10 April 2003

Water Docket
Environmental Protection Agency
Mailcode 4101T
1200 Pennsylvania Ave NW
Washington DC 20460

ATTENTION Docket ID No. OW-2002-0050

We are submitting this letter as an official comment on the Advanced Notice of Proposed Rulemaking (ANPRM) on the Clean Water Act Regulatory Definition of "Waters of the United States" (Docket ID No. OW-2002-0050). The undersigned are professional aquatic scientists from over 40 states with broad knowledge and expertise in stream ecosystems including their physical structure, chemistry, and biology. The 85 scientists who have signed this letter include members of the National Academy of Sciences and its scientific Boards, individuals who have been or who are President of national scientific organizations, and leading researchers on the ecology, water quality, and biota of streams and rivers.

We are responding to the request in the ANPRM for information on "the extent of resource impacts to isolated, intrastate, non-navigable waters" and "the functions and values of wetlands and other waters that may be affected by the issues discussed in this ANPRM." We focus our comments on ephemeral, intermittent, and other headwater tributaries. These headwater streams provide essential goods and services; their elimination from Clean Water Act jurisdiction would have an adverse impact on downstream ecosystems. Rivers are networks, and their downstream navigable portions are inextricably linked to small headwaters just as fine roots are an essential part of the root structure of a tree or our own circulatory system is dependent on the function of healthy capillaries. The small ephemeral stream is not isolated from the mighty river.

Scientific research on rivers and streams over the past several decades has been founded on the concept of the longitudinal connectivity of river networks, i.e. that ecological processes in large rivers reflect what is occurring in their headwaters as well as in adjacent floodplains, tributaries, and even downstream ecosystems (e.g. Hynes 1975, Vannote et al. 1980, Minshall et al. 1985, Junk et al. 1989, Ward 1989, Pringle 1997, Fausch et al. 2002). **Considering navigable rivers to be isolated from their ephemeral and intermittent headwaters (as implied in the ANPRM) stands in direct contradiction to long standing and robust scientific evidence**.

In the following five points, we discuss the scientific basis for our statement that removing ephemeral, intermittent and other small headwater streams from Clean Water Act jurisdiction will adversely impact our Nation's waters and make it less likely that we can achieve the goal of the Clean Water Act, which is "to restore and maintain the chemical, physical and biological integrity of the Nation's waters."

1. A large fraction of the channels in a stream network do not flow year round. Because of limitations of current databases, the total length of small streams is seriously underestimated in the U.S. Therefore the proposed rulemaking will impact a much greater extent of critical aquatic habitat than currently estimated.

Calculations of the miles of stream channel impacted by this rulemaking will be underestimates of the actual length of channel impacted because small streams are not adequately captured in our national hydrography databases. These databases are derived from maps drawn at a scale of 1:100,000 (http://nhd.usgs.gov). Even maps drawn to a scale of 1:24,000 underestimate the true extent of small streams. For example, 1:24,000 scale maps identify only 21% of the stream channel length in the 728 km^2 Chattooga River basin in North Carolina (Hansen 2001) and 49% of the stream channels supporting salamanders in a Georgia watershed (M. Elliott, University of Georgia, personal communication). This shortcoming of nationwide databases was recognized in a recent report on the state of the Nation's ecosystems, which noted that data on miles of small streams were not available for the nation (Heinz Center 2002). Even the streams indicated on topographic maps do not represent the true extent of streams in the landscape. Headwater streams shown on a map meet no clearly defined statistical characteristic of the extent of streamflow (Leopold 1994). The terms ephemeral, intermittent and perennial apply to a continuum of flow persistence. Intermittent streams can flow year round in very wet years. In river networks with glacial and alluvial sediments, streams without visible surface flow often remain flowing within their bed throughout the year, continuing geochemical processes and supporting a diverse array of often unique biota. Aquatic insect assemblages and salamander larvae requiring 9 - 18 months of flow can be found in many channels represented as intermittent streams on a topographic map (Meyer and Wallace 2001).

Available estimates show that a sizable fraction of channel length in a river network is in ephemeral, intermittent and headwaters streams, even though these represent underestimates of the true extent of these ecosystems. In arid states such as Arizona, 96% of stream miles have been classified as ephemeral or intermittent (Chapter 2, Table 3 in http://www.adeq.state.az.us/environ/water/assess/305/index.html). In one Arizona county where more extensive mapping has been done, 99% of stream miles have been classed as ephemeral or intermittent (J. Fonseca, Pima County Flood Control District, Tucson AZ, personal communication). Analysis of a 1:24,000 USGS digital line graph coverage of Utah's streams shows that 89% of the state's stream length is in intermittent and ephemeral channels (R. Hilderbrand, U. of Maryland, personal communication). Estimates based on 1:100,000 maps for Colorado classify 71% of stream miles as intermittent (L. Poff, Colorado State University, personal communication). Existing databases for Kansas list as intermittent 82% of stream miles in the state (Chou et al. 1999). In the arid and semi-arid West, even large rivers such as the Rio Grande do not flow continuously.

Intermittent streams are also significant in states that receive more rainfall. In Hawaii, headwater streams may flow continuously, but their lower reaches are intermittent and serve as barriers to invasion of exotic species; these have been called "interrupted streams" (Polhemus et al. 1992). In Alabama, 80% of stream miles in the National Forests are considered intermittent because they go dry during late summer or autumn, particularly during drought years (S. Chubb, U.S. Forest Service, personal communication). In western Kentucky, 75% of the second order streams flow only in February through May, but all have a resident community of chironomids and capniid stoneflies (D. White, Murray State University, personal communication). Intermittent streams in Michigan comprise 48% of the length of stream channels in the state (R. Cifaldi and J.D. Allan, University of Michigan, personal communication).

These examples illustrate the extent of intermittent channels in river networks throughout the Nation. Eliminating this large a fraction of stream networks from the protections offered by the Clean Water Act will profoundly alter the physical, chemical and biotic integrity of that network. Protection of the public good provided by our surface water resources requires protection of all elements of the river network including ephemeral, intermittent, and headwater streams.

2. Human activities in the watershed have resulted in significant loss of small streams.

Groundwater withdrawal for irrigation or other human uses and interception of recharge by impervious surfaces has resulted in significant lowering of the water table, which affects headwater streams by making perennial streams intermittent (Postel 1999). Channels without water can extend far downstream; for example, a channel of the Santa Cruz River near Tucson, Arizona, was dry for several decades because of groundwater pumping (Grimm et al. 1997), and water withdrawals from riverine aquifers have dewatered reaches of the Arkansas River (Ferrington 1993). Reaches of the Rio Grande no longer have water because of water withdrawal for human uses. As more of the landscape is covered with impervious surface, groundwater recharge is reduced, leading to lower baseflows, which can lead to intermittent flow (Paul and Meyer 2001). In contrast, some intermittent streams have become perennial because of the continuous addition of effluent from municipal wastewater treatment plants (Paul and Meyer 2001).

The length of headwater streams in the landscape has been significantly reduced because of piping and filling activities done in the name of agriculture, mining, and development. For example, suburban development around Rock Creek in Maryland reduced the drainage density (m stream channel / m^2 watershed area) by 58% (Leopold 1994); drainage density of urban and suburban watersheds in the Chattahoochee River basin near Atlanta is one third less than drainage density in watersheds in this basin that are covered in forest and pasture (Meyer and Wallace 2001). At least 1450 km of streams were eliminated in the Southern Appalachians from 1986 - 1998 because of mountaintop removal valley-fill coal mining practices (U.S. Fish and Wildlife Service 1998). Untold miles of streams in the midwestern U.S. have been converted into drainage ditches that route water quickly out of the watershed. Because of their simplified channel structure, they no longer provide the ecological services of unchannelized headwater streams (Brookes 1994). Recognizing the value of headwater systems and their vulnerability to human disturbance, an international group of scientists meets regularly to present recent research and to design improved management practices (e.g. Haigh et al. 1998). The loss of headwater streams has profoundly altered the structure and function of stream networks (Meyer and Wallace 2001). Elimination of small tributaries from Clean Water Act jurisdiction would lead to further loss and degradation of these systems to the detriment of the physical, chemical and biotic integrity of ecosystems downstream.

3. Ephemeral, intermittent and small headwater streams contribute to the physical integrity of the river network.

Small streams provide hydrologic retention capacity (i.e., the ability to hold and store water). Their contribution is apparent because when these small streams have been eliminated as a result of human activity, frequency and intensity of flooding increases downstream, and base flows are lower (e.g., Dunne and Leopold 1978). The increased frequency and intensity of flooding associated with replacement of small streams with impervious surfaces increases bank erosion, channel widening and incision, and other changes in channel form (Arnold et al. 1982). In San Diego, California, extensive channel erosion contributed two-thirds of the in-stream sediment load and resulted in loss of valuable urban land (Trimble 1997). An increase in flood frequency and magnitude negatively impacts the stream biota, particularly when this is combined with increasing sediment transport (e.g., Waters 1995). The loss of hydrologic retention provided by small streams in agricultural catchments, has resulted in increased transport of excess nutrients to downstream ecosystems (Steinman and Rosen 2000).

Small streams also contribute to the physical integrity of downstream ecosystems by retaining sediments. Sediment eroded from hillslopes during storms is stored in these small channels and released over a longer period of time to downstream ecosystems. If sediment retention is reduced in headwater channels, downstream sediment transport during storms will increase. Sediment accumulation in larger streams and rivers can affect fish feeding and spawning, aquatic insect communities, and overall stream productivity (Lemly 1982, Newcombe and McDonald 1991, Lenat and Crawford 1994, Waters 1995, Newcombe and Jensen 1996).

Organic debris dams are a prominent feature of headwater streams (e.g., Bilby and Likens 1980). They provide sediment retention, important habitat structure, and sites for critical metabolic activity (e.g., Steinhart et al. 2000). These functions are eliminated when headwaters are channelized, piped, or filled, which is more likely to occur if headwaters are removed from Clean Water Act jurisdiction.

Evidence for the importance of headwater streams in maintaining the physical integrity of downstream ecosystems can be seen by observing the consequences of their loss from the network. Filling of stream valleys by mountaintop removal valley-fill coal mining has resulted in a greater proportion of fine particles in stream sediments and an altered flow and temperature regime downstream of the filled valleys (Wiley et al. 2001). Substrate particle size, water temperature, and flow regime are physical parameters with significant impact on the biota of a stream (Allan 1995). The value of the thermal refuge provided by very small streams is detailed under point 5 (below).

4. Ephemeral, intermittent and headwater tributaries are essential to the maintenance of the chemical integrity of navigable rivers.

The basic chemical composition of unpolluted streams draining a landscape is largely established in headwater streams (Gibbs 1970, Likens 1999, Johnson et al. 2000). These are the channels of the drainage network in closest contact with the soil and are the sites of extensive chemical and biological activity that influences water quality downstream.

Recent scientific research has demonstrated that small streams in the network are the sites of the most active uptake, transformation, and retention of nutrients (Alexander et al. 2000, Peterson et al. 2001). These streams are shallow, and water spends a longer time in contact with biologically and chemically reactive substrates in small, shallow channels. Once a chemical element enters a stream, the distance it travels downstream before being removed from the water column increases with increasing discharge as stream size increases (Peterson et al. 2001, Hall et al. 2001); hence destruction of small streams in the network results in increased downstream transport of nutrients. When headwater streams are eliminated, floodwaters are delivered more rapidly, and more of the nutrients being applied to farm fields or lawns are delivered to receiving systems downstream. Downstream waterways such as navigable rivers, lakes, estuaries, and coastal waters, may be sensitive to the resulting high nutrient concentrations with eutrophication as a likely consequence of loss of the nutrient retention capacity afforded by headwater streams. Nuisance algal blooms, deoxygenation of the water column, and fish kills are undesirable features of eutrophication. As an example of the ability of headwater streams to retain nutrients, recent studies have shown that 64% of the inorganic nitrogen entering a stream is retained or transformed in the headwaters (Peterson et al. 2001). Biofilms in small headwater channels are also sites of active uptake of inorganic (e.g., heavy metals) and organic (e.g., PCBs) pollutants (Schorer and Symader 1998). The chemical and biological tranformations that occur in headwater streams (e.g., denitrification, microbial uptake, excretion of organic nitrogen) reduce the biological availability of nutrients exported downstream.

Small streams serve as buffers for larger rivers, reducing the amount of non-point source nutrients entering navigable rivers. Nutrients and contaminants enter streams from non-point sources primarily during storms, and it is during storms when ephemeral and intermittent streams are most likely to contain water. Hence the nutrient removal capacity of these small streams are engaged at the time when most nutrients are entering the stream network from non-point sources. Federal, state, and local programs are spending considerable sums of money implementing best management practices to reduce non-point source inputs of nutrients because these are a major threat to water quality (Wang et al. 2002). Eliminating protection for intermittent and ephemeral streams negates the efforts at non-point source nutrient reduction being done in support of the Clean Water Act.

5. Ephemeral, intermittent and headwater tributaries contribute to the biotic integrity of river networks by supplying food resources to downstream and riparian ecosystems and providing thermal refuges, spawning areas, nursery areas, and critical habitats for unique and economically valuable species.

a. Small streams supply food resources to riparian and downstream ecosystems.

Headwater streams are sites for physical and biological processing of inputs of organic matter from the watershed such as falling leaves (e.g., Wallace et al. 1997) and a source of energy for downstream reaches (Kaplan et al. 1980, Gomi et al. 2002, Piccolo and Wipfli 2002). The dissolved organic matter and fine particles exported from headwaters are important food resources for ecosystems downstream (Vannote et al. 1980, Piccolo and Wipfli 2002, Wipfli and Gregovich 2002). An example of the significance of this subsidy comes from fishless headwater streams in Alaska, where enough prey and detritus is exported from headwater streams to support 100 - 2000 young-of-the-year salmonids in each kilometer of salmon-bearing streams (Wipfli and Gregovich 2002). Degradation of small streams in the network is likely to result in reduced inputs of food resources for downstream ecosystems.

Invertebrate inhabitants of headwater streams are sources of food to fish, water shrews, and salamanders within the headwater reach. Additionally, emerging aerial adults of aquatic insects are often used as food by terrestrial species such as spiders, birds, and bats; they represent an important reciprocal link between streams and terrestrial biota (Fisher 1991, Gray 1993, Murakami and Nakano 2001, Nakano and Murakami 2001, Sanzone 2001, Sanzone et al. 2003). Fisher (1991) reported that flycatchers used a large portion of the insect biomass emerging from Sycamore Creek, Arizona. Insectivorous birds inhabiting the riparian zone of a prairie stream in Kansas required 57 – 87% of the daily emergence of adult aquatic insects from the adjacent stream (Gray 1993). Insects from intermittent streams may serve as an important food resource for bats (Seidman and Zabel 2001). Reciprocal subsidies between stream and terrestrial habitats are important for maintaining animal assemblages across landscapes (Nakano and Murakami 2001).

b. Small streams provide a thermal refuge at critical life history stages or during critical times of the year.

Small, spring-fed headwater streams can serve as thermal refuges for fishes, providing a refuge from freezing for stream fishes during winter (e.g., Power et al. 1999) and cool refuges for young-of-the-year during summer (e.g., Curry et al. 1997). Small streams serve as a thermal refuge for species that spend most of their lives in larger systems. The Arkansas darter, *Etheostoma cragini*, a federal candidate darter species, uses small first order streams as a summer time refuge from heat and drought in the Ozarks (Radwell 2001). Arkansas darter populations are also found in intermittent streams in Colorado, where their persistence depends upon deep pools fed by cool groundwater and temporarily isolated from other pools by dry stream channel (Labbe and Fausch 2000). Brook trout (*Salvelinus fontinalis*) in the Ford River in Michigan retreat to cooler headwaters in summer (Hayes et al. 1998). Young-of-the-year brook trout that were spawned in a Wisconsin lake also migrated into small, groundwater-fed inlet streams and spent the summer there, where stream temperatures, sustained by groundwater, were consistently cooler than in the littoral zone of the lake during summer (Curry et al. 1997). Groundwater is often warmer than stream water during winter, so small spring-fed streams provide a refuge from freezing for stream fishes (Power et al. 1999). Given the climatic extremes of continental North America, access to thermal refuges such as those provided by small spring-fed streams is an important aspect of survival for stream fishes (Power et al. 1999).

c. Small streams serve as vital spawning habitats.

Small headwater streams provide essential breeding habitat for numerous species, many of which live in larger streams during most of the year. The trispot darter (*Etheostoma trisella*) spends most months in large perennial streams, but it moves upstream to spawn and attaches its eggs to submerged blades of grass in tiny rivulets that flow from ephemeral ponds in fields (Ryon 1986). The slackwater darter (*Etheostoma boschungi*) breeds in tiny streams, many of which are now small ditches flowing through pastures (Mettee et al. 1996). Trout production in a California stream was dependent on intermittent streams: over a 4 year period, 39 – 47% of all rainbow trout recruits in Sagehen Creek, California, came from an intermittent tributary that flowed only 4 months each year (Erman and Hawthorne 1976). Migratory cyprinid fishes were found spawning in intermittent tributaries of the Sacramento River (http://www.ecst.csuchico.edu/~loggins/cyprin.html). Recent research in West Virginia has demonstrated that, although adult brook trout were found in streams throughout the watershed, over 80% of brook trout reproduction occurred in headwater streams and intermittent seeps (Lamothe 2002). Degradation of those habitats would impact the viability of the brook trout population in the entire watershed.

d. Small streams serve as nursery habitat for juvenile fishes.

Intermittent streams provide rearing habitat for juvenile chinook salmon (Murray and Rosenau 1989, Richards et al. 1992, Scrivener et al. 1994). Juvenile coho salmon and steelhead also use intermittent streams as winter refugia (Peterson and Reid 1984). Small headwater streams serve as vital nursery areas for brook trout in a Michigan stream; the scientists conducting this study recognized "the importance of headwater streams as fish habitat and the need to maintain the integrity of these systems as a connector between the mainstem and their watersheds" (Hayes et al. 1998, p.184).

e. Small streams provide critical habitat for unique and threatened species.

Headwater streams provide unique habitats for numerous species. Their degradation and elimination from the network increases extinction vulnerability for aquatic invertebrate, amphibian, and fish species (e.g., Morse et al. 1993, Meyer and Wallace 2001). Ephemeral and intermittent streams can support a diverse and sometimes unique community of aquatic organisms. For example, in western Oregon, the number of invertebrate taxa in intermittent streams exceeded that of permanent headwaters, and several undescribed species were associated with intermittent streams (Dieterich and Anderson 2000). Up to 60% of the taxa in intermittent Kansas streams were species with adaptations for intermittent flow that can be considered specialists for this type of stream (Chou et al. 1999). Candidates for threatened and endangered caddisflies in California are found in small spring streams (Erman and Nagano 1992). The proportion of federally at risk species is often high in headwater streams. For example, in the National Forests of Alabama, 70 of the 113 "at risk" aquatic species are primarily headwater stream or spring residents. These "at risk" taxa include crayfish, mussels, snails, amphibians, and fish (S. Chubb, U. S. Forest Service, Alabama, personal communication). The threatened Louisiana pearlshell mussel, *Margaritifera hembeli*, occurs only in small headwater streams with shallow gravel riffles (Johnson and Brown 2000, Bolden and Brown 2002). Some terrestrial species are also dependent on high quality headwater streams. For example, the Louisiana Waterthrush (*Seiurus motacilla*) shows a strong habitat preference for unpolluted headwater streams (Prosser and Brooks 1998).

In karst regions, small streams contribute to the recharge of subterranean phreatic and cave aquifers that harbor unique species. For example, small streams in the Ozarks enter caves that harbor threatened and endangered species of cave fishes, crayfishes, amphipods and other organisms. The water quality and quantity in these small streams is important to the continued existence of the subterranean fauna (Elliot 2000).

Ephemeral and intermittent streams provide vital habitat for amphibians, many of which are state and/or federally threatened and endangered, such as Chiricahua leopard frog, lowland leopard frog, California red-legged frog, and Arroyo toads. The Pacific tree frog and black salamander rely on intermittent streams during part of their life cycle (Reid and Ziemer 1994). Many amphibian species are most abundant in intermittent streams, perhaps because they offer freedom from predators (Reid and Ziemer 1994). In the Mattole watershed in California, Pacific giant salamander (*Dicamptodon tenebrosis*) and black salamander (*Aneides flavipunctatus*) are more abundant along intermittent streams (Welch et al. in review). A native amphibian of the Mojave Desert, the red-spotted toad (*Bufo punctatus*) is dependent on the ephemeral nature of water in small spring-fed streams (Bradford et al. in press). Over half (16 of 29) amphibian genera in the Southeast have species that live in small streams, seeps, bogs or swamps (Dodd 1997). Many stream salamanders require headwater seeps and small streams in forested habitats to maintain viable populations (Petranka 1998). Plethodontid salamanders are extremely diverse in Appalachia, and their lungless condition appears to be an adaptation for small headwater streams, which are their principal larval habitat, where they spend from a few months to five years (Beachy and Bruce 1992). Riparian ecosystems adjacent to small headwater streams are sensitive to stream degradation, and these ecosystems can be sites of high biodiversity in watersheds; e.g., six amphibian species use them as habitat in Douglas fir forests in western Washington (Wilkins and Peterson 2000).

Headwater streams also provide habitat for several endangered fish species in the southeastern U.S. Etnier (1997) identified sixteen fish taxa occurring in first and second order southeastern streams, a quarter of which are jeopardized because of non-point source pollution or extremely limited range. The imperilment of fishes in the western US has been related to the degradation and loss of intermittent streams (Moyle and Nichols 1973, Moyle and Williams 1990). Five native fish species were found using intermittent streams in the Sacramento River basin: Sacramento squawfish (*Ptychocheilus grandis*), hardhead (*Mylopharodon conocephalus*), hitch (*Lavinia exilicauda*), speckled dace (*Rhinichthys osculus*) and Sacramento sucker (*Catostomus occidentalis*) (http://www.ecst.csuchico.edu/~loggins/cyprin.html).

Just as estimates of the extent of ephemeral, intermittent and small headwater streams in the US are likely underestimates of true extent, so are estimates of headwater species at risk a likely underestimate (Burkhead and Jelks 2000). Estimates of the numbers of threatened and endangered invertebrate species are very conservative because of insufficient knowledge of the fauna, inadequate numbers of practicing taxonomists able to identify new species, and absence of recent comprehensive surveys (Morse et al. 1997, Burkhead and Jelks 2000, Strayer 2000). It is likely that there are many new species and unrecognized ecological relationships in small streams, especially those tightly linked with groundwater (Strayer 2000). These are the very ecosystems that are threatened by this proposed rulemaking.

In conclusion, ephemeral, intermittent, and small headwater streams are an integral part of a river network; they are not isolated from the larger navigable channels in the network. They provide ecological goods and services of value to society. Although they may not have a direct hydrologic connection to a navigable river during all months of the year, they have a direct impact on the physical, chemical, and biotic integrity of navigable rivers. To summarize the main points of our discussion, which we have supported by over 85 references to the scientific literature: the extent of ephemeral, intermittent and small headwater streams is great but poorly quantified; they are being profoundly altered by human activities; they impact the physical integrity of larger rivers because they alter rates of runoff and retain sediments; they impact downstream chemical integrity by their capacity for nutrient and contaminant uptake, retention and transformation; they impact biological integrity of the stream network by providing food resources, thermal refuges, spawning sites, nursery areas for juveniles, and habitat for unique biota. **On the basis of decades of scientific research, we conclude that ephemeral, intermittent, and small headwater streams CANNOT be considered isolated or unrelated to the ecological integrity of navigable waterways**. **The changes discussed in the proposed rulemaking and guidance document will degrade rather than maintain and improve the quality of U.S. waters. If our nation hopes to achieve the goals of the Clean Water Act, ephemeral, intermittent and small headwater streams should remain under its jurisdiction.**

Sincerely,

Judith L. Meyer
Distinguished Research Professor of Ecology
Institute of Ecology
University of Georgia

Athens GA

J. Bruce Wallace
Professor
Department of Entomology
University of Georgia
Athens GA

Gene E. Likens
Director and G. Evelyn Hutchinson Chair in Ecology
Institute of Ecosystem Studies
PO Box AB
Millbrook NY

Kenneth W. Cummins,
Director, Institute for Forest and Watershed Management
Humboldt State University
Arcata CA

Jack A. Stanford
Director, Flathead Lake Biological Station
University of Montana
Polson MT

David D. Hart
Vice President and Director
Patrick Center for Environmental Research
Academy of Natural Sciences
Philadelphia PA

Alan D. Steinman, Director
Annis Water Resources Institute
Lake Michigan Center
Muskegon MI

Bernard W. Sweeney
Director and Senior Research Scientist
Stroud Water Research Center
970 Spencer Road
Avondale PA

Amelia K. Ward
Professor and Director
Center for Freshwater Studies
University of Alabama
Tuscaloosa AL

David S. White
Distinguished Research Professor
Director, Hancock Biological Station and Center for Reservoir Research
561 Emma Drive
Murray KY

Amy D. Rosemond
Assistant Director
Institute of Ecology
University of Georgia
Athens GA

Patrick J. Mulholland
Distinguished Research Staff Member
Environmental Sciences Division
Oak Ridge National Laboratory
Oak Ridge TN

Margaret A. Wilzbach,
Assistant Leader
California Cooperative Fish Research Unit
Humboldt State University
Arcata CA

John C. Morse
Professor of Entomology and
Director of the Clemson University Arthropod Collection
Department of Entomology
Clemson University
Clemson SC

Manuel C. Molles, Jr.
Professor and Director,
Museum of Southwestern Biology
Department of Biology
University of New Mexico
Albuquerque NM

Peter B Moyle
Professor, Fish Biology
Department of Wildlife, Fish, and Conservation Biology
University of California, Davis
Davis CA

Kenneth M. Brown

Professor of Biological Sciences and
Associate Dean of the College of Basic Sciences
Louisiana State University
Baton Rouge LA

Richard W. Merritt,
Chairman Department of Entomology
Michigan State University
East Lansing, MI

Barbara L. Peckarsky
Professor
Departments of Ecology & Evolutionary Biology and Entomology
Cornell University
Ithaca NY

J. David Allan
Professor
School of Natural Resources & Environment
The University of Michigan
Ann Arbor MI

Jackson R. Webster
Professor of Ecology
Department of Biology
Virginia Tech
Blacksburg VA

Arthur C. Benke
Professor
Department of Biological Sciences
University of Alabama
Tuscaloosa, AL

David A. Etnier
Dept. of Ecology & Evolutionary Biology
University of Tennessee
Knoxville TN

Bruce Peterson
Senior Scientist
Ecosystems Center
Marine Biological Laboratory
Woods Hole MA

Alan P. Covich
Professor
Fishery and Wildlife Biology
Colorado State University
Fort Collins CO

Kurt D. Fausch
Professor
Department of Fishery and Wildlife Biology
and Graduate Degree Program in Ecology
Colorado State University
Fort Collins CO

Robert A. Kinzie
Zoology Department Chair;
Ecology, Evolution and Conservation Biology Graduate Program
University of Hawaii at Manoa
Honolulu HI

Robert J. Naiman
Professor
School of Aquatic and Fishery Sciences
University of Washington
Seattle WA

Leonard C. Ferrington Jr.
Associate Professor
Department of Entomology
University of Minnesota
Saint Paul MN

Alexander D. Huryn
Associate Professor of Aquatic Entomology
Department of Biological Sciences
University of Maine
Orono ME

Matt Whiles
Assistant Professor of Zoology
Southern Illinois University
Carbondale IL

Colbert E. Cushing
Department of Fishery and WildlifeBiology
Colorado State University
Fort Collins CO

N. LeRoy Poff
Associate Professor
Department of Biology
Colorado State University
Fort Collins CO

Steven R. Chipps
South Dakota Cooperative Research Unit
South Dakota State University
Brookings SD

James E. Deacon
Emeritus Distinguished Professor of Environmental Studies
University of Nevada Las Vegas
Las Vegas NV

Dr. Benjamin M. Stout III
Department of Biology
Wheeling Jesuit University
Wheeling WV

Christine May
Watershed Scientist
Pacific Southwest Research Station
Arcata CA

Sybil P. Seitzinger
Institute of Marine and Coastal Sciences
Rutgers University
New Brunswick NJ

Keller Suberkropp
Professor
Department of Biological Sciences
University of Alabama
Tuscaloosa AL

Colden V. Baxter
Department of Fishery and Wildlife Biology
Colorado State University
Fort Collins, CO

Robert B. Whitlatch
Professor of Marine Sciences

Department of Marine Sciences
University of Connecticut
1080 Shennecossett Road
Groton CT

Stephen K. Hamilton
Associate Professor
Kellogg Biological Station
Michigan State University
Hickory Corners MI
Keith Gido
Assistant Professor
Kansas State University
Division of Biology
Manhattan KS

Robert O. Hall, Jr.
Assistant Professor
Department of Zoology and Physiology
University of Wyoming
Laramie WY

Nancy B. Grimm
Professor
Department of Biology
Arizona State University
Tempe AZ

Margaret A. Palmer
Professor of Biology and Entomology
University of Maryland
College Park MD

Peter Vila
Assistant Professor of Environmental Studies
Shepherd College
Institute for Environmental Studies
Shepherdstown WV

Fran Gelwick
Assistant Professor
Department of Wildlife and Fisheries Sciences
Texas A&M University
College Station TX

Stuart Findlay

Scientist
Institute of Ecosystem Studies
Millbrook NY

J. Todd Petty
Assistant Professor
Division of Forestry
West Virginia University
Morgantown WV

Laura G. Leff
Associate Professor
Department of Biological Sciences
Kent State University
Kent OH

Gregory W. Courtney
Associate Professor
Department of Entomology
Iowa State University
Ames IA

David L. McNeely
Professor of Biology
Langston University
Langston OK

Thomas E. Lisle
Research Hydrologist
Redwood Sciences Laboratory
Arcata CA

Walter Dodds
Division of Biology
Kansas State University
Manhattan KS

Darold Batzer
Associate Professor
Dept. of Entomology,
University of Georgia,
Athens GA

Bill P. Stark

Sadler Professor of Biology
Mississippi College
Clinton MS

Peter H. Adler
Professor
Department of Entomology
Clemson University
Clemson SC

Art Brown
Associate Professor of Biological Sciences
University of Arkansas
Fayetteville AR

E. F. Benfield
Professor of Ecology
Department of Biology
Virginia Tech
Blacksburg VA

Catherine Pringle
Professor of Ecology
Institute of Ecology
University of Georgia
Athens GA
Richard E. Sparks
Professor Emeritus
University of Illinois Water Resources Center
Urbana IL

Todd Crowl
Professor
Ecology Center
Utah State University
Logan UT

Gary D. Grossman
Professor
Warnell School of Forest Resources
University of Georgia
Athens GA

David L. Kirchman
Professor and Associate Dean
College of Marine Studies

University of Delaware
Lewes DE

Lucinda B. Johnson
Natural Resources Research Institute
University of Minnesota
Duluth MN

David L. Strayer
Scientist
Institute of Ecosystem Studies
Millbrook NY

G. Milton Ward
Associate Professor
Department of Biological Sciences
University of Alabama
Tuscaloosa AL

Steven N. Handel
Professor
Dept. of Ecology, Evolution, and Natural Resources
Rutgers University
New Brunswick NJ

Emily H. Stanley
Assistant Professor
University of Wisconsin Center for Limnology
Madison WI

Christopher Woltemade
Dept. of Geography-Earth Science
Shippensburg University
Shippensburg PA

Richard R. Montanucci
Associate Professor of Biological Sciences
Clemson University
Clemson SC

Sherri L. Johnson
Department of Fisheries and Wildlife
Oregon State University
Corvallis OR

F. Richard Hauer

Flathead Lake Biological Station
University of Montana
Polson MT

Scott Wissinger
Biology Department
Allegheny College
Meadville PA

William H. McDowell
Department of Natural Resources
University of New Hampshire
Durham NH

Michael L. May
Department of Entomology
Rutgers University
New Brunswick NJ

Mark Pyron
Assistant Professor
Aquatic Biology and Fisheries Center
Ball State University
Muncie IN

Brian H. Hill
Ecologist
1710 E. 7th St.
Duluth MN

Michael J. Paul
Aquatic Ecologist
Tetra Tech, Inc.
Owings Mills MD

Hartwell H. Welsh, Jr.
Redwood Sciences Lab
1700 Bayview Drive
Arcata CA

Perry Trial
Bay Ecosystem Biologist
Upper Laguna Madre Ecosystem
Texas Parks and Wildlife Department

Corpus Christi TX

Emma J. Rosi-Marshall
Biology Department
University of Notre Dame
Notre Dame IN

Jeffrey Jack
Assistant Professor
Department of Biology
University of Louisville
Louisville KY

Gene S. Helfman
Professor
Institute of Ecology
University of Georgia
Athens GA

Literature cited

Allan, J.D. 1995. *Stream Ecology*. Kluwer Academic Publishers, Boston.

Alexander, R.B., R.A. Smith, and G.E. Schwarz. 2000. Effect of stream channel size on the delivery of nitrogen to the Gulf of Mexico. *Nature* 403: 758-761.

Arnold, C.L., P.J. Boison and P.C. Patton. 1982. Sawmill Brook – An example of rapid geomorphic change related to urbanization. *Journal of Geology* 90: 155-166.

Beachy, C.K and R.C.Bruce. 1992. Lunglessness in plethodontid salamanders is consistent with the hypothesis of a mountain stream origin: a response to Ruben and Boucot. *American Naturalist* 139: 839-847.

Bilby, R.E. and G.E. Likens. 1980. Importance of organic debris dams in the structure and function of stream ecosystems. *Ecology* 61: 1107-1113.

Bolden, S.R. and K.M. Brown. 2002. The relative importance of transplants, habitat, and density to growth and survival in the Louisiana pearlshell, *Margaritifera hembeli*. *Journal of the North American Benthological Society* 21: 89-96.

Bradford, D.F., A.C. Neale, M.S. Nash, D.W. Sada and J.R. Jaeger. 2003. Habitat patch ocupancy by the red-spotted toad (Bufo punctatus) in a naturally fragmented desert landscape. *Ecology*. In press.

Brookes, A. 1994. River channel change. pp. 55 – 75 *In* P. Calow and G.E. Petts (eds.) *The River Handbook* Vol. 2. Blackwell Science.

Burkhead, N.M. and H.L. Jelks. 2000. Diversity, levels of impairment, and cryptic fishes in the southeastern United States. pp. 30-32 In R.A. Abell, D.M. Olson, E. Dinerstein et al. (eds.) *Freshwater Ecoregions of North America: A Conservation Assessment.* Island Press, Washington D.C.

Chou, R.Y.M., L.C. Ferrington Jr., B.L. Hayford, and H.M. Smith. 1999. Composition and phenology of Chironomidae (Diptera) from an intermittent stream in Kansas. Archiv fur Hydrobiologie 147: 35-64.

Curry, R.A., C. Brady, D.L.G. Noakes and R.G. Danzmann. 1997. Use of small streams by young brook trout spawned in a lake. *Transactions of the American Fisheries Society* **126**: 77-83.

Dieterich, M. and N.H. Anderson. 2000. The invertebrate fauna of summer-dry streams in western Oregon. *Archiv für Hydrobiologie* **147**: 273 - 295.

Dodd, C.K., Jr. 1997. Imperiled amphibians: A historical perspective . pp. 165 - 200 In G.W. Benz and D.E. Collins (eds.) *Aquatic Fauna in Peril: the Southeastern*

Perspective. Special Publication 1, Southeastern Aquatic Research Institute, Lenz Design and Communications, Decatur, Georgia.

Dunne, T. and L.B. Leopold. 1978. *Water in Environmental Planning*. W. H. Freeman and Company, New York.

Elliott, W. 2000. Conservation of the North American cave and karst biota. pp.671 – 695. *In* H. Wilkins, D. Culver, and W. Humphreys (eds.) *Subterranean Ecosystems.* Elsevier, Oxford, United Kingdom.

Erman, D.C. and V.M. Hawthorne. 1976. The quantitative importance of an intermittent stream in the spawning of rainbow trout. *Transactions of the American Fisheries Society* 105: 675-681.

Erman, N.A. and C.D. Nagano. 1992. A review of the California caddisflies (Trichoptera) listed as candidate species on the 1989 Federal "Endangered and threatened wildlife and plants-animal notice of review.' *California Fish and Game* 78: 45-56.

Etnier, D.A. 1997. Jeopardized southeastern freshwater fishes: a search for causes. pp. 87-104. In . G.W. Benz and D.E. Collins (eds.) *Aquatic Fauna in Peril: The Southeastern Perspective* . Special Publication 1, Southeastern Aquatic Research Institute. Lenz Design and Communications, Decatur, Georgia.

Fausch, K.D., C.E. Torgersen, C.V. Baxter, and H.W. Li. 2002. Landscapes to riverscapes: Bridging the gap between research and conservation of stream fishes. *BioScience* 52: 483-498.

Ferrington, L.C., Jr., 1993. Endangered rivers: A case history of the Arkansas River in the Central Plains. *Aquatic Conservation: Marine and Freshwater Ecosystems* 3: 305 - 316.

Fisher SG. 1991. Presidential address: emerging global issues in freshwater ecology. *Bulletin of the North American Benthological Society* 8: 235-245.

Gibbs, R.J. 1970. Mechanisms controlling world water chemistry. *Science* 170: 1088 – 1090.

Gomi, T., R.C. Sidle and J.S. Richardson. 2002. Understanding processes and downstream linkages of headwater systems. *BioScience* 52: 905-916.

Gray, L. J. 1993. Response of insectivorous birds to emerging aquatic insects in riparian habitats of a tallgrass prairie stream. *American Midland Naturalist* 129: 288-300.

Grimm, N.B., A. Chacon, C.N. Dahm et al. 1997. Sensitivity of aquatic ecosystems to climatic and anthropogenic changes: the basin and range, American Southwest and Mexico. *Hydrological Processes* 11: 1023-1041, Haigh, M.J., J. Krecek, G.S. Rajwar, M.P. Kilmartin (eds). 1998. *Headwaters: Water Resources and Soil Conservation*. A.A. Balkema, Rotterdam, Netherlands.

Hall, R.O., Jr., E.S. Bernhardt, and G.E. Likens. 2001. Relating nutrient uptake with transient storage in forested mountain streams. *Limnology and Oceanography* 47: 255-265.

Hansen, W.F. 2001. Identifying stream types and management implications. *Forest Ecology and Management* 143: 39-46.

Hayes, D.B., W.W. Taylor, M.T. Drake, S.M. Marod, and G.E. Whelan. 1998. The value of headwaters to brook trout (*Salvelinus fontinalis*) in the Ford River, Michigan, USA. pp. 175 – 185 In M.J. Haigh, J. Krecek, G.S. Rajwar, M.P. Kilmartin (eds) *Headwaters: Water Resources and Soil Conservation*. A.A. Balkema, Rotterdam, Netherlands.

Heinz Center. 2002. *The State of the Nation's Ecosystems*. Cambridge University Press. New York.

Hynes, H.B.N. 1975. The stream and its valley. *Proceedings of the International Association for Theoretical and Applied Limnology* 19: 1-15.

Johnson, C.E., C.T. Driscoll, T.G. Siccama and G.E. Likens. 2000. Element fluxes and landscape position in a northern hardwood forest watershed ecosystem. *Ecosystems* 3: 159 –184.

Johnson, P.D. and K.M. Brown. 2000. The importance of micro-habitat factors and habitat stability to the threatened Louisiana pearlshell mussel, *Margaritifera hembeli* (Conrad). *Canadian Journal of Zoology* 78: 271-277.

Junk, W.J., P.B. Bayley, and R.E. Sparks. 1989. The flood pulse concept in river-floodplain systems. pp. 110-127 In D.P. Dodge (ed) *Proceedings of the International Large River Symposium*. Canadian Special Publication of Fisheries and Aquatic Sciences 106.

Kaplan, L.A., R.A. Larson and T.L. Bott. 1980. Patterns of dissolved organic carbon in transport. *Limnology and Oceanography* 25: 1034 – 1043.

Labbe, T.R. and K.D. Fausch. 2000. Dynamics of intermittent stream habitat regulate persistence of a threatened fish at multiple scales. *Ecological Applications* 10: 1774-1791.

Lamothe, P. 2002. Spatial population structure of brook trout in a central Appalachian watershed. M.S. Thesis. West Virginia University. Morgantown WV. 109 pp.

Lemly, D.A. 1982. Modification of benthic insect communities in polluted streams: combined effects of sedimentation and nutrient enrichment. *Hydrobiologia* 87: 229 – 245.

Lenat, D.R. and J.K. Crawford. 1994. Effects of land use on water quality and aquatic biota of three North Carolina piedmont streams. *Hydrobiologia* 294: 185 – 199.

Leopold, L. B. 1994. *A View of the River.* Harvard University Press. Cambridge MA.

Likens, G.E. 1999. The science of nature, the nature of science: Long-term ecological studies at Hubbard Brook. *Proceedings of the American Philosophical Society* 143: 558-572.

Mettee, M.F, P.E. O'Neil, and J.M. Pierson. 1996. *Fishes of Alabama*. Oxmoor House. Birmingham, Alabama.

Meyer, J.L. and J.B. Wallace. 2001. Lost linkages and lotic ecology: rediscovering small streams. Pp. 295 – 317 in M.C. Press, N.J. Huntly, and S. Levin (eds.). *Ecology: Achievement and Challenge*. Blackwell Science.

Minshall, G.W., K.W. Cummins, R.C. Peterson, et al. 1985. Developments in stream ecosystem theory. *Canadian Journal of Fisheries and Aquatic Sciences* 42: 1045-1055.

Morse, J. C., B.P. Stark, and W.P. McCafferty. 1993. Southern Appalachian streams at risk: Implications for mayflies, stoneflies, caddisflies, and other aquatic biota. *Aquatic Conservation: Marine and Freshwater Ecosystems* **3**: 293-303.

Morse, J.C., B.P. Stark, W.P. McCafferty, and K.J. Tennessen. 1997. Southern Appalachian and other southeastern streams at risk: implications for mayflies, dragonflies and damseflies, stoneflies and caddisflies. pp. 17-42. In G.W. Benz and D.E. Collins (eds.) *Aquatic Fauna in Peril: the Southeastern Perspective.* Special Publication 1, Southeastern Aquatic Research Institute, Lenz Design and Communications, Decatur, Georgia.

Moyle, P.B., and R.D. Nichols. 1973. Ecology of some native and introduced fishes of the Sierra Nevada Foothills in Central California. *Copeia* 3: 478-490.

Moyle, P.B. and J.E. Williams. 1990. Biodiversity loss in the temperate zone: decline of the native fish fauna of California. *Conservation Biology* 4:275-284.

Murakami, M. and S. Nakano. 2001. Species-specific foraging behavior of birds in a riparian forest. *Ecological Research* 16:913-23.

Murray, C. B. and M. L Rosenau. 1989. Rearing of juvenile chinook in nonnatal tributaries of the lower Fraser River, British Columbia. *Transactions of the American Fisheries Society* 118(3):284-289.

Nakano, S., and M. Murakami. 2001. Reciprocal subsidies: dynamic interdependence between terrestrial and aquatic food webs. *Proceedings of the National Academy of Sciences* 98: 166-170.

Newcombe, C.P. and J.O.T. Jensen. 1996. Channel suspended sediment and fisheries: A synthesis for quantitative assessment of risk and impact. *North American Journal of Fisheries Management* 16(4): 693-727.

Newcombe, C.P. and D.D. MacDonald. 1991. Effects of suspended sediments on aquatic ecosystems. *North American Journal of Fisheries Management* 11:72 – 82.

Paul, M.J. and J.L. Meyer 2001. Streams in the urban landscape. *Annual Review of Ecology and Systematics* 32: 333-366.

Peterson, B.J., W.M. Wolheim, P.J. Mulholland, J.R. Webster, J.L. Meyer, J.L. Tank, E. Marti, W.B. Bowden, H.M. Valett, A.E. Hershey, W.H. McDowell, W.K. Dodds, S.K. Hamilton, S. Gregory, and D. D. Morrall. 2001. Control of nitrogen export from watersheds by headwater streams. *Science* 292: 86-90.

Peterson, N.P., and L.M. Reid. 1984. Wallbase channels: their evolution, distribution, and use by juvenile coho salmon in the Clearwater River, Washington. In: J.M. Walton and D.B. Houston, eds: *Proceedings of the Olympic Wild Fish Conference*. 23-25 March 1983, Port Angeles, Washington: 215-225.

Petranka, J.W. 1998. *Salamanders of the United States and Canada*. Smithsonian Institution Press. Washington D.C. 587 pp.

Piccolo, J.J. and M.S. Wipfli. 2002. Does red alder (Alnus rubra) in upland riparian forests elevate macroinvertebrate and detritus export from headwater streams to downstream habitats in southeastern Alaska? *Canadian Journal of Fisheries and Aquatic Sciences* 59: 503-513.

Polhemus, D.A., J. Maciolek, and J. Ford. 1992. An ecosystems classification of inland water for the tropical Pacific islands. *Micronesica* 25(2): 155-173.

Postel, S. 1999. *Pillar of Sand*. W.W. Norton. New York.

Power, G., R.S. Brown, and J.G. Imhof. 1999. Groundwater and fish – insights from northern North America. *Hydrological Processes* 13: 401-422.

Pringle, C.M. 1997. Exploring how disturbance is transmitted upstream: going against the flow. *Journal of the North American Benthological Society* 16: 425-438.

Prosser, D.J. and R.P. Brooks. 1998. A verified habitat suitability index for the Louisiana Waterthrush. *Journal of Field Ornithology* 69: 288 – 298.

Radwell, A. 2001. Efforts to protect critical fish habitat has heuristic value for student subunit. *Fisheries* 26 (3): 28.

Reid, L.M. and R. R. Ziemer 1994. Evaluating the biological significance of intermittent streams. USDA Forest Service, Pacific Southwest Research Station website: http://www.rsl.psw.fs.fed.us/projects/water/2IntermitStr.htm.

Richards, C., P. J. Cernera, M. P. Ramey and D. W. Reiser. 1992. Development of off-channel habitats for use by juvenile chinook salmon. *American Journal of Fisheries Management* 12:721-727.

Ryon, M.G. 1986. The life history and ecology of *Etheostoma trisella* (Pisces: Percidae). *American Midland Naturalist* 115: 73-86.

Sanzone, D.M. 2001. *Linking communities across ecosystem boundaries: the influence of aquatic subsidies on terrestrial predators*. Ph.D. Dissertation, University of Georgia, Athens, Georgia. 261 p.

Sanzone, D.M., J.L. Meyer, E. Marti, E.P. Gardiner, J.L. Tank and N.B. Grimm. 2003. Carbon and nitrogen transfer from a desert stream to riparian predators. *Oecologia* 134: 238-250.

Schorer, M. and W. Symader. 1998. Biofilms as dynamic components for the sorption of inorganic and organic pollutants in fluvial systems. pp. 187 – 196 In M.J. Haigh, J. Krecek, G.S. Rajwar, M.P. Kilmartin (eds*) Headwaters: Water Resources and Soil Conservation*. A.A. Balkema, Rotterdam, Netherlands.

Scrivener, J. C., T. C. Brown, and B. C. Anderson. 1994. Juvenile chinook salmon (*Oncorhynchus tshawytscha*) utilization of Hawks Creek, a small and nonnatal tributary of the upper Fraser River. *Canadian Journal of Fisheries and Aquatic Sciences* 51:1139-1146.

Seidman, V.M. and C.J. Zabel. 2001. Bat activity along intermittent streams in northwestern California. *Journal of Mammology* 82(3): 738 – 747.

Steinhart, G.S., G.E. Likens and P.M. Groffman. 2000. Denitrification in stream sediments in five northeastern (USA) streams. *Proceedings of the International Association of Theoretical and Applied Limnology* 27: 1331 – 1336.

Steinman, A.D. and B.H. Rosen. 2000. Lotic-lentic linkages associated with Lake Okeechobee, Florida. *Journal of the North American Benthological Society* 19: 733 - 741.

Strayer, D.L. 2000. North America's freshwater invertebrates: a research priority. p. 104 In R.A. Abell, D.M. Olson, E. Dinerstein et al. (eds.) *Freshwater Ecoregions of North America: A Conservation Assessment.* Island Press, Washington D.C.

Trimble, S.W. 1997. Contribution of stream channel erosion to sediment yield from an urbanizing watershed. *Science* 278: 1442 -1444.

United States Fish and Wildlife Service. 1998. Permitted stream losses due to valley filling in Kentucky, Pennsylvania, Virginia, and West Virginia: A partial inventory. Pennsylvania Ecological Services Field Office, State College PA.

Vannote, R.L., G.W. Minshall, K.W. Cummins, J.R. Sedell, and C.E. Cushing. 1980. The river continuum concept. *Canadian Journal of Fisheries and Aquatic Sciences* 37: 130-137.

Wallace, J. B., S.L. Eggert, J.L. Meyer, and J.R. Webster. 1997. Multiple trophic levels of a stream linked to terrestrial litter inputs. *Science* 277: 102-104.

Wang, L., J. Lyons and P. Kanehl. 2002. Effects of watershed best management practices on habitat and fish in Wisconsin streams. *Journal of the American Water Resources Association* 38: 663-680.

Ward, J.V. 1989. The four dimensional nature of lotic ecosystems. *Journal of the North American Benthological Society* 8: 2 – 8.

Waters, T.F. 1995. *Sediment in Streams: Sources, Biological Effects and Control*. American Fisheries Society Monograph 7. Bethesda, Maryland.

Welch, H.H. Jr., G.R. Hodgson and A.J. Lind. Ecogeography of the herpetofauna of a Northern California (U.S.A.) watershed: linking species' patterns to landscape processes. In review. *Ecography*.

Wiley, J.B., R.D. Evaldi, J.H. Eychaner, and D.B. Chambers. 2001. Reconnaissance of stream geomorphology, low streamflow, and stream temperature in the mountaintop coal-mining region, southern West Virginia, 1999-2000. Water Resources Investigations Report 01-4092.U. S. Geological Survey.

Wilkins, R.N. and N.P. Peterson. 2000. Factors related to amphibian occurrence and abundance in headwater streams draining second-growth Douglas-fir forests in southwestern Washington. *Forest Ecology and Management* 139: 79 - 91.

Wipfli, .S. and D.P. Gregovich. 2002. Export of invertebrates and detritus from fishless headwater streams in southeastern Alaska: implications for downstream salmonid production. *Freshwater Biology* 47: 957-969.