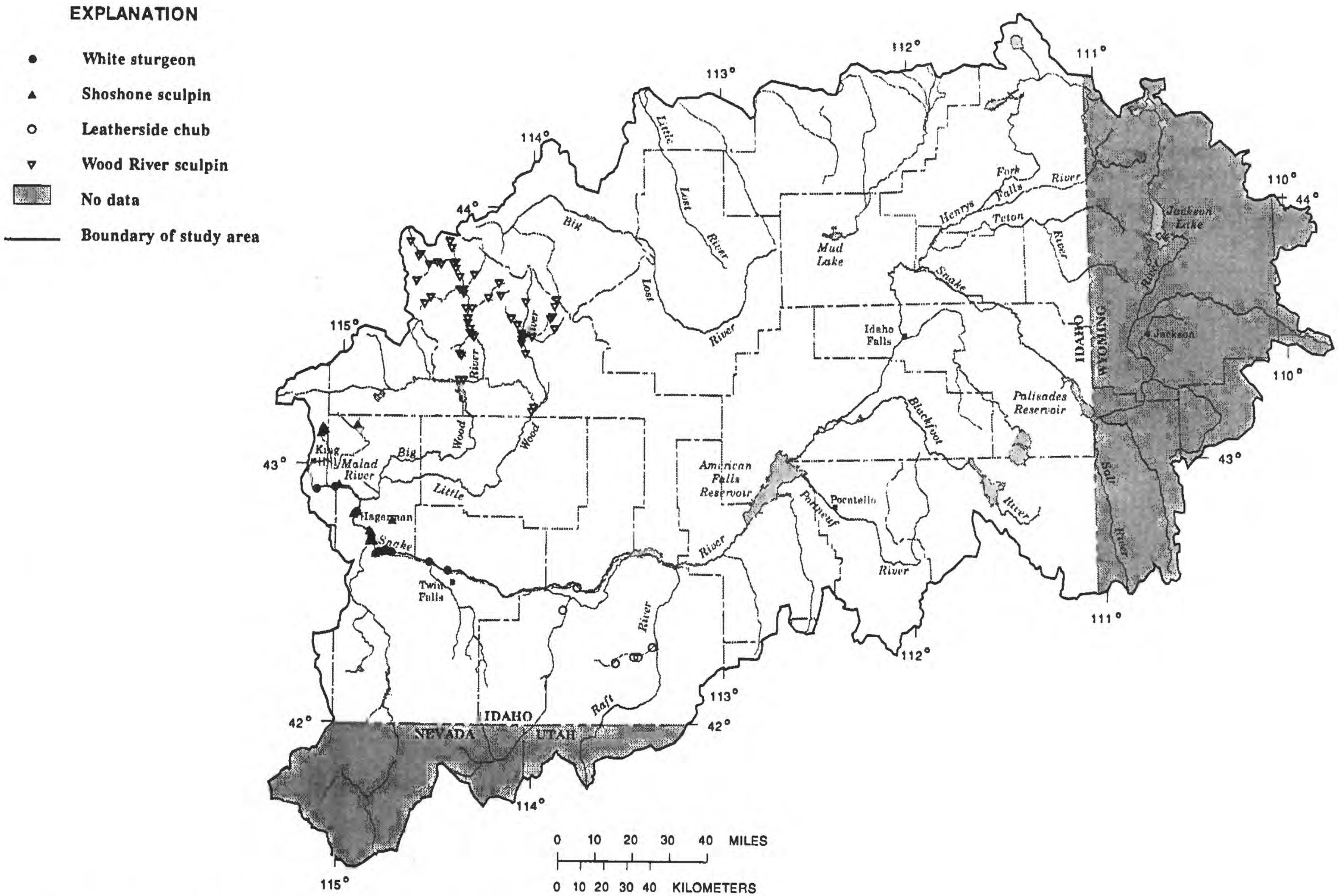


Figure 13. Distributions of fish Species of Special Concern, excluding cutthroat trout, in the upper Snake River Basin, 1980–90. (From Allen and others, 1990)

figure 5. Site 11 upstream and site 12 downstream from areas of intensive agricultural land use represent a comparison of cumulative effects of irrigation-return flows, grazing, aquaculture, and water diversions. Large differences in trout biomass were apparent at these two sites between 1981 and 1990 (fig. 14). Biomass estimates of fish from site 11 ranged from 106 to 288 pounds per acre, whereas estimates from site 12 were much lower—from 0.8 to 61 pounds per acre. Yankey and others (1991) attributed this difference to poorer habitat and lack of suitable spawning areas due to excessive sedimentation from bank erosion and irrigation-return flows. Maret and others (1993) found poor salmonid spawning habitat in lower Rock Creek due to excessive fine sediment (less than 2.0 mm) and low DO in stream substrate. They concluded that the lower reach of Rock Creek (lower 20 mi) would not support a trout fishery without supplemental stockings.

Table 7. Fish community metrics used in assessing biotic integrity of cold-water streams in Idaho

[•, denotes metric was used in assessing biotic integrity]

Metrics	Fisher (1989)	Robinson and Minshall (1992)	Chandler and others (1993)
Species richness and composition			
Number of intolerant species	•	•	•
Number of introduced species	•	•	•
Percentage introduced		•	
Number of native species		•	
Number of salmonid species	•	•	•
Number of species	•	•	
Percentage of salmonids	•		
Number of tolerant species		•	
Abundance of tolerant species		•	
Tolerant species biomass		•	
Trophic composition			
Number of benthic insectivores		•	•
Percentage of insectivores	•	•	•
Percentage of omnivores		•	•
Percentage of salmonids	•	•	
Percentage of carnivores		•	
Abundance, condition, and age structure			
Average salmonid length	•		
Average salmonid weight	•		
Salmonid condition index		•	
Percentage of anomalies	•		•
Percentage of hybrids	•		
Salmonid biomass	•	•	
Salmonid abundance		•	
Total fish abundance		•	•
Total fish biomass	•	•	
Percentage of young-of-year salmonids		•	•
Comparative index			
Jaccard Coefficient of Similarity			•

Reservoirs have increased the diversity of fish in the basin by the introduction of fish species adapted to lentic habitats. The locations (within the last 10 years) where warm-water channel catfish have been collected are shown in figure 12. Hill (1992c) indicated that the fish community in the middle Snake River reach is composed of 97 percent nongame taxa, of which 82 percent are suckers. He attributed this poor fishery to extremely poor water-quality conditions as a result of high concentrations of nutrients, fine sediment, elevated water temperature, and excessive aquatic plant growth and algae blooms. Summer water temperatures commonly exceed 20°C in this reach. Temperatures exceeding 20°C are detrimental to most trout species (MacDonald and others, 1991). DO concentrations as low as 1.0 mg/L also have been measured (Hill, 1992a). These low DO concentrations also can be limiting to the fishery because salmonids generally require a concentration of 6.0 mg/L or more for survival in Idaho streams (Harvey, 1989).

The Federal Energy Regulatory Commission (1990) reported that the trout populations in this reach also are limited due to lack of spawning habitat, seasonally poor water quality, and competition and predation from other game and nongame fish. Hill (1992c) noted the absence of young-of-the-year salmonids in electrofishing sam-

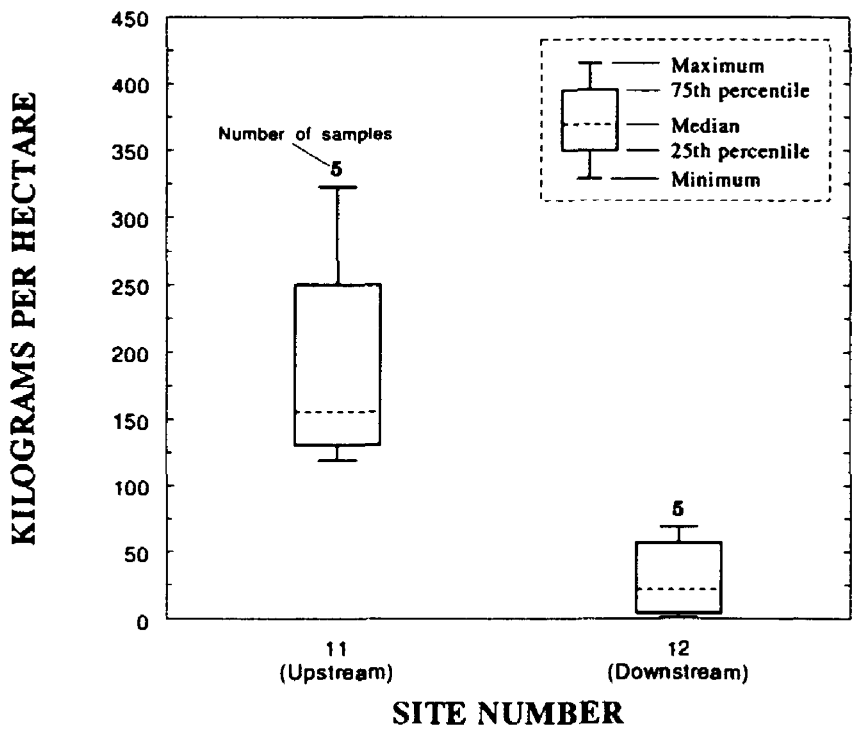


Figure 14. Estimates of trout biomass at Rock Creek sites upstream and downstream from areas of agricultural land use, 1981, 1985, 1987, 1988, and 1990. (Data from Yankey and others, 1991; site locations shown in figure 5; to convert kilograms per hectare to pounds per acre, multiply by 0.892)

ples at all collection sites in this reach during 1991. Limited salmonid spawning was observed in springs and small tributaries along this reach (F.E. Partridge, Idaho Department of Fish and Game, oral commun., 1992).

SPECIES OF SPECIAL CONCERN

Six native fish species have been listed as Species of Special Concern by IDFG: white sturgeon, Shoshone sculpin, leatherside chub (*Gila copei*), Wood River sculpin, cutthroat trout, and bull trout. These species, in addition to the redband trout, are candidates for threatened or endangered listing by the USFWS (Moseley and Groves, 1992). The distribution of these species, based on information in the IRIS data base (Allen and others, 1990), is shown in figures 11 and 13. Four fish species are listed by the WGFD as Species of Special Concern in the Wyoming part of the basin: cutthroat trout, leatherside chub, bluehead sucker (*Catostomus discobolus*), and hornyhead chub (*Nocomis biguttatus*) (Robin Jones, Wyoming Natural Diversity Database, written commun., 1992).

Although white sturgeon have been found in the lower part of the study basin (fig. 13), their numbers are declining due to reduced river flows and poor water-quality conditions in the middle Snake River reach (Platts and Pratt, 1992).

The Shoshone sculpin has been found only in a few springs in the middle Snake River reach (fig. 13). The loss of habitat caused by water diversions and aquacultural development is an immediate threat to this species (Simpson and Wallace, 1982).

The leatherside chub has been found in clear, cool streams in Wyoming and in tributaries to the Snake River downstream from American Falls Reservoir (fig. 13). This species has been collected in tributaries of the Raft River. Thurow (1987) reported that this species also has been observed in the Big Wood River drainage. One specimen has been observed in the headwaters of the Snake River near Jackson Lake (Robin Jones, Wyoming Natural Diversity Database, written commun., 1992).

The Wood River sculpin is endemic to the Wood River drainage (fig. 13). Degradation of habitat and water quality by land development, water diversions, and land management activities are immediate threats to this species in Idaho (Simpson and Wallace, 1982).

Three subspecies of cutthroat trout are recognized by the IDFG as Species of Special Concern: the west-slope (*Oncorhynchus clarki lewisi*), Snake River fine-spotted (*Oncorhynchus clarki* sp.), and Yellowstone (*Oncorhynchus clarki bouvieri*). Distributions of all three subspecies are shown in figure 11.

The west-slope subspecies is not common and has been collected at only a few locations in the Big Wood River Basin. Their presence is likely the result of introductions (Allen and others, 1990). West-slope cutthroat trout may have been native to the Big and Little Lost Rivers due to headwater transfer from the Salmon River drainage in north-central Idaho; however, this has not been confirmed (Behnke, 1992).

The Yellowstone subspecies is the most widely distributed subspecies of cutthroat trout in the basin (Behnke, 1992). Habitat degradation, introduction of nonnative salmonid species, and harvesting by fishermen have contributed to the decline of the Yellowstone subspecies (Thurow and others, 1988). Wild populations are confined largely to headwater areas throughout their former range (Trotter, 1987). The Yellowstone cutthroat trout also is recognized by WGFD as a subspecies of concern (Robin Jones, Wyoming Natural Diversity Database, written commun., 1992). Remaining populations of this subspecies in the Wyoming part of the basin are located primarily in remote headwater areas upstream from Jackson Lake (Varley and Gresswell, 1988). Although the fine-spotted and Yellowstone subspecies coexist in many regions of the basin, according to Trotter (1987), they remain genetically distinct.

The Snake River fine-spotted cutthroat is found primarily downstream from Jackson Lake to Palisades Reservoir but has been stocked in many other tributaries in the basin. This subspecies also is found in the Snake River and its tributaries downstream from Palisades Reservoir (George Stephens, Idaho Conservation Data Center, written commun., 1992).

Bull trout have been collected in the Little Lost River drainage (Allen and others, 1990, fig. 11). According to Hubbs and Miller (1948), bull trout are glacial relicts that also have been found in the northern isolated drainages of Camas, Medicine Lodge, and Birch Creeks.

The redband trout, a close relative of the rainbow trout, is found primarily in the Wood River drainage (Allen and others, 1990). This nonanadromous subspecies of rainbow trout can tolerate higher water temperatures than most other salmonids because of its adaptation to arid environments (Behnke, 1992).

The relatively rare hornyhead chub and bluehead sucker have been observed in tributaries of the Snake River near Jackson Lake (Robin Jones, Wyoming Natural Diversity Database, written commun., 1992). The distribution of these species is limited to a few occurrences each in Wyoming. The bluehead sucker is also rare in Idaho, although it has been reported in the South Fork Snake River and Willow Creek (Thurow and others, 1988).

STATUS AND TRENDS IN FISH TISSUE CONTAMINANTS

Fish are indicators of biologically available contaminants because pesticides and trace elements accumulate in their bodies at higher levels than in surrounding water. This bioaccumulation of contaminants in fish tissue provides an indication of the presence of environmental pollutants. Synthetic organic compounds and trace elements in fish tissue can be used to evaluate national and regional long-term trends in water quality. Information on contaminant concentrations in fish and other aquatic biota also can be used as an indicator of potential risk to human health and wildlife. Currently, there are no State fish consumption advisories on any streams in the basin.

In this report, synthetic organic compound and trace-element concentrations in biota are expressed in parts per million, or micrograms per gram (μg/g), wet weight. Some concentrations reported as dry weight were converted to wet weight by multiplying the dry-weight concentration by a factor of 1 minus the percentage of moisture content and are expressed as a decimal.

Most of the fish tissue data have been collected from sites shown in figure 15 and included the Henrys Fork, Portneuf River, Rock Creek, Salmon Falls Creek, Cedar Draw Creek, the main-stem Snake River, and other major tributaries. The fish tissue data were summarized from published reports (tables 8 and 9) and USEPA STORET data (tables 10 and 11). Although many of the reports contained descriptions of sampling methods and quality assurance procedures, this information was unavailable in the USEPA STORET data base.

Remark code inconsistencies in the STORET data base such as reported concentrations less than the detection limit and changes in detection limits prevented accurate determination of the actual number of detections. Also, no remark code or comments were used to differentiate between analyses based on composite or individual fish tissue samples. The data set provided only a qualitative description of constituent concentrations. The STORET data base contained fish tissue data for 28 sites in the basin. Selected data sets summarized in tables 8 and 9 are from published reports and were not included in the STORET summary (tables 10 and 11), which consists of data on fish tissue from nine sites on the Snake River and Henrys Fork.

The USFWS has assessed concentrations of potentially toxic substances in whole fish samples since 1967 as part of the National Contaminant Biomonitoring Program (NCBP) (Schmitt, 1990). This data base contained the most complete long-term information on fish tissue contaminants in the basin; however, samples were collected from only one large river site at Hagerman (fig. 15, site 16). Selected contaminants in fish tissue from the King Hill site were analyzed on a one-time basis as part of the USEPA National Bioaccumulation Study. The U.S. Department of the Interior collected site-specific contaminant data (fig. 15, sites 8 and 9) at American Falls Reservoir as part of the Irrigation Drainage Program. This study is one of the few sources of data on contaminants in aquatic vegetation and invertebrates in the basin (Low and Mullins, 1990). The Rock Creek study near Twin Falls (fig. 15, sites 11 and 12) provided an extensive data set upstream and downstream from an area affected by irrigation-return flows (Clark, 1989). Other studies by the IDHW (written commun., 1991) and Clark and Litke (1991) made up the remainder of fish tissue data. No data on fish tissue were available for the Wyoming part of the basin.

Contaminant data on aquatic flora and faunas are generally lacking, with the exception of a few site-specific studies. Most contaminant data summarized in this report are from whole fish tissue unless otherwise noted. Whole fish analyzed included bottom-feeding fish, such as sucker (*Catostomus* spp.) and carp (*Cyprinus carpio*), and trout. Concentrations of organochlorine compounds in whole fish were generally higher than in fish fillet samples because muscle tissue typically contains lower concentrations of lipophilic substances (Schmitt and others, 1981). In addition, most

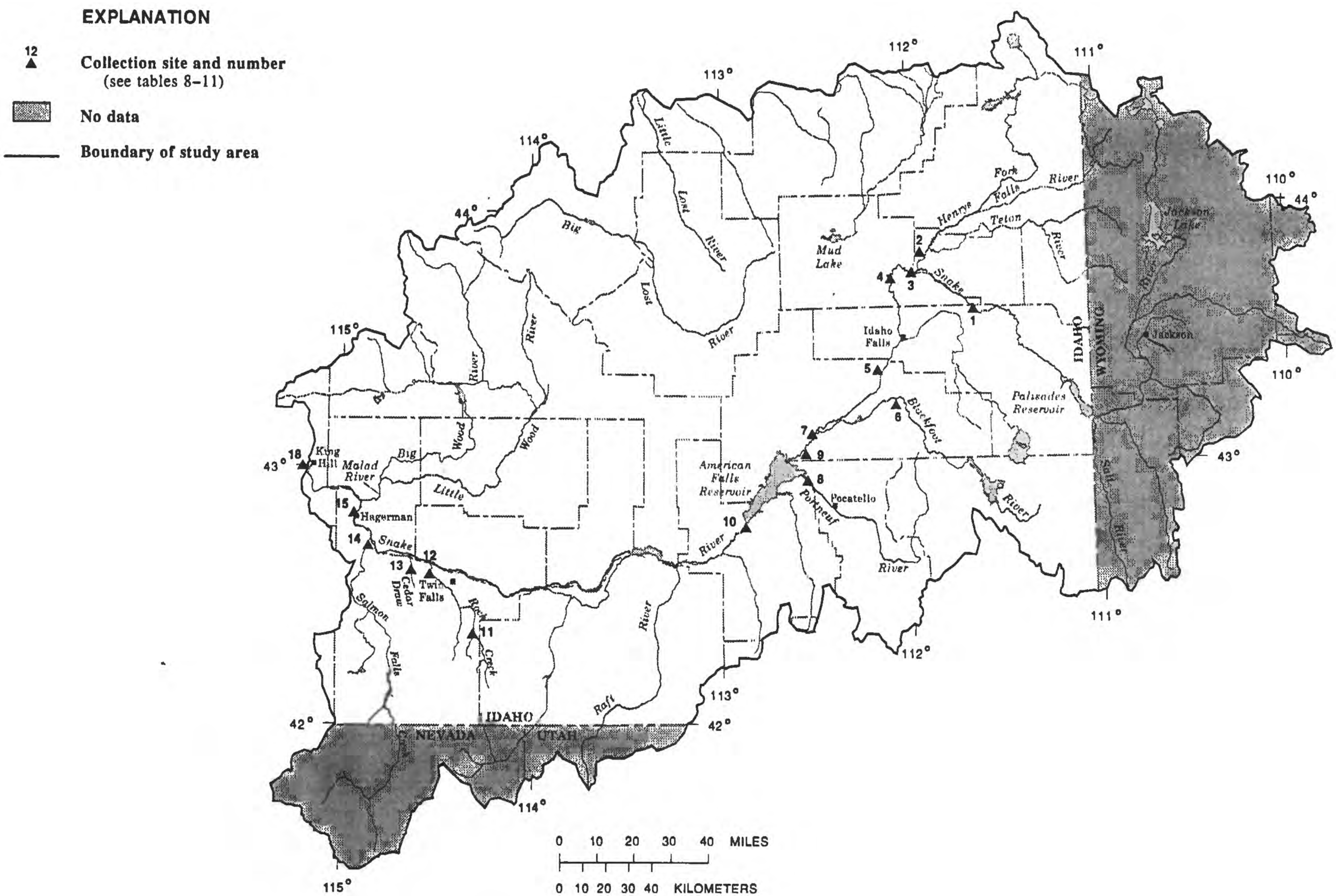


Figure 15. Fish tissue collection sites in the upper Snake River Basin.

Table 8. Synthetic organic compounds in tissue of fish collected from selected sites in the upper Snake River Basin, 1970–90

[Whole-body composite concentrations are reported in micrograms of constituent per gram, wet weight; collection sites shown in figure 15; —, no data available; IDHW-DEQ, Idaho Department of Health and Welfare, Division of Environmental Quality; USGS, U.S. Geological Survey; USFWS, U.S. Fish and Wildlife Service; BOR, Bureau of Reclamation; RCWP, Rural Clean Water Program; USEPA, U.S. Environmental Protection Agency]

Site No. end name, collecting agency, and program	Year	No. of samples	Synthetic organic compound	No. of detections	Range of detected concentrations
1 Snake River near Heise					
IDHW-DEQ Fish Tissue Ambient Monitoring Program	[1]1990	2	None	0	—
2 Henrys Fork near Rexburg					
IDHW-DEQ Fish Tissue Ambient Monitoring Program	[1]1990	2	None	0	—
3 Snake River near Menan					
IDHW-DEQ Fish Tissue Ambient Monitoring Program	[1]1990	2	None	0	—
8 Portneuf River near American Falls Reservoir					
USGS, USFWS, and BOR Irrigation Drainage Study	[2]1988	3	cis-Chlordane	3	0.010–0.060
			trans-Chlordane	3	0.010–0.060
			p,p'DDD	2	0.020–0.030
			p,p'DDE	3	0.070–0.130
			trans-Nonachlor	3	0.011–0.050
			Total PCB's	3	0.270–0.440
9 Spring Creek near Fort Hall					
USGS, USFWS, and BOR Irrigation Drainage Study	[2]1988	3	cis-Chlordane	1	0.020
			trans-Chlordane	1	0.010
			p,p'DDD	2	0.020–0.030
			p,p'DDE	2	0.090–0.100
			trans-Nonachlor	1	0.010
			Total PCB's	2	0.140–0.360
11 Rock Creek near Rock Creek (headwaters)					
IDHW-DEQ RCWP Intensive Survey	[3]1982	2	Total DDT	2	0.004–0.012
			Total PCB's	2	0.003–0.005
	[3]1985	1	p,p'DDE	1	0.004
			Heptachlor epoxide	1	0.002
			Pentachlorophenol	1	0.025
	[3]1987	3	Alpha BHC	2	0.001–0.003
			Beta BHC	1	0.002
			Gamma BHC	2	0.002–0.004
			p,p'DDE	3	0.007–0.013
			p,p'DDT	3	0.002–0.005
			Dieldrin	3	0.001–0.002
			Hexachlorobenzene	1	0.075
			Oxychlordane	1	0.001
	[3]1988	3	p,p'DDD	1	0.008
			p,p'DDE	2	0.016–0.024
			p,p'DDT	1	0.011
			Heptachlor	2	0.012–0.016
			Heptachlor epoxide	1	0.002
12 Rock Creek near Twin Falls (mouth)					
IDHW-DEQ RCWP Intensive Survey	[3]1982	2	p,p'DDT	2	0.106–1.273
			Dieldrin	2	0.011–0.041
			Total PCB's	2	0.011–0.041
			Toxaphene	1	0.645
	[3]1985	2	p,p'DDD	1	0.010
			p,p'DDE	2	0.109–0.226
			p,p'DDT	1	0.012
			trans-Nonachlor	1	0.004
			PCB 1242	1	0.063
			PCB 1260	2	0.010–0.012
			Pentachlorophenol	2	0.005–0.024
			Toxaphene	1	4.911
	[3]1987	4	Alpha BHC	2	0.000–0.001
			Beta BHC	2	0.001–0.010
			p,p'DDD	4	0.005–0.023
			p,p'DDE	4	0.081–0.300
			p,p'DDT	4	0.018–0.094
12 Rock Creek near Twin Falls (mouth)—Continued					
			Dacthal	2	0.004–0.018
			Dieldrin	4	0.003–0.010
			Endrin	1	0.001
			Endosulfan	1	0.096
			Heptachlor epoxide	1	0.002
			trans-Nonachlor	3	0.006–0.012
			Oxychlordane	3	0.002–0.094
	[3]1988	5	Alpha BHC	1	0.053
			p,p'DDD	5	0.002–0.072
			p,p'DDE	5	0.148–0.475
			p,p'DDT	5	0.019–0.058
			Dacthal	1	0.010
			Dieldrin	3	0.007–0.025
			Heptachlor	2	0.000–0.001
			Hexachlorobenzene	1	0.001
			trans-Nonachlor	1	0.010
			Oxychlordane	2	0.003–0.004
13 Cedar Draw Creek near Filer					
IDHW-DEQ RCWP Intensive Survey	[4]1987	5	Alpha BHC	2	0.017–0.041
			p,p'DDE	5	0.004–0.084
	[4]1988	[5]15	Alpha BHC	1	0.002
			p,p'DDD	5	0.001–0.005
			p,p'DDE	15	0.005–0.078
			p,p'DDT	11	0.001–0.011
			Dieldrin	7	0.001–0.005
			Endosulfan	1	0.002
			Heptachlor	6	0.001–0.019
			Lindane	1	0.001
			trans-Nonachlor	4	0.001–0.005
			Oxychlordane	4	0.002–0.019
14 Salmon Falls Creek near Buhl					
IDHW-DEQ Fish Tissue Ambient Monitoring Program	[1]1990	4	p,p'DDE	4	0.196–0.424
15 Snake River near Hagerman					
USFWS National Contaminant Biomonitoring Program	[6]1970	4	Alpha BHC	4	0.009–0.010
			p,p'DDD	4	0.080–0.260
			p,p'DDE	4	0.210–2.540
			p,p'DDT	4	0.060–0.210
			Dieldrin	4	0.010–0.020
			PCB 1254	4	0.120–1.160
	[6]1971	6	p,p'DDD	6	0.070–0.320
			p,p'DDE	6	0.090–1.870
			p,p'DDT	6	0.060–0.220
			Dieldrin	5	0.020–0.040
			PCB 1254	6	0.150–1.800
	[6]1972	4	p,p'DDD	4	0.100–0.230
			p,p'DDE	4	0.320–2.500
			p,p'DDT	2	0.060–0.440
			Dieldrin	2	0.040–0.070
			PCB 1254	3	0.050–3.700
	[6]1973	4	p,p'DDE	4	0.230–0.930
			p,p'DDT	2	0.110–0.130
			Dieldrin	1	0.030
			PCB 1254	1	0.310
	[6]1974	4	p,p'DDD	4	0.080–0.300
			p,p'DDE	4	0.290–4.300
			Dieldrin	3	0.010–0.030
			PCB 1254	4	0.110–0.530
	[7]1976	4	Alpha BHC	4	0.009–0.010
			cis-Chlordane	4	0.010–0.040
			trans-Chlordane	4	0.010–0.030
			p,p'DDD	4	0.020–0.110
			p,p'DDE	4	0.150–0.990

Table 8. Synthetic organic compounds in tissue of fish collected from selected sites in the upper Snake River Basin, 1970–90—Continued

Site No. and name, collecting agency, and program	Year	No. of samples	Synthetic organic compound	No. of detections	Range of detected concentrations
15 Snake River near Hagerman— Continued					
			p,p'DDT	3	0.009–0.010
			Dieldrin	3	0.010–0.030
			PCB 1254	2	0.200–1.100
			PCB 1260	1	0.400
	[7]1978	3	cis-Chlordane	3	0.010–0.030
			trans-Chlordane	1	0.010
			p,p'DDD	3	0.040–0.160
			p,p'DDE	3	0.160–0.490
			p,p'DDT	3	0.100–0.400
			Dieldrin	3	0.010–0.020
			cis-Nonachlor	3	0.010–0.020
			trans-Nonachlor	1	0.010–0.030
			PCB 1248	1	0.100
			PCB 1254	2	0.200–0.280
			PCB 1260	3	0.100–0.700
	[8]1981	3	trans-Chlordane	1	0.010
			p,p'DDD	3	0.030–0.060
			p,p'DDE	3	0.190–0.620
			p,p'DDT	1	0.010
			Dieldrin	2	0.009–0.010
			Endrin	1	0.010
15 Snake River near Hagerman— Continued					
			cis-Nonachlor	1	0.010
			trans-Nonachlor	2	0.010–0.020
			PCB 1254	1	0.100
			PCB 1260	2	0.100–0.200
			Toxaphene	1	0.100
	[9]1984	3	cis-Chlordane	2	0.009–0.010
			p,p'DDD	3	0.020–0.040
			p,p'DDE	3	0.140–0.340
			p,p'DDT	3	0.010–0.020
			Dacthal	1	0.010
			Endrin	1	0.010
			cis-Nonachlor	1	0.010
			trans-Nonachlor	3	0.009–0.010
			PCB 1260	2	0.009–0.010
16 Snake River near King Hill					
USEPA National Bioaccumulation Study	[10]1984	1	p,p'DDE	1	0.197
			trans-Nonachlor	1	0.004
			Total PCB's	1	0.041
IDHW-DEQ Fish Tissue Ambient Monitoring Program	[1]1990	2	None	0	—

[1]Idaho Department of Health and Welfare (written commun., 1991); [2]Low and Mullins (1990); [3]Clark (1989); [4]Clark and Litke (1991); [5]Individual trout analyzed; [6]Schmitt and others (1981); [7]Schmitt and others (1983); [8]Schmitt and others (1985); [9]Schmitt and others (1990); [10]U.S. Environmental Protection Agency (1992).

trace elements concentrate in the viscera (heart and liver) of fish (Johnson and others, 1977).

Tissue contaminant concentrations shown in table 12 are compared with the NCBP 1980–81 nationwide geometric mean concentrations for synthetic organic compounds and trace elements. The NCBP concentrations are included as a nationwide baseline with which to compare basin concentrations. In addition, the National Academy of Sciences and National Academy of Engineering criteria (1973) for the protection of predatory fish and wildlife were used to assess selected organochlorine concentrations in tissue. These criteria state that (1) p,p'DDT and its metabolites should not exceed 1.0 µg/g, wet weight; (2) residues of aldrin, BHC, chlordane, dieldrin, endrin, heptachlor epoxide, and toxaphene should not exceed 0.1 µg/g, wet weight, either singly or in combination; and (3) total PCB residue should not exceed 0.5 µg/g, wet weight. The Food and Drug Administration action levels are specific to edible parts of fish and shellfish but are not directly comparable to concentrations in whole fish (U.S. Environmental Protection Agency, 1992). Contaminant concentrations associated with adverse biological effects reported in toxicity studies also were used to evaluate the status of contaminant concentrations in fish tissue.

Synthetic Organic Compounds

Synthetic organic compounds enter the aquatic environment primarily from the atmosphere, industrial and municipal effluent, and agricultural nonpoint source runoff. These compounds commonly adsorb on suspended particles and are deposited along the stream bottom. In turn, bottom-sediment contaminants may be ingested by bottom-dwelling organisms. Bottom-feeding species such as suckers are particularly vulnerable to the accumulation of these compounds. Chlorinated insecticides and PCB's are probable carcinogens, and the use of many of them has been discontinued since the 1970's (U.S. Environmental Protection Agency, 1989). However, DDT and PCB's and their metabolites are expected to remain in tissue in the foreseeable future, even though their use has been discontinued due to their persistence in the environment (U.S. Environmental Protection Agency, 1992). Concentrations of p,p'DDE and PCB's were detected at 98 and 90 percent, respectively, of 388 sites sampled throughout the Nation between 1986 and 1989 (U.S. Environmental Protection Agency, 1992).

Concentrations of p,p'DDT and its metabolites and PCB's were found in most of the fish tissue samples

Table 9. Trace elements in tissue of fish collected from selected sites in the upper Snake River Basin, 1977–90

[Whole-body composite concentrations are reported in micrograms of constituent per gram, wet weight; collection sites shown in figure 15; —, no data available; IDHW-DEQ, Idaho Department of Health and Welfare, Division of Environmental Quality; USGS, U.S. Geological Survey; USFWS, U.S. Fish and Wildlife Service; BOR, Bureau of Reclamation; RCWP, Rural Clean Water Program; USEPA, U.S. Environmental Protection Agency; <, less than]

Site No. and name, collecting agency, and program	Year	No. of samples	Trace element	No. of detections	Range of detected concentrations
1 Snake River near Heise					
IDHW-DEQ	[1]1990	2	Cadmium	1	0.05
Fish Tissue Ambient			Copper	2	0.97–2.24
Monitoring Program			Lead	—	—
			Mercury	2	0.07–0.11
2 Henrys Fork near Rexburg					
IDHW-DEQ	[1]1990	2	Cadmium	1	0.04
Fish Tissue Ambient			Copper	2	0.77–0.99
Monitoring Program			Lead	—	—
			Mercury	2	0.07–0.28
3 Snake River near Menan					
IDHW-DEQ	[1]1990	2	Cadmium	—	—
Fish Tissue Ambient			Copper	2	0.81–1.09
Monitoring Program			Lead	1	0.20
			Mercury	1	0.06
8 Portneuf River near American Falls Reservoir					
USGS, USFWS,	[2]1988	3	Arsenic	3	0.06–0.13
and BOR Irrigation			Cadmium	3	<0.50
Drainage Study			Copper	3	<2.50
			Lead	3	<10.00
			Mercury	3	0.10–0.22
			Selenium	3	0.21–0.71
			Zinc	3	19.91–137.16
9 Spring Creek near Fort Hall					
USGS, USFWS,	[2]1988	2	Arsenic	2	0.14–0.51
and BOR Irrigation			Cadmium	2	<0.50
Drainage Study			Copper	2	<2.50
			Lead	2	<10.00
			Mercury	2	0.04–0.07
			Selenium	2	0.39
			Zinc	2	3.32–21.98
11 Rock Creek near Rock Creek (headwaters)					
IDHW-DEQ RCWP	[3]1988	3	Copper	3	0.52–0.56
Intensive Survey			Mercury	3	0.15–0.18
			Zinc	3	8.48–15.26
12 Rock Creek near Twin Falls (mouth)					
IDHW-DEQ RCWP	[3]1988	2	Copper	2	0.76–1.57
Intensive Survey			Mercury	2	0.06–0.07
			Zinc	2	7.30–9.84
13 Cedar Draw Creek near Filer					
IDHW-DEQ RCWP	[4]1985	7	Arsenic	7	<0.01–0.26
Intensive Survey			Cadmium	7	<0.001–0.011
			Chromium	7	<0.01–0.36
			Copper	7	0.18–1.36
13 Cedar Draw Creek near Filer —Continued					
			Lead	7	<0.01–0.12
			Manganese	7	0.11–0.45
			Mercury	7	0.01–0.12
			Zinc	7	4.53–31.86
	[4]1988	[5]15	Copper	15	0.43–0.98
			Mercury	15	0.02–0.09
			Zinc	15	5.60–9.21
14 Salmon Falls Creek near Buhl					
IDHW-DEQ	[1]1990	4	Cadmium	—	—
Fish Tissue Ambient			Copper	4	0.54–2.09
Monitoring Program			Lead	1	0.25
			Mercury	4	0.07–0.40
15 Snake River near Hagerman					
USFWS National	[6]1977	4	Arsenic	—	—
Contaminant			Cadmium	—	—
Biomonitoring			Lead	—	—
Program			Mercury	—	—
			Selenium	—	—
	[7]1978	3	Arsenic	3	0.09–0.10
			Cadmium	3	0.01–0.20
			Copper	3	0.6–3.1
			Lead	3	0.10–0.17
			Mercury	3	0.06–0.10
			Selenium	3	0.38–0.69
			Zinc	3	22.6–54.0
	[7]1980	3	Arsenic	3	0.05–0.06
			Cadmium	3	0.01
			Copper	3	0.6–0.7
			Lead	3	0.10–0.29
			Mercury	3	0.03–0.15
			Selenium	3	0.32–0.54
			Zinc	3	16.4–25.1
	[8]1984	3	Arsenic	3	0.06–0.28
			Cadmium	1	0.01
			Copper	3	0.49–1.06
			Lead	3	0.02–0.09
			Mercury	3	0.03–0.06
			Selenium	3	0.33–0.45
			Zinc	3	13.29–26.20
16 Snake River near King Hill					
USEPA National Bioaccumulation Study	[9]1984	3	Mercury[10]	2	0.14–0.16
IDHW-DEQ	[1]1990	2	Cadmium	—	—
Fish Tissue Ambient			Copper	2	0.74–0.90
Monitoring Program			Lead	1	0.14
			Mercury	1	0.50

[1]Idaho Department of Health and Welfare (written commun., 1991); [2]Low and Mullins (1990); [3]Clark (1989); [4]Clark and Litke (1991); [5]Individual trout analyzed; [6]May and McKinney (1981); [7]Lowe and others (1985); [8]Schmitt and Braumbaugh (1990); [9]U.S. Environmental Protection Agency (1992); [10]Only trace element analyzed.

Table 10. Ranges of concentrations of synthetic organic compounds in tissue of fish collected by the Idaho Department of Health and Welfare from selected sites in the upper Snake River Basin, 1976–82

[Quality assurance and methods are not known; whole-body composites and individual fish concentrations in micrograms per gram, wet weight; data from U.S. Environmental Protection Agency STORET data base (1992); <, less than; —, no data available]

Collection site No. (fig. 15)	Site name	STORET Nos.	Date	No. of analyses	BHC	cis-Chlordane	trans-Chlordane	p,p' DDD	p,p' DDE	p,p' DDT	Total DDT	Dieldrin	Endrin	HCB
1	Snake River near Heise	06A004–IDA 2080000	1978–82	38	—	<0.001	<0.001	<0.001–0.010	<0.001–0.094	<0.001–0.050	<0.001–0.142	<0.001–0.007	<0.001	<0.001–0.005
2	Henrys Fork near Rexburg	151105 2080257	1976–82	69	<0.005–0.170	<0.0001	<0.0001	<0.001–0.186	0.003–1.765	<0.001–0.566	<0.001–1.991	<0.0003–0.034	<0.001	<0.001–0.005
3	Snake River near Menan	151182	1978–82	21	<1.001–0.015	—	—	<0.001–0.134	0.002–0.893	<0.001–0.055	0.002–1.080	—	<0.001	<0.001
4	Snake River at Roberts	2080003	1976	26	<0.005–0.027	—	—	0.005–0.317	0.095–1.313	<0.005–0.430	—	0.001–0.069	—	<0.005
5	Snake River at Shelley	2080007	1978–82	36	0.005–0.025	—	—	0.002–0.260	0.054–1.860	0.004–0.580	0.094–0.909	<0.0003–0.035	—	<0.001–0.005
6	Snake River above Blackfoot	2080009	1976–78	6	<0.005–0.052	—	—	<0.002–0.160	0.016–0.857	<0.002–0.360	0.016–0.868	<0.0003–0.021	—	0.001–0.005
7	Snake River below Blackfoot	151102 2080011	1976–81	18	—	—	—	1.001–0.100	0.029–0.675	<0.001–0.960	0.031–0.364	<0.001–0.019	<0.001	<0.001–0.005
10	Snake River at Neeley	06A003–IDA 2080012	1976–82	45	—	0.001–0.015	<0.001–0.015	<0.001–0.083	0.002–0.387	<0.001–0.089	0.002–0.550	<0.001–0.020	<0.001	<0.0003–0.012
16	Snake River near King Hill	07A002–IDA	1979	1	<0.001	—	—	0.020	0.310	0.004	0.330	0.006	<0.001	—

Collection site No. (fig. 15)	Site name	STORET Nos.	Date	No. of analyses	Aldrin	Heptachlor epoxide	cis-Nonschlor	trans-Nonschlor	Oxychlordana	PCB 1254	PCB 1260	PCP	Sevin	2,4-D
1	Snake River near Heise	06A004–IDA 2080000	1978–82	38	—	<0.001	<0.001	<0.001–0.004	—	<0.001–0.619	0.003–4.997	<0.001–0.012	—	—
2	Henrys Fork near Rexburg	151105 2080257	1976–82	69	<0.001	0.002	<0.001	<0.001–0.033	—	<0.001–6.074	<0.001–0.893	<0.001–0.011	—	—
3	Snake River near Menan	151182	1978–82	21	<0.001	<0.001–0.002	—	<0.001–0.018	—	<0.001–0.084	0.002–0.189	<0.001–0.016	—	—
4	Snake River at Roberts	2080003	1976	26	—	0.005–0.051	—	—	—	0.014–0.960	—	—	0.050–0.110	<1.00–6.00
5	Snake River at Shelley	2080007	1978–82	36	—	0.003	—	0.001–0.021	—	0.090–1.800	—	—	—	—
6	Snake River above Blackfoot	2080009	1976–78	6	—	<0.002	—	<0.001–0.004	—	0.006–1.100	—	—	—	—
7	Snake River below Blackfoot	151102 2080011	1976–81	18	<0.001	<0.001–0.041	—	<0.001–0.045	<0.001	<0.001–1.400	0.044–0.131	<0.001–0.033	<0.005–0.007	<1.00–5.00
10	Snake River at Neeley	06A003–IDA 2080012	1976–82	45	<0.001	<0.002–0.004	<0.001	<0.001–0.007	—	<0.001–0.850	<0.001–0.172	<0.001–0.130	—	—
16	Snake River near King Hill	07A002–IDA	1979	1	<0.001	—	—	0.027	—	0.172	—	0.010	—	—

throughout the basin (tables 8 and 10). Concentrations of these compounds exceeded guidelines for the protection of predatory fish and wildlife (1.0 µg/g, wet weight, for p,p'DDT and its metabolites and 0.5 µg/g, wet weight, for total PCB's) (National Academy of Sciences and National Academy of Engineering, 1973). Highest concentrations of p,p'DDT and its metabolites were found in fish in the Snake River near Hagerman. A maximum concentration of 4.3 µg/g of p,p'DDE was found in 1974 in fish at this site. Maximum concentrations of p,p'DDT and its metabolites in fish at this site generally declined between 1970 and 1984; most concentrations were below the National Academy of Sciences and National Academy of Engineering (NAS/NAE) criterion (fig. 16). A similar decline in PCB concentrations was observed in fish at this site (fig. 17). Statistical trend analysis showed no significant increasing or decreasing trends in mean concentrations of organochlorine constituents in fish at this site, although the sample size was small and the data had a large standard error (Schmitt and others, 1990).

The STORET fish tissue data showed little change in concentrations of PCB's for sites on the Snake River from Heise to King Hill (table 10). In contrast, unusually high concentrations of PCB's were found in samples of tissue from fish in the Snake River near Heise (4.997 µg/g) and the Henrys Fork near Rexburg (6.074 µg/g) between 1976 and 1982. Samples of tissue from fish collected at these sites in 1990 (table 8) contained no detectable concentrations of synthetic organic compounds (Idaho Department of Health and Welfare, written commun., 1991).

Samples of tissue from fish collected at Rock Creek sites (fig. 15, site 11) contained fewer detectable and lower concentrations of synthetic organic compounds compared with fish collected at the downstream site near Twin Falls (fig. 15, site 12) for the same time period (table 8). The downstream site near Twin Falls is affected by nonpoint source sediment and associated pollutants from irrigated agriculture (Clark, 1989). Samples of tissue from fish collected at the downstream site contained unusually high concentrations of

Table 11. Ranges of concentrations of trace elements in tissue of fish collected by the Idaho Department of Health and Welfare from selected sites in the upper Snake River Basin, 1976–82

[Quality assurance and methods are not known; whole-body composites and individual fish concentrations in micrograms per gram, wet weight; data from U.S. Environmental Protection Agency STORET data base (1992); <, less than; —, no data available]

Collection site No. (fig. 15)	Site name	STORET Nos.	Date	No. of analyses	Arsenic	Cadmium	Copper	Lead	Mercury
1	Snake River near Heise	06A004-IDA 2080000	1978–82	38	0.050–0.800	0.005–0.080	<0.060–1.300	0.010–0.800	<0.0001–0.330
2	Henrys Fork near Rexburg	151105 2080257	1976–82	69	<0.050–0.700	0.005–0.070	0.260–18.200	<0.010–1.800	0.030–0.660
3	Snake River near Menan	151182	1978–82	21	<0.050–0.700	0.005–0.070	0.290–4.100	<0.010–0.700	0.030–0.440
4	Snake River at Roberts	2080003	1976	26	<0.500	—	—	—	0.020–0.170
5	Snake River at Shelley	2080007	1978–82	36	—	—	—	—	<0.0001–0.099
6	Snake River above Blackfoot	2080009	1976–78	25	—	—	—	—	<0.0001–0.358
7	Snake River below Blackfoot	151102 2080011	1976–81	28	<0.300–0.800	0.010–0.280	<0.600–3.300	<0.400–0.800	0.030–0.480
10	Snake River at Neeley	06A003-IDA 2080012	1976–82	39	<0.100–0.800	<0.010–0.080	0.480–6.800	<0.100–1.500	<0.0001–0.640
16	Snake River near King Hill	07A002-IDA	1979	1	—	<0.070	1.300	<0.700	0.240

toxaphene ranging from 0.645 to 4.911 µg/g in 1982 and 1985, respectively. These concentrations exceeded the NAS/NAE (1973) criterion of 0.1 µg/g. Toxaphene is used to control insect pests on various crops and on livestock (Schmitt and others, 1983).

In 1984, the USEPA collected fish from the Snake River near King Hill (fig. 15, site 16) and analyzed tissue samples for dioxins and furans as part of the National Bioaccumulation Study (U.S. Environmental Protection Agency, 1992). These compounds have been detected in surface water and aquatic biota downstream from paper and pulp mills, wood preservation and other industries, and municipal discharges (U.S. Environmental Protection Agency, 1990b). Two composite samples (fillets and whole) of a bottom-feeding fish (sucker) were analyzed for six dioxin and nine furan compounds. Only one dioxin compound (1,2,3,4,6,7,8 heptachlorinated dibenzodioxin) was detected (0.005 µg/g). This dioxin congener is not as toxic as other dioxin and furan compounds (U.S. Environmental Protection Agency, 1990b). The lack of discharge sources and the relatively low concentrations detected indicate

Table 12. Geometric mean concentrations of synthetic organic compounds and trace elements in tissue of fish collected for the U.S. Fish and Wildlife Service National Contaminant Biomonitoring Program, 1980–81

[Concentrations represent a nationwide baseline of 107 to 112 stations for synthetic organic compounds and trace elements, respectively; data from Lowe and others (1985) and Schmitt and others (1990); whole-body composites are reported in micrograms of constituent per gram, wet weight; <, less than]

Synthetic organic compound			
Alpha BHC	<0.01	Heptachlor epoxide	0.01
Gamma BHC	<.01	Methoxychlor	<.01
cis-Chlordane	.03	Mirex	<.01
trans-Chlordane	.02	cis-Nonachlor	.02
p,p'DDD	.07	trans-Nonachlor	.04
p,p'DDE	.20	Oxychlordane	.01
p,p'DDT	.05	PCA	<.01
Total DDT	.29	PCB 1248	.11
Dacthal	<.01	PCB 1254	.24
Dieldrin	.04	PCB 1260	.25
Endrin	<.01	Total PCB's	.53
HCB	<.01	Toxaphene	.28
Trace element			
Arsenic	0.14	Mercury	0.11
Cadmium	.03	Selenium	.47
Copper	.68	Zinc	23.82
Lead	.17		

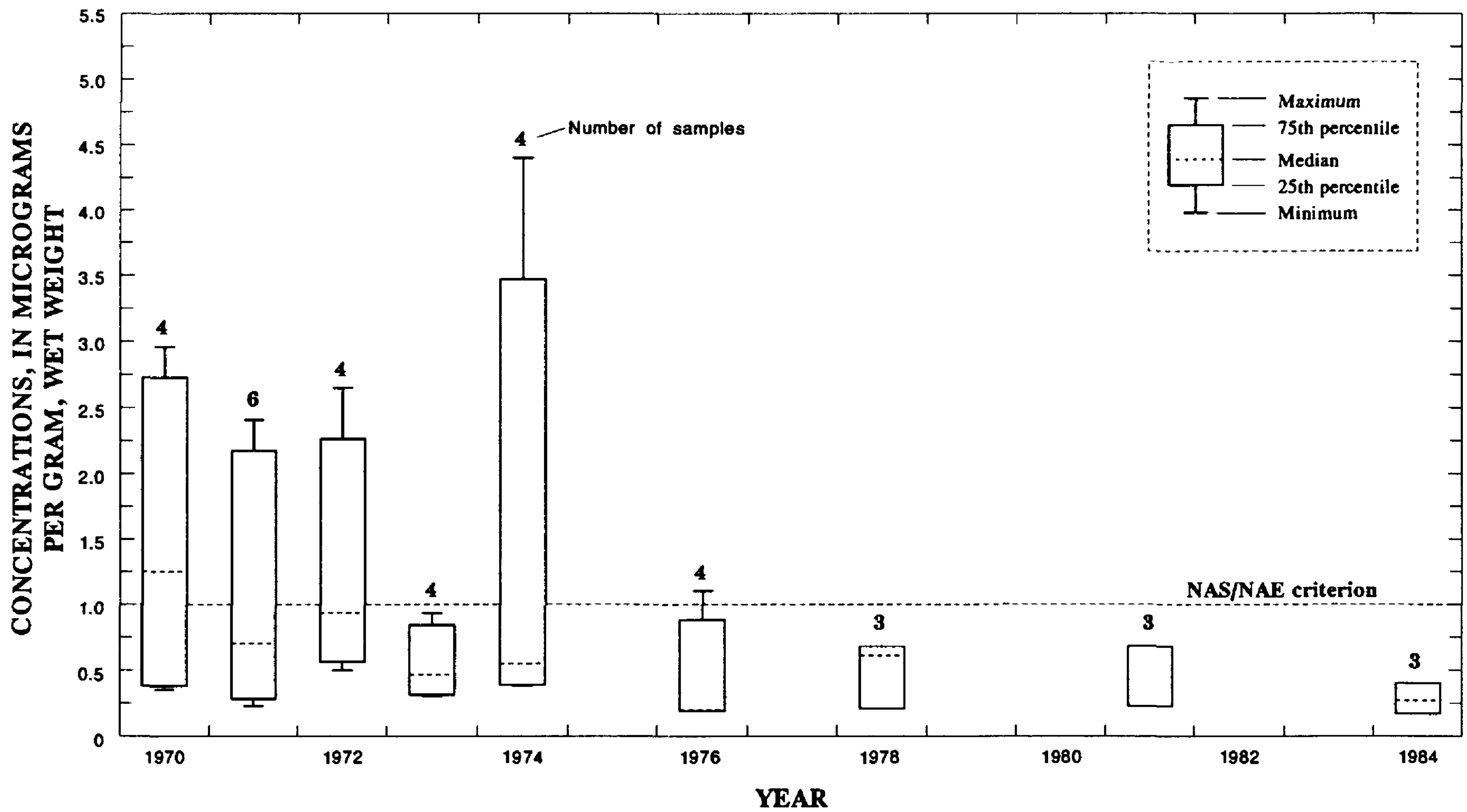


Figure 16. Concentrations of total DDT in whole fish collected from the Snake River near Hagerman for the U.S. Fish and Wildlife Service National Contaminant Biomonitoring Program, 1970–84. [NAS/NAE, National Academy of Sciences and National Academy of Engineering; data from Lowe and others (1985); the criterion shown is not to be exceeded for the protection of predatory fish and wildlife (NAS/NAE, 1973)]

that the dioxin and furan contaminants are not a problem in the basin.

Trace Elements

Most trace elements are essential to animal and plant nutrition but can be toxic in high concentrations. Trace elements in the aquatic environment are present naturally from weathering of rocks and mineral soils and from human sources such as the burning of fossil fuels, industrial discharges, automobile emissions, mining, and agricultural pesticides and fertilizers.

Elevated cadmium and mercury concentrations in tissue of fish from American Falls Reservoir near Pocatello have been reported by Runyan (1972), Jarmon (1973), Kent (1976), and Johnson and others (1977). Low and Mullins (1990) also reported slightly elevated mercury and selenium concentrations in fish in tributaries to the reservoir. Johnson and Kent (1978) listed sewage and industrial effluent from Pocatello and irrigation drainage as possible sources of trace elements in fish in the reservoir (fig. 15, sites 8 and 9). The elevated concentrations also may be indicative of transient reservoir fish that had been exposed to accumulations of trace elements in the bottom sediments. Elevated concentrations of trace elements in biota and sediment are possible in other impoundments on the Snake River.

Concentrations of arsenic, cadmium, copper, lead, and mercury in tissue of fish from Snake River sites (table 10) collected during 1976–82 from the USEPA STORET data base showed no clear pattern. Highest concentrations of these trace elements (table 11) exceeded the nationwide baseline concentration shown in table 12. Fish from the Henrys Fork near Rexburg site had the highest concentrations of copper (18.2 µg/g), lead (1.8 µg/g), and mercury (0.66 µg/g). Generally, reported concentrations of trace elements were similar or slightly above the 1980–81 NCBP baseline, except for arsenic, mercury, and selenium.

The NCBP trace-element concentrations in tissue of fish collected between 1977 and 1984 from the

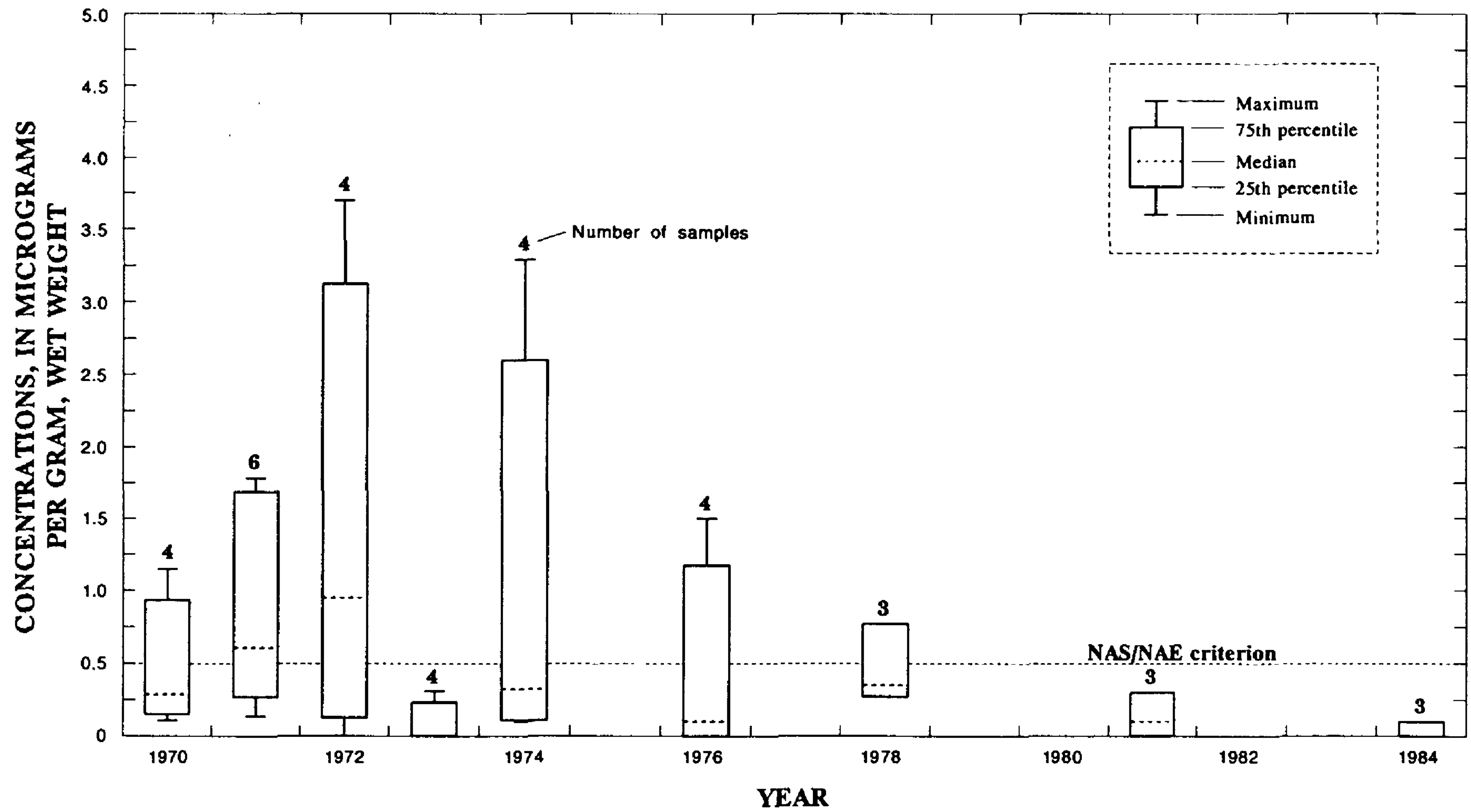


Figure 17. Concentrations of total PCB's in whole fish collected from the Snake River near Hagerman for the U.S. Fish and Wildlife Service National Contaminant Biomonitoring Program, 1970–84. [NAS/NAE, National Academy of Sciences and National Academy of Engineering; data from Lowe and others (1985); the criterion shown is not to be exceeded for the protection of predatory fish and wildlife (NAS/NAE, 1973)]

Snake River near Hagerman (site 15) generally were similar to the nationwide baseline concentrations (tables 9 and 12). Schmitt and Brumbaugh (1990) noted no trend in mean concentrations of trace elements at this site.

Platts and Martin (1978) analyzed cutthroat trout viscera and gills from 11 sites in the Blackfoot River Basin for cadmium, copper, mercury, vanadium, and zinc. They found that trace-element concentrations were not affecting fish health and that phosphate mining in the watershed was not adversely affecting fish communities.

Generally, mercury concentrations in tissue of fish from most sites in the upper Snake River Basin (table 9) and listed in the STORET data base (table 11) exceeded the 1980–81 NCBP baseline of 0.11 μg/g. Mercury rapidly bioaccumulates and is a nonessential element for fish and other wildlife. The Food and Drug Administration action level in fish tissue is 1.0 μg/g for mercury (U.S. Environmental Protection Agency, 1992). No concentrations in tissue of fish from the 16 sites summarized exceeded this action level. However, biomagnification may occur in the food chain through fish-eating birds. Eisler (1987) recommended that concentrations should not exceed 0.1 μg/g to protect birds that consume fish and other aquatic organisms. IDHW (written commun., 1991) found mercury concentrations of 0.50 μg/g in tissue of fish from the Snake River near King Hill (table 9) and recommended additional sampling to assess its occurrence in edible fish species.

Selenium has been reported in tissue of fish from a few locations in the study area. Low and Mullins (1990) found selenium concentrations as high as 0.71 μg/g in fish in the Portneuf River near American Falls Reservoir (table 9). This concentration exceeded the NCBP 1980–81 baseline of 0.47 μg/g. The only other site where selenium exceeded the NCBP concentration was the Snake River near Hagerman (table 9). Walsh and others (1977) reported that selenium concentrations above 0.5 μg/g in whole fish are considered harmful to fish and predators.

Some arsenic concentrations reported in tissue of fish from Spring Creek near Fort Hall (0.51 μg/g), Cedar Draw Creek near Filer (0.26 μg/g), and Snake River near Hagerman (0.28 μg/g) (table 9) exceeded the 1980–81 NCBP baseline of 0.14 μg/g. Arsenic concentrations reported in the STORET data base were highest (0.7–0.8 μg/g) in fish from five Snake River sites (table 11). Arsenic concentrations above 0.5 μg/g in whole fish are considered harmful to fish and predators (Walsh and others, 1977).

A maximum concentration of 137.16 μg/g of zinc was found in tissue of fish from the Portneuf River near American Falls Reservoir (table 9). This concentration exceeded the NCBP baseline of 23.82 μg/g (table 12). Lowe and others (1985) noted that the high zinc concentrations were found only in carp, which tend to accumulate higher concentrations of zinc than other species do. The toxicological effects of zinc in tissue are not well known.

SUMMARY

Assessment of aquatic life and associated water quality in streams in the upper Snake River Basin is an important component of the National Water-Quality Assessment Program, which began in 1991. Monitoring of biological integrity can provide an index of water quality and trends that affect beneficial uses of surface-water resources, detect problems that other methods might miss or underestimate, and provide a systematic process for measuring progress of pollution abatement programs. Biological criteria for monitoring fish and aquatic invertebrate communities have been developed for ecoregions on the basis of data from minimally affected reference streams, and monitoring protocols have been developed for wadable streams in the Pacific Northwest.

Biological data collected by Federal, State, and academic organizations were used to assess the status and trends of aquatic life and water quality in the basin. Most of the biological data were for fish and macroinvertebrate communities. The U.S. Environmental Protection Agency STORET and the Idaho Department of Fish and Game Idaho Rivers Information System data bases provided information on contaminants, community composition, and species distributions. The Idaho Department of Health and Welfare Rock Creek Rural Clean Water Program (RCWP) provided the only long-term data on aquatic life in the basin.

The 35,800-mi^2 upper Snake River Basin contains 24 major subbasins in 4 major ecoregions. The basin contains about 8,461 mi of streams; 79 percent are in Idaho and 21 percent are in Wyoming. Surface water in the basin generally is supportive for aquatic life and most is suitable for cold-water biota. Streamflow in the basin is highly regulated by dams and diversions and is

used primarily for agriculture and hydroelectric-power generation. Streamflow in most major tributaries to the Snake River upstream from Milner Dam is altered by one or more storage reservoirs. Predominant land uses in the study area are rangeland, forest land, and agricultural land. The Snake River Basin/High Desert is the predominant ecoregion in the basin and composes 50 percent of the surface area. Predominant features of this ecoregion include tablelands with moderate to high relief, sagebrush steppe vegetation, land uses of grazing and irrigated agriculture, and desert soils.

The Snake River is the predominant hydrologic feature in the basin. Aquatic life in the middle reach of the Snake River is affected by nutrient and sediment inputs from point and nonpoint sources and low streamflows resulting from drought conditions and diversions. Excessive plant growth, extreme fluctuations of dissolved oxygen, and high water temperature have limited the diversity of aquatic life in this reach.

Most aquatic habitat studies in the basin have focused on salmonid fisheries. Some of the specific variables used to measure stream habitat conditions in the basin are intragravel dissolved-oxygen concentrations and amount of fine sediment related to salmonid embryo survival, cobble embeddedness, thalweg profile, pool and riffle quality, and residual pool index. Monitoring protocols have been developed for assessing these habitat conditions for Idaho streams. Water temperature also has been identified as an important habitat variable affecting cold-water aquatic life in the basin.

Nonpoint source pollution is the predominant influence on surface-water quality of the basin. Pollutants of greatest concern in the basin are nutrients, sediment, bacteria, and organic wastes. Thermal pollution also is a concern in some areas. Water resources development and stream alterations, irrigated agriculture, grazing, aquaculture, and species introductions are the major human activities affecting the aquatic life. Primary affected beneficial uses are cold-water biota, salmonid spawning, and water-contact recreation.

Macroinvertebrates have been collected in the basin to assess environmental effects and to characterize conditions in reference streams within specific ecoregions. Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa usually predominate in healthy aquatic habitats in the basin. Reduction in numbers of these taxa is indicative of degraded conditions. Long-term data on macroinvertebrate communities in the basin are lacking, with the exception of the Rock Creek RCWP data on the effects of agricultural land use on macroinvertebrate communities. The median EPT index at sites downstream from areas of intensive agricultural land use was lower than at an upstream control site, indicating the detrimental effects of agricultural land use on macroinvertebrate communities.

Twenty-six macroinvertebrate metrics have been used to assess cold-water streams in Idaho. The EPT taxa richness, Shannon's diversity index, percentage of EPT, Hilsenhoff's biotic index, Simpson's dominance index, percentage of dominant taxa, and percentage of filterers were factors used to distinguish stream types and ecoregions.

Macroinvertebrate Species of Special Concern are gastropods and bivalve mollusks, which have been extensively surveyed in the middle Snake River and associated spring habitats. Five mollusks in the basin currently are listed as endangered or threatened species: the Utah valvata snail, Bliss Rapids snail, Snake River Physa snail, Idaho springsnail, and Banbury Springs limpet. The Columbia pebblesnail, shortface limpet, and California floater are other Species of Special Concern and are candidates for Federal listing. The mollusk faunas in the middle Snake River have changed from endemic, cold-water faunas to more pollution-tolerant and exotic species.

Chinook salmon, steelhead, and Pacific lamprey (anadromous species) have been eliminated from the upper Snake River Basin downstream from Shoshone Falls as a result of the construction of hydroelectric-power facilities. Most fish data were collected to assess sportfishery and associated habitat conditions. Most native fish faunas are cold-water species, representing 5 families and 26 species. An additional 13 species have been introduced primarily for sportfishery enhancement.

Because of the introduction of warm-water species, fish communities in the middle Snake River were the most dissimilar to those in other drainages in the basin. Shoshone Falls, a natural barrier to fish migrations, has influenced fish species distributions. Native fish species in the basin that are not found upstream from this natural barrier are the bridgelip sucker, largescale sucker, chiselmouth, leopard dace, northern squawfish, peamouth, white sturgeon, Wood River sculpin, and Shoshone sculpin. Typical headwater streams in the basin have sparse fish faunas, few species, and low abundances. Trout and sculpin typically are the predominant fish collected in small headwater streams. Twenty-six fish community metrics have been measured in Idaho to assess cold-water stream conditions. Most of these metrics are associated with attributes of salmonid fisheries. Number of salmonid species, number of tolerant species, percentage of salmonids, salmonid biomass, abundance of pollution-tolerant species, and salmonid condition index are important metrics in distinguishing stream types and ecoregions in the basin.

Eight fish species in the basin are recognized by Idaho Department of Fish and Game and Wyoming Game and Fish Department as Species of Special Concern. These include the white sturgeon, Shoshone sculpin, leatherside chub, Wood River sculpin, cutthroat trout, bull trout, bluehead sucker, and hornyhead chub.

Synthetic organic compounds and trace elements in fish tissue can be used to evaluate national and regional long-term trends in water quality. Currently, no State fish consumption advisories have been issued on any streams in the basin. Fish tissue contaminants are generally below National Contaminant Biomonitoring Program (NCBP) baseline concentrations. However, concentrations of DDT and PCB's were found in most samples of tissue from fish collected in the basin between 1970 and 1990. Some concentrations exceeded criteria for the protection of predatory fish and wildlife. Selected long-term data on DDT and PCB's indicate declining concentrations in fish tissue during the same period. Other synthetic organochlorine compounds found in tissue generally were below NCBP 1980–81 geometric mean concentrations. Samples of tissue from fish collected in the Snake River near King Hill during a one-time sampling in 1984 did not contain dioxins and furans at concentrations of concern.

Slightly elevated concentrations of arsenic, cadmium, mercury, selenium, and zinc in tissue of fish in the basin have been reported. Mercury concentrations in fish from most sites exceeded the NCBP baseline concentration; however, concentrations did not exceed the Food and Drug action level for fish consumption. The Idaho Department of Health and Welfare found mercury concentrations of 0.50 μg/g and recommended additional sampling to assess concentrations in edible fish. Between 1976 and 1982, concentrations of copper, lead, and mercury reported in the STORET data base were highest in tissue of fish from the Henrys Fork near Rexburg.

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SUPPLEMENTAL INFORMATION

Table A. Macroinvertebrate functional feeding groups and tolerances to organic compounds, sediment, and warm-water pollution in streams in the upper Snake River Basin

[Pollution tolerance values range from 0 to 11; 0 is the least tolerant and 10 the most tolerant; 11 is unknown. Tolerances from Hilsenhoff (1987). Sources of information: Pennak (1978); Merritt and Cummins (1984); Hilsenhoff (1987); Plafkin and others (1989); Klemm and others (1990); Wisseman (1990); W.H. Clark and T.R. Maret, Idaho Department of Health and Welfare, written commun. (1991); Nebraska Department of Environmental Control (1991); Frest (1992); T.J. Frest, Deixis Consultants, written commun. (1992). Functional feeding group: CG, Collector-Gatherer; CF, Collector-Filterer; MH, Macrophyte Herbivore; OM, Omnivore; PA, Parasite; PH, Piercer-Herbivore; PR, Predator; SC, Scraper; SH, Shredder; UN, Unknown]

Taxon	Functional feeding group	Pollution tolerance value
Platyhelminthes		
Turbellaria (Flatworms)		
Planariidae	PR	4
Dugesa sp.	PR	4
D. dorotocephala	PR	4
Polycelis coronata	PR	4
Nematoda	PA	5
Nematomorpha	PA	11
Annelida (Worms)		
Hirudinea	PR	10
Oligochaeta	CG	5
Lumbriculidae	CG	11
Naididae	CG	11
Tubificidae	CG	10
Arthropoda		
Crustacea		
Amphipoda (Scuds)		
Gammarus sp.	CG	4
G. lacustris	CG	4
Hyalella sp.	CG	4
H. azteca	CG	4
Decapoda (Crayfish)		
Pacifastacus sp.	OM	6
Isopoda (Sow bugs)		
Ascellus sp.	CG	8
Caecidotea communis	CG	11
Ostracoda (Seed shrimp)	CG	8
Arachnoidea		
Hydracarina (Water mites)	PR	8
Lebertia sp.	PR	8
Mideopsis sp.	PR	11
Sperchon sp.	PR	11
Insecta		
Coleoptera (Beetles)		
Carabidae	PR	11
Dryopidae	SH	5
Helichus sp.	SH	5
Dytiscidae	PR	5
Laccophilus sp.	PR	8
Oreodytes sp.	PR	5
Elmidae	CG	4
Cleptelmis sp.	CG	4
Dubiraphia sp.	CG	4
Gonielmis sp.	CG	5
Heterlimnius sp.	CG	4
H. corpulentus	CG	4
Lara sp.	SH	4
Microcylloepus sp.	CG	2
Narpus sp.	CG	4
Optioservus sp.	SC	4
O. quadrimaculatus	SC	4
Rhizelmis sp.	UN	11
Zaitzevia sp.	CG	4
Haliplidae	MH	7
Agabus sp.	PR	4
Brychius sp.	SC	11
Haliplus sp.	MH	6
Hydraenidae	SC	4
Hydraena sp.	UN	11
Hydrophilidae	PR	5
Ametor scabrosus	UN	11
Psephenidae	SC	4
Psephenus falli	SC	4
Diptera (True flies)		
Ceratopogonidae	PR	6
Bezzia sp.	CG	6
Chironomidae	OM	6
Chironomus sp.	CG	10
Conchapelopia sp.	PR	6
Cricotopus sp.	OM	7
Diamesia sp.	CG	5
Dicrotendipes sp.	CG	8
Glyptotendipes sp.	SH	10
Microspectra sp.	CG	7
Orthocladius sp.	CG	6
Pagastia sp.	CG	1
Parametriocnemus sp.	CG	5
Paratanytarsus sp.	CG	6
Phaenospectra sp.	SC	7
Polypedilum sp.	OM	6
Rheotanytarsus sp.	CF	6
Thienemanniella sp.	CG	6
Dixidae	CG	1
Empididae	PR	6
Chelifera sp.	PR	6
Clinocera sp.	PR	6
Hemerodromia sp.	PR	6
Ephydridae	CG	6
Pelecorhynchidae	PR	3
Glutops sp.	PR	3
Psychodidae	CG	10
Pericoma sp.	CG	4
Ptychopteridae	CG	7
Ptychoptera sp.	CG	7
Rhagionidae	PR	6
Atherix sp.	PR	2
A. pachypus	PR	11
A. variegata	PR	2
Simuliidae	CF	6
Prosimulium sp.	CF	3
Simulium sp.	CF	6
S. bivittatum	CF	6
S. vittatum	CF	6
Stratiomyidae	CG	8
Euparyphus sp.	CG	11
Odontyomyia sp.	CG	11
Tipulidae	OM	3
Antocha sp.	CG	3
Dicranota sp.	PR	3
Hesperoconopa sp.	OM	1
Hexatoma sp.	PR	2
Limnophila sp.	PR	4
Pedicia sp.	PR	6
Tipula sp.	OM	4
Ephemeroptera (Mayflies)		
Baetidae	CG	4
Baetis sp.	OM	5
B. bicaudatus	OM	2
B. insignificans	CG	6
B. intermedius	CG	6
B. tricaudatus	OM	5
Callibaetis sp.	CG	9
Callibaetis nigritus	CG	11
Ephemerellidae	CG	1
Caudatella hystrix	CG	1
Drunella sp.	SC	0
D. coloradensis	PR	0
Ephemerellidae–Continued		
D. doddsi	PR	0
D. flavilinea	SC	1
D. grandis	UN	11
D. spinifera	PR	0
Ephemerella sp.	CG	1
E. aurivilli	CG	0
E. coloradensis	CG	2
E. doddsi	CG	2
E. grandis	CG	1
E. hecuba	CG	11
E. inermis	CG	1
E. infrequens	UN	11
E. margarita	UN	11
E. tibialis	CG	2
Serratella tibialis	CG	2
Ephemeridae	CG	4
Hegagenia sp.	CG	6
Heptageniidae	SC	4
Cinygmula sp.	SC	4
Epeorus sp.	SC	0
E. albertae	SC	0
E. deceptious	SC	0
E. grandis	SC	0
E. longimanus	UN	11
Heptagenia sp.	SC	4
H. elegantula	SC	4
Nixe sp.	SC	2
N. criddlei	SC	2
N. simplicioides	UN	11
Rhithrogena sp.	SC	0
R. hageni	CG	0
R. robusta	UN	2
Stenonema sp.	SC	6
Leptophlebiidae	CG	2
Leptophlebia sp.	CG	2
Paraleptophlebia sp.	OM	1
P. bicornuta	CG	4
P. heteronea	CG	2
Polymitarcyidae	CG	2
Ephoron album	CG	2
Siphlonuridae	CG	7
Ameletus sp.	CG	0
A. cooki	UN	11
A. oregonensis	UN	11
A. similor	UN	11
A. sparsatus	UN	11
A. velox	CG	0
Tricorythidae	CG	4
Caenis sp.	CG	7
C. simulans	UN	2
Tricorythodes sp.	CG	5
T. minutus	CG	4
Hemiptera (True bugs)		
Corixidae	OM	8
Cenocorixa bifida	OM	11
Hesperocorixa sp.	PH	11
Sigara altenata	PH	11
Gelastocoridae	PR	11
Gelastocoris sp.	PR	11
Gerridae	PR	5
Gerris sp.	PR	5
G. remigis	PR	5
Naucoridae	PR	5

Table A. Macroinvertebrate functional feeding groups and tolerances to organic compounds, sediment, and warm-water pollution in streams in the upper Snake River Basin—Continued

Taxon	Functional feeding group	Pollution tolerance value
Lepidoptera (Caterpillars)		
Pyralidae	SH	5
Parargyractis sp.	SH	6
Petrophila sp.	SH	6
Odonata (Dragonflies)		
Coenagrionidae	PR	9
Argia sp.	PR	7
Enallagma sp.	PR	9
Ishnura sp.	PR	9
Gomphidae	PR	1
Ophiogomphus sp.	PR	1
Plecoptera (Stoneflies)		
Capniidae	SH	1
Capnia sp.	SH	1
Paracapnia sp.	SH	1
Chloroperlidae	PR	1
Alloperla sp.	PR	0
Leuctridae	SH	0
Paraleuctra sp.	SH	0
Nemouridae	SH	2
Amphinemura sp.	SH	2
Malenka sp.	SH	2
Nemoura sp.	UN	11
Prostoia besametsa	SH	2
Zapada sp.	SH	2
Z. cinctipes	SH	2
Z. oregonensis	SH	2
Perlidae	PR	1
Acroneuria californica	UN	11
A. pacifica	UN	11
Beloneuria sp.	PR	3
Calineuria sp.	PR	3
Hesperoperla sp.	PR	1
H. pacifica	PR	1
Perlodidae	PR	2
Arcynopterx parallela	UN	11
Isogenoides sp.	UN	11
I. zionensis	UN	11
Isogenus sp.	PR	2
I. modestus	UN	11
Isoperla sp.	PR	2
I. fulva	PR	2
I. mormona	UN	11
Kogotus sp.	PR	2
Megarcys sp.	PR	2
M. signata	UN	11
Setvena bradleyi	PR	2
Skwala sp.	PR	2
S. parallela	UN	11
Yugus sp.	PR	2
Pteronarcyidae	OM	0
Pteronarcella badia	OM	0
Pteronarcys californica	OM	0
Taeniopterygidae	OM	2
Taenionema sp.	SC	2
Trichoptera (Caddisflies)		
Brachycentridae	CF	1
Amiocentrus sp.	CG	1
A. aspilus	CG	2
Brachycentrus sp.	OM	1
B. americanus	OM	1
B. occidentalis	OM	1
Trichoptera (Caddisflies)–Continued		
Micrasema sp.	SH	1
Oligoplectrum sp.	CF	1
Glossosomatidae	SC	0
Culoptila cantha	SC	0
Glossosoma sp.	SC	0
G. montana	SC	0
Protoptila coloma	SC	1
P. tenebrosa	SC	1
Helicopsychidae	SC	3
Helicopsyche sp.	SC	3
H. borealis	SC	3
Hydropsychidae	CF	4
Arctopsyche grandis	CF	2
Cheumatopsyche sp.	CF	5
C. campyla	CF	6
C. enonis	CF	6
C. pettiti	CF	6
Hydropsyche sp.	CF	4
H. californica	CF	4
H. occidentalis	CF	4
H. oslari	CF	4
Parapsyche sp.	PR	1
P. elis	PR	1
Hydroptilidae	PH	4
Agraylea sp.	PH	8
Hydroptila sp.	PH	6
H. ajax	SC	6
H. arctia	SC	6
H. argosa	SC	6
Leucotrichia sp.	SC	2
Neotrichia sp.	PH	2
N. halia	PH	2
Ochrotrichia sp.	PH	4
O. stylata	UN	11
Lepidostomatidae	SH	1
Lepidostoma sp.	SH	1
L. cinereum	SH	3
Leptoceridae	CG	3
Ceraclea sp.	CG	3
Mystacides sp.	CG	4
Nectopsyche sp.	SH	3
N. gracilis	SH	3
N. halia	SH	3
N. lahontanenses	SH	3
N. stigmatica	SH	3
Triaenodes sp.	SH	6
Limnephilidae	SH	4
Clostoeca sp.	SH	11
Dicosmoecus atripes	PR	1
D. gilvipes	SC	2
Ecclisomyia sp.	CG	2
Grensia sp.	SH	6
Hesperophylax sp.	SH	5
Limnephilus sp.	SH	5
Moselyana sp.	CG	4
Neophylax sp.	SC	3
Oligophlebodes sp.	SC	1
Onocosmoecus unicolor	SH	1
Psychoglypha sp.	CG	1
Philopotamidae	CF	3
Wormaldia sp.	CF	3
W. gabriella	CF	3
Trichoptera (Caddisflies)–Continued		
Polycentropidae	CF	6
Polycentropus sp.	PR	6
P. amereus	UN	11
Rhyacophilidae	PR	0
Rhyacophila sp.	PR	0
R. acropedes	PR	1
R. angelita	PR	0
R. coloradensis	PR	0
R. hyalinata	PR	0
R. tucula	UN	11
R. vaccua	UN	11
R. vagrita	PR	0
R. vespula	UN	11
Psychomyiidae	CG	11
Psychomyia sp.	SC	2
Tinodes sp.	SC	6
Uenoidae	SC	11
Neothremma sp.	SC	0
Mollusca		
Gastropoda (Snails)		
Amnicola sp.	SC	6
Banbury Springs limpet (undescribed *Lanx* sp.)	SC	0
Bliss Rapids snail (no scientific name)	SC	2
Ferrissia sp.	SC	6
Fisherola nuttali	SC	3
Fluminicola sp.	SC	3
F. columbiana	SC	2
F. hindsi	SC	4
Fontelicella sp.	SC	8
Fossaria sp.	SC	8
Gyraulus sp.	SC	8
Lymnaea sp.	SC	8
Parapholyx sp.	SC	8
Physa sp.	SC	8
P. natricina	SC	1
Physella sp.	SC	8
Planorbella sp.	SC	7
Potamopyrgus antipodarum	SC	9
Pyrgulopsis idahoensis	SC	8
Radix sp.	OM	1
Stagnicola hinkleyi	OM	4
Valvata humeralis	OM	2
V. sincera	OM	2
V. utahensis	OM	2
Vorticifex sp.	SC	8
V. effusa	SC	4
Pelecypoda (Clams)		
Anodonta californiensis	CF	4
Corbicula fluminea	CF	8
Gonidea sp.	CF	4
Margaritifera sp.	CF	4
Pisidium sp.	CF	4
P. nitidum	CF	4
P. punctatum	CF	4
Sphaerium sp.	CF	8
S. nitidum	CF	4

Table B. Fish origin, trophic group, and tolerance to organic compounds, sediment, and warm-water pollution in streams in the upper Snake River Basin

[Data from Scott and Crossman (1973); Simpson and Wallace (1982); Sigler and Sigler (1987)]

Family	Common name	Species	Origin	Trophic group of edults	Tolerance to pollution
Acipenseridae	White sturgeon	*Acipenser transmontanus*	Native	Omnivore	Intolerant
Catostomidae	Bluehead sucker	*Catostomus discobolus*	Native	Herbivore	Tolerant
	Bridgelip sucker	*Catostomus columbianus*	Native	Herbivore	Intermediate
	Largescale sucker	*Catostomus macrocheilus*	Native	Omnivore	Tolerant
	Mountain sucker	*Catostomus platyrhynchus*	Native	Herbivore	Intermediate
	Utah sucker	*Catostomus ardens*	Native	Omnivore	Tolerant
Centrarchidae	Black crappie	*Pomoxis nigromaculatus*	Introduced	Insectivore	Tolerant
	Bluegill	*Lepomis macrochirus*	Introduced	Insectivore	Tolerant
	Largemouth bass	*Micropterus salmoides*	Introduced	Piscivore	Tolerant
	Smallmouth bass	*Micropterus dolomieui*	Introduced	Piscivore	Intermediate
Cichlidae	Tilapia	*Tilapia* sp.	Introduced	Insectivore	Tolerant
Cottidae	Mottled sculpin	*Cottus bairdi*	Native	Insectivore	Intermediate
	Paiute sculpin	*Cottus beldingi*	Native	Insectivore	Intolerant
	Shorthead sculpin	*Cottus confusus*	Native	Insectivore	Intolerant
	Shoshone sculpin	*Cottus greenei*	Native	Insectivore	Intolerant
	Torrent sculpin	*Cottus rhotheus*	Native	Insectivore	Intolerant
	Wood River sculpin	*Cottus leiopomus*	Native	Insectivore	Intolerant
Cyprinidae	Carp	*Cyprinus carpio*	Introduced	Omnivore	Tolerant
	Chiselmouth	*Acrocheilus alutaceus*	Native	Herbivore	Intermediate
	Hornyhead chub	*Nocomis biguttatus*	Native	Omnivore	Intermediate
	Leatherside chub	*Gila copei*	Native	Insectivore	Intermediate
	Leopard dace	*Rhinichthys falcatus*	Native	Insectivore	Intermediate
	Longnose dace	*Rhinichthys cataractae*	Native	Insectivore	Intermediate
	Northern squawfish	*Ptychocheilus oregonensis*	Native	Piscivore	Tolerant
	Peamouth	*Mylocheilus caurinus*	Native	Insectivore	Intermediate
	Redside shiner	*Richardsonius balteatus*	Native	Insectivore	Intermediate
	Speckled dace	*Rhinichthys osculus*	Native	Insectivore	Intermediate
	Utah chub	*Gila atraria*	Native	Omnivore	Tolerant
Ictaluridae	Black bullhead	*Ameiurus melas*	Introduced	Omnivore	Tolerant
	Brown bullhead	*Ameiurus nebulosus*	Introduced	Omnivore	Tolerant
	Channel catfish	*Ictalurus punctatus*	Introduced	Omnivore	Tolerant
Percidae	Walleye	*Stizostedion vitreum*	Introduced	Piscivore	Intermediate
	Yellow perch	*Perca flavescens*	Introduced	Insectivore	Intermediate
Salmonidae	Brook trout	*Salvelinus fontinalis*	Introduced	Insectivore	Intolerant
	Brown trout	*Salmo trutta*	Introduced	Insectivore	Intolerant
	Bull trout	*Salvelinus confluentus*	Native	Piscivore	Intolerant
	Cutthroat trout	*Oncorhynchus clarki* sp.	Native	Insectivore	Intolerant
	Mountain whitefish	*Prosopium williamsoni*	Native	Insectivore	Intolerant
	Rainbow trout	*Oncorhynchus mykiss* sp.	Native	Insectivore	Intolerant