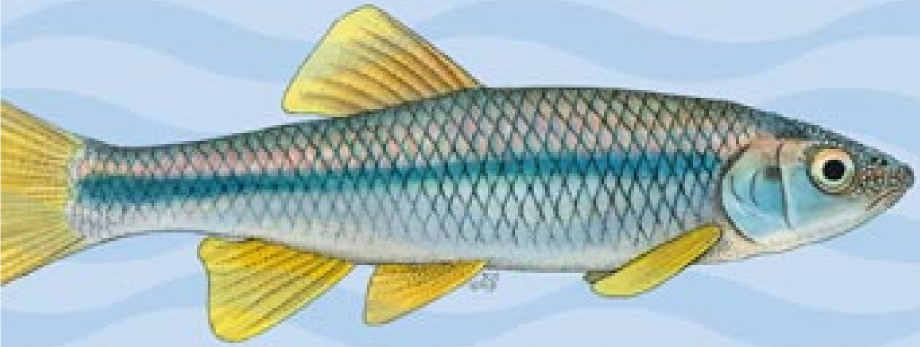
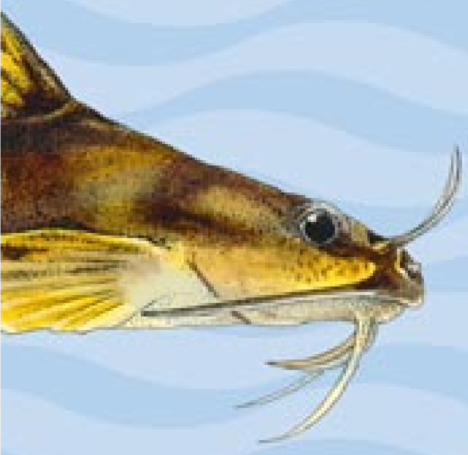
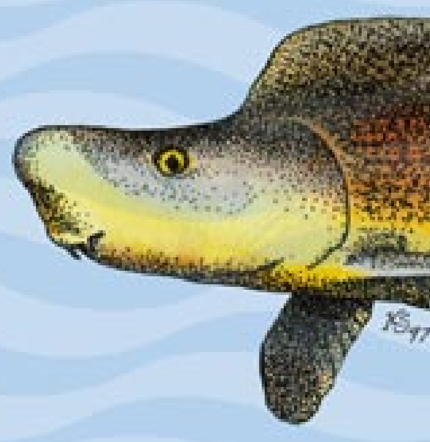




Rivers of Life

Critical Watersheds for Protecting Freshwater Biodiversity

The Nature Conservancy

A NatureServe® Publication

Rivers of Life

Critical Watersheds for Protecting Freshwater Biodiversity

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The Nature Conservancy, in cooperation with Natural Heritage Programs and the Association for Biodiversity Information

A NatureServe® Publication

This report is based on material developed for the forthcoming book *Precious Heritage: The Status of Biodiversity in the United States*, a joint project of The Nature Conservancy and the Association for Biodiversity Information.

Citation: Master, Lawrence L., Stephanie R. Flack and Bruce A. Stein, eds. 1998. *Rivers of Life: Critical Watersheds for Protecting Freshwater Biodiversity*. The Nature Conservancy, Arlington, Virginia.

ISBN: 1-886765-09-X

This publication is available on The Nature Conservancy's Web site at http://www.tnc.org/science/.

This publication is a product of NatureServe®, which is made possible by Canon U.S.A.'s Clean Earth Campaign. The NatureServe® program is designed to promote biodiversity conservation by raising public awareness and advancing scientific knowledge.

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Summary

Hidden beneath the shimmering surface of our nation's rivers and lakes is an extraordinary variety of aquatic creatures, largely unseen and unfamiliar to most of us. Though we are a nation devoted to the beauty and recreational values of our streams, creeks, and rivers, few of us know that U.S. streamlife is exceptional on a global level, even compared with the tropics. This remarkable freshwater diversity should be a source of great national pride. Instead, it is a source of grave concern.

Rivers and lakes are the circulatory system of our nation. These ecosystems furnish a variety of services, from clean drinking water and recreational opportunities to transportation and food. The very quality of our lives, and freshwater species' survival, is tied to their health.

Our Aquatic Impoverishment

Inhabitants of freshwater ecosystems have, as a whole, suffered far more than plants and animals dependent on upland habitats such as forests and prairies. Although the plight of salmon in the Pacific Northwest and New England is widely recognized, this report focuses on the many other freshwater species groups that are in dire straits:

- Two-thirds of the nation's freshwater mussels are at risk of extinction, and almost 1 in 10 may already have vanished forever.
- Half of all crayfish species are in jeopardy.
- Freshwater fishes and amphibians are doing little better, with about 40 percent of the species in these groups at risk.

These losses are not confined to urban areas or to a specific region of the country. Aquatic systems are under stress nationwide, with the largest number of imperiled species found in the Southeast. Arid western states have fewer species, but a greater proportion of them are at risk of extinction.

These dramatic declines in freshwater animal species are due primarily to the intensive human use—and abuse—of their habitats. Two centuries of dam construction, water withdrawals, land-use alterations, pollution, and introductions of non-native species have caused accelerated and, in many

State and federal agencies are working together to reintroduce the endangered razorback sucker (Xyrauchen texanus) *to Arizona's upper Verde River, profiled on page 41.*

cases, irreparable losses of freshwater species. Rivers are affected by, and reflect, the condition of the lands through which they travel. Since the Clean Water Act became law in 1972, the United States has made great strides in improving water quality by controlling “end of pipe” pollution, but nonpoint source pollution—polluted and sediment-laden runoff from urban and rural areas—is still a major problem.

Freshwater species and habitats provide a wealth of goods and services to humanity. Nearly a billion people worldwide rely on fishes as their primary source of protein. In 1990, the total global harvest of freshwater fish was valued at $8.2 billion; the value of the U.S. freshwater sport fishery in 1991 was nearly twice that, with direct expenditures totaling approximately $16 billion. And these figures do not reflect the immense worth of ecological services provided by freshwater systems, such as flood control.

Watersheds: A Practical Approach to Conservation

Given the fluid nature of water, protecting aquatic biodiversity is no easy task. Human activities directly upslope, or even miles upstream, may affect streamlife in another place.

Many concerned citizens know that watersheds—natural drainage basins—are critical for addressing water-related issues, from protecting drinking water to conserving freshwater species. But which watersheds should be priorities for conservation attention? Where should we allocate scarce conservation resources to protect freshwater species and ecosystems?

Although at-risk freshwater species can be assessed at the level of states or large regional watersheds, *Rivers of Life: Critical Watersheds for Protecting Freshwater Biodiversity* presents the first analysis to define conservation priorities on a scale that is practical for action. Approximately 2,100 small watersheds cover the continental United States. These small watershed areas reflect a scale appropriate for planning and carrying out conservation actions. Using information from natural heritage data centers and other sources, this report identifies *the 15 percent of these small watershed areas that will conserve populations of all freshwater fish and mussel species at risk in the United States.* These watersheds form a blueprint for where targeted conservation actions could provide the greatest benefit for the largest number of vulnerable freshwater fish and mussel species.

Rivers of Life

Protecting and restoring priority watersheds will take creativity, commitment, and the involvement of local communities. The returns from such efforts will benefit not only the rich diversity of fishes and other aquatic life but the human communities themselves. The art and science of aquatic conservation are exemplified by work under way in eight of these critical watersheds. Ranging from the meandering Altamaha in Georgia to the upper Verde River of Arizona, these watersheds, which are profiled in the following pages, reflect the importance of local action and community-level partnerships in saving freshwater species and ecosystems.

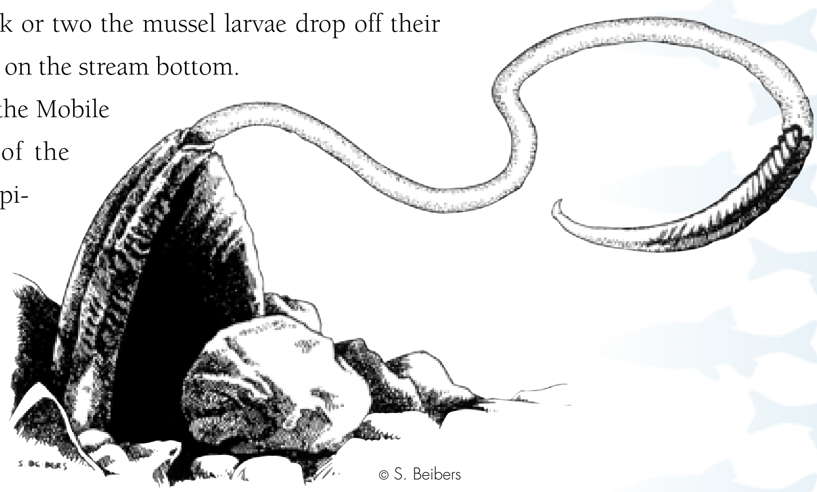
A Global Center of Freshwater Biodiversity: The United States

The decline of salmon populations in the Pacific Northwest and New England is the focus of great public attention, investment, and debate. Few people recognize, however, what an astonishing abundance of other life forms also inhabits our nation's streams, rivers, and lakes. Mostly hidden from view, these creatures go largely unnoticed and unappreciated. Colorful and whimsical names hint at the diversity and beauty living beneath these waters: Wabash pigtoe mussel, dromedary pearly mussel, white catspaw pearly mussel, warpaint shiner, Devils Hole pupfish, and frecklebelly madtom.

Worthy of these epithets, many freshwater species display complex and intriguing lifestyles that have evolved as adaptations to their watery world. Consider the orangenacre mucket (*Lampsilis perovalis*). As adults, these mussels are unable to move a significant distance. How, then, can they colonize new habitat, especially upstream areas?

The orangenacre mucket employs a sophisticated ruse to get help from passing fishes in moving its young around. The female mussel creates a fishing lure, using her offspring as bait.[1] The larval offspring are packaged at the end of a jelly-like tube, which can stretch up to eight feet. Dancing in the current of rocky riffles, the end of this tube bears a striking resemblance to a minnow. When a fish takes the bait, the tube shatters and releases the larvae—called glochidia—into the stream. A few are able to attach themselves to the gills of the duped fish, where they absorb nutrients from the host and continue their development. After a week or two the mussel larvae drop off their mobile incubator, settling to a new home on the stream bottom.

Found only in rivers and creeks in the Mobile River basin of Alabama, populations of the orangenacre mucket have declined precipitously, and the mussel is now federally listed as endangered. The orangenacre



An orangenacre mucket (Lampsilis perovalis) *extends a minnow-like "lure" to attract potential fish hosts for its larvae.*

© S. Beibers

mucket's reproductive strategy illustrates the complex web of interactions and interdependencies within freshwater ecosystems. Mussel and fish are linked, and both require suitable conditions for survival: the right water flow, clarity, temperature, oxygen levels, and substrate. Unfortunately, the odds are now against a young mussel settling into such suitable habitat.

Despite these intricate dependencies—or perhaps because of them—an astounding array of mussels, fishes, and other organisms has evolved to populate the fresh waters of our country. Indeed, the United States stands out as a global center of freshwater biodiversity.

Fresh Waters Run Rich

Rivers and lakes cover less than 1 percent of the Earth's surface; by volume these fresh waters amount to just 0.01 percent of the world's total water. The remainder is marine (97.5 percent), permanently frozen, or in aquifers beneath the ground surface.[2] Despite their slight significance in surface area and volume, rivers and lakes harbor at least 12 percent of the world's known animal species, including 41 percent (8,400 species) of all known fishes.[3] Considering the rate at which scientists are discovering previously unknown species, freshwater fishes may actually constitute more than half of all vertebrate species on Earth.[2]

This diversity of freshwater life is not randomly distributed around the globe. The tropics, especially rainforests, are widely recognized as centers of species diversity. Few people realize, however, that the United States is a world center of freshwater species diversity (Table 1). Although

Table 1. Global Significance of U.S. Freshwater Species

The United States harbors an impressive diversity of freshwater species in comparison with most other countries. For several groups of organisms the United States ranks first in the number of known species.

Taxonomic Group	Number of Described U.S. Species	Number of Described Species Worldwide	Percentage of Known Species Worldwide Found in U.S.	U.S. Ranking Worldwide in Species Diversity
Fishes	801	8,400	10	7
Crayfishes	322	525	61	1
Freshwater Mussels	300	1,000	30	1
Freshwater Snails	600	4,000	15	1
Stoneflies	600	1,550	40	1
Mayflies	590	2,000	30	1
Caddisflies	1,400	10,564	13	1
Dragonflies & Damselflies	452	5,756	8	uncertain
Stygobites	327	2,000	16	1

Note: Numbers are rounded for some groups. *Sources: 4-19*

© Blair Nikula

Found in clear, cold high-quality northeastern streams, the vulnerable brook snaketail dragonfly (Ophiogomphus aspersus) *is among the more than 80 U.S. dragonfly and damselfly species at risk due to habitat loss or degradation.*

most of the world's freshwater fish species are tropical, the United States, with 801 species, ranks seventh among countries in the world in recorded fish species—after Brazil, Venezuela, Indonesia, China, Zaire, and Peru.[4,5] In contrast, only 193 freshwater fish species are known from all the countries of Europe and 188 species from the continent of Australia.[6]

Freshwater invertebrates are in general less well studied than fishes, although groups such as mollusks, crayfishes, and some aquatic insects are sufficiently well known to allow for meaningful global comparisons. These invertebrates also reveal the extraordinary diversity of America's fresh waters. The United States is home to three-fifths of the world's known crayfishes, 96 percent of which occur no place else.[7,8] Almost one-third (approximately 300 species) of all known freshwater mussels occur in the United States.[7,9] By comparison, China has only 38 known mussel species, India has 54, and the rivers of Europe and Africa have only 10 and 56 species, respectively.[10] The United States is also comparatively rich in freshwater snails and in an unusual assemblage of freshwater invertebrates called stygobites, which are restricted to life underground.[11-15] Although freshwater insects are less well known worldwide, again the United States ranks first among countries in described species for three relatively well-studied groups: stoneflies, mayflies, and caddisflies.[7,16-20]

Imperiled Assets: Freshwater Species at Risk

The most grievous assault on the Earth's environment is the destruction of species, both plant and animal. It is the destruction of life itself; life which has evolved over hundreds of millions of years into a diversity of forms that stagger the imagination; life of a beauty and complexity that fill one with awe and wonder.

Russell Train, former Administrator,
U.S. Environmental Protection Agency, 1990

As a whole, organisms that depend on freshwater ecosystems are in grave condition. The *1997 Species Report Card,*[21] released by The Nature Conservancy in cooperation with the state Natural Heritage Network (see box, page 9), found that:

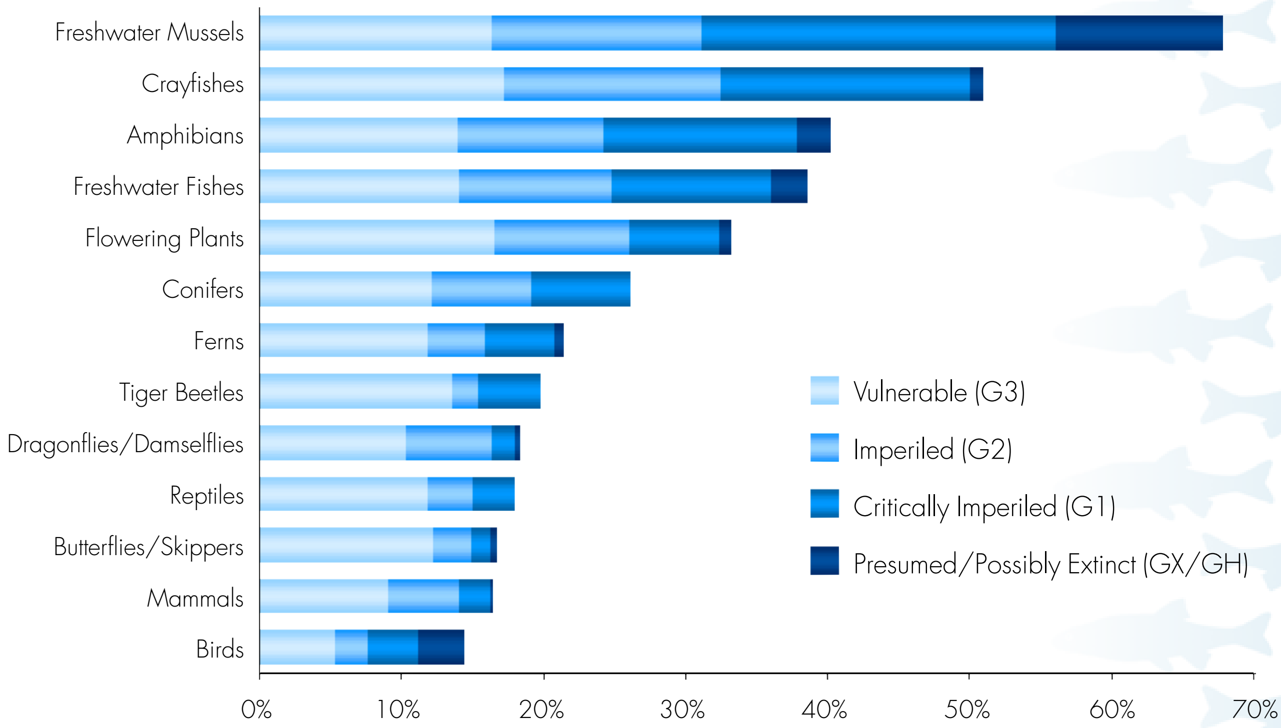
- 67 percent of U.S. freshwater mussels are vulnerable to extinction or are already extinct; more than 1 in 10 mussels may have become extinct during this century alone.
- 303 fish species—37 percent of the U.S. freshwater fish fauna—are at risk of extinction; 17 species have already gone extinct, mostly in this century.
- 51 percent of U.S. crayfishes are imperiled or vulnerable.
- 40 percent of amphibians are imperiled or vulnerable.
- At least 106 major populations of salmon and steelhead trout on the West Coast have been extirpated, and an additional 214 salmon, steelhead trout, and sea-run cutthroat trout stocks are at risk of extinction.[22]

Freshwater species as a whole are much more imperiled than terrestrial species. An assessment of the proportion of imperiled and vulnerable species in different groups of organisms in the United States (Figure 1) reveals that the most imperiled groups are those that consist entirely or primarily of freshwater species.

Startling as these findings are, they are consistent with other recent assessments of the deteriorating condition of freshwater species and ecosystems in the United States.[2,6,23-29] Although extinction is a natural process, scientists report that current extinction rates are on the order of 1,000 times normal rates.[30,31] Reflecting the severity of the situation, more than 300 freshwater species are listed or proposed for listing under the U.S. Endangered Species Act. Moreover, scientists report that under existing and often worsening habitat conditions, conservation efforts for most federally listed or candidate aquatic species are inadequate to prevent continuing declines in abundance, distribution, and other measures of viability.

Figure 1. Proportion of U.S. Species at Risk

The species groups that are proportionately the most imperiled—mussels, crayfishes, and amphibians—consist entirely or primarily of freshwater species. (Source: 1997 Species Report Card[21])



SPECIES CONSERVATION STATUS

Conservation status is assessed by The Nature Conservancy and Natural Heritage Network using a 1 to 5 ranking system, ranging from critically imperiled (G1) to demonstrably secure (G5).[32] Species known to be extinct, or missing and possibly extinct, also are recorded. In general, species classified as vulnerable (G3) or rarer may be considered to be "at risk."

"G" refers to global or rangewide status. National (N) and state (S) status ranks also are assessed.

The terms "endangered" and "threatened" are legal designations referring to species listed under the U.S. Endangered Species Act and subject to its provisions.

GX PRESUMED EXTINCT
not located despite intensive searches

GH POSSIBLY EXTINCT
of historical occurrence; still some hope of rediscovery

G1 CRITICALLY IMPERILED
typically 5 or fewer occurrences or 1,000 or fewer individuals

G2 IMPERILED
typically 6 to 20 occurrences or 1,000 to 3,000 individuals

G3 VULNERABLE
rare; typically 21 to 100 occurrences or 3,000 to 10,000 individuals

G4 APPARENTLY SECURE
uncommon but not rare; some cause for long-term concern; usually more than 100 occurrences and 10,000 individuals

G5 SECURE
common; widespread and abundant

Where Is the Problem?

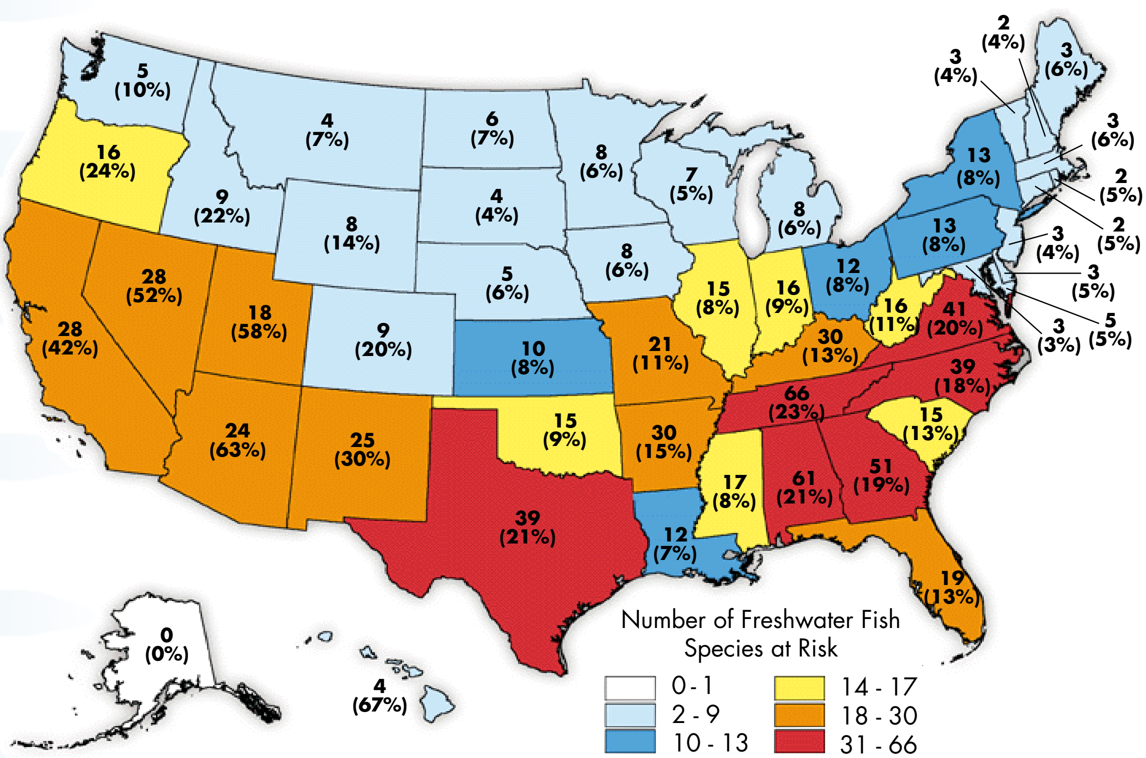
To answer this question, we can look at many geographic scales. From a political and administrative perspective, it is useful to view state distributions of at-risk freshwater species. An analysis of distributions by large watersheds, or regions, gives a more natural perspective of species concentrations. But focusing on smaller watershed areas is crucial for taking conservation action, because this is the scale at which many threats to water quality, ecosystem integrity, and species survival must be addressed. This first national analysis of at-risk species distributions not only focuses on the practical watershed scale, but also suggests a set of key watersheds that collectively encompass all at-risk fish and mussel species in the continental United States.

State of the States

The diversity of freshwater species in different states and the serious threats confronting their habitats are reflected in the map depicted below (Figure 2). States with the greatest number of freshwater fish species at risk are concentrated largely in the southeastern United States; the arid western states, however, have the highest proportion of extinct, imperiled, and vulnerable fishes. Five states—California, Texas, Nevada, Tennessee, and Alabama—each have at least 14 fish species that are endemic—found nowhere else in the world.

Figure 2. State Distribution of At-Risk Freshwater Fishes

Southeastern states have the greatest numbers of imperiled and vulnerable species, while states in the arid West have fewer species but lead in the percentage of their fish species that are at risk. (Figures are for full species only and do not include subspecies or distinct populations.)



A NATURAL PARTNERSHIP

Rivers of Life draws on the scientific work of the Natural Heritage Network, a unique institutional collaboration devoted to collecting, managing, and sharing information about species and ecosystems at risk. More than 500 participating scientists, along with collaborating biologists from other institutions, share the task of evaluating the conservation status of species and documenting their distribution.

Operating in all 50 U.S. states, Canada, Latin America, and the Caribbean, individual heritage data centers typically are part of state agencies charged with natural resource or wildlife management. To assist in land-use planning, environmental review, and targeting of conservation efforts, the individual natural heritage data centers maintain detailed maps and computer records for locations of the most imperiled species in their state.

The Association for Biodiversity Information and The Nature Conservancy work together to provide support to the Natural Heritage Network. (See page 66 for addresses of participating state agencies and programs, or visit their Internet home pages at http://www.heritage.tnc.org/.)

A Regional Perspective

Species ranges do not respect state lines. Freshwater species are distributed based on hydrology, especially watershed boundaries, and the local geologic and climatic forces that shape the landscape. Reflecting hydrologic factors, the United States can be divided into large freshwater regions * where significantly different aquatic assemblages occur, as shown in Figure 3. These regions consist of large or multiple river basins and provide a more natural picture of the most biologically diverse regions of the United States.[33]

Although at-risk freshwater species are distributed throughout the United States, two particular regions include 35 percent of all vulnerable and imperiled fish and mussel species (161 of 465 species): the Tennessee-Cumberland River basins (including Tennessee and parts of six other states) and the Mobile River basin (including most of Alabama, parts of Georgia and Mississippi, and a bit of Tennessee). Seventy percent (113) of these at-risk species occur nowhere else in the world; they are endemic or restricted to one of these two regions. These basins are also rich in other freshwater species, including snails and turtles.[34] The Interior Highlands region (located in Arkansas, southern Missouri, southwestern Oklahoma, and northeastern Texas) has the next-highest count of fish and mussel species at risk, with 54 species. All U.S. freshwater regions and their numbers of at-risk fish and mussel species are listed in Appendix A.

The extraordinary diversity of southeastern U.S. rivers results from the coincidence of a diverse physical geography, favorable climate, and a long but dynamic history. The numerous streams of the southeastern United States flow across geologically and topographically diverse landforms. This varied landscape was spared the repeated habitat-crushing advances of continental ice sheets during

* *The U.S. Forest Service classifies freshwater ecological units in a seven-level hierarchy: subzones, regions, subregions, river basins, subbasins, watersheds, and subwatersheds.[33] In this report, we use the more generic term "region" to refer to a subregion and the more generic term "watershed" to refer to a subbasin, which is the same as the U.S. Geological Survey's eight-digit Hydrologic Cataloging Unit. In the contiguous United States, there are all or parts of 48 subregions and 2,111 subbasins. The U.S. Environmental Protection Agency uses the subbasin, or eight-digit Hydrologic Cataloging Unit, for its "Index of Watershed Indicators."*

the Pleistocene era, allowing living things to persist and evolve over time. Patterns of evolution were affected by the changes in climate, stream drainage patterns, and coastline position that accompanied glacial movements in the North. These changes isolated many populations, enabling them to diverge genetically and evolve into new species.

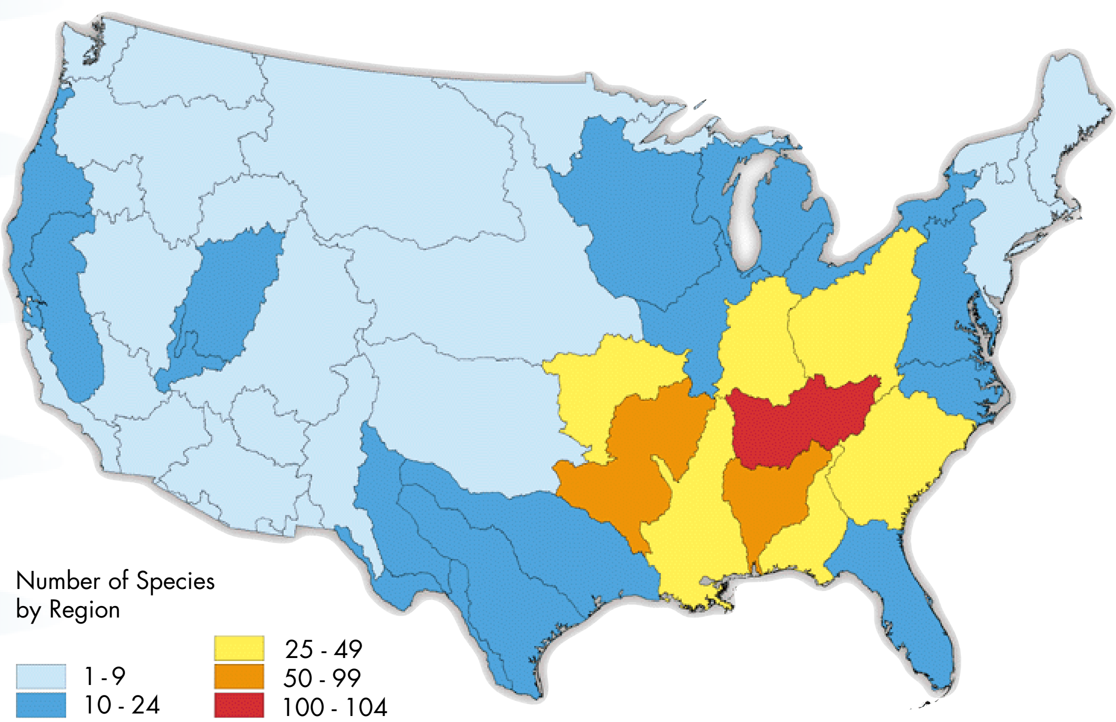
On Salmon and Subspecies

The preceding analysis reflects the status of full taxonomic species, which are particularly important to conservation of biodiversity from a genetic perspective. However, within-species genetic diversity is also crucial to preserve, and is represented at the subspecies and population levels. For example, 14 fish species are found only in Nevada; however, an additional 39 fish subspecies exist only within that state's borders.[35] The conservation importance of within-species diversity has been recognized under the U.S. Endangered Species Act, which allows for the listing of subspecies and distinct populations as endangered or threatened.

Population-level genetic variability is perhaps best known in anadromous fishes such as salmon and sea-run trout. Because of their economic and ecological importance, salmonids are the most studied and intensively managed freshwater organisms in the United States. These wide-ranging

Figure 3. Regional Concentrations of At-Risk Fish and Mussel Species

The number of at-risk fish and mussel species by freshwater regions in the United States. The Tennessee-Cumberland and Mobile River basins in the Southeast have extraordinarily diverse assemblages of freshwater animal species, many of which are imperiled or vulnerable.



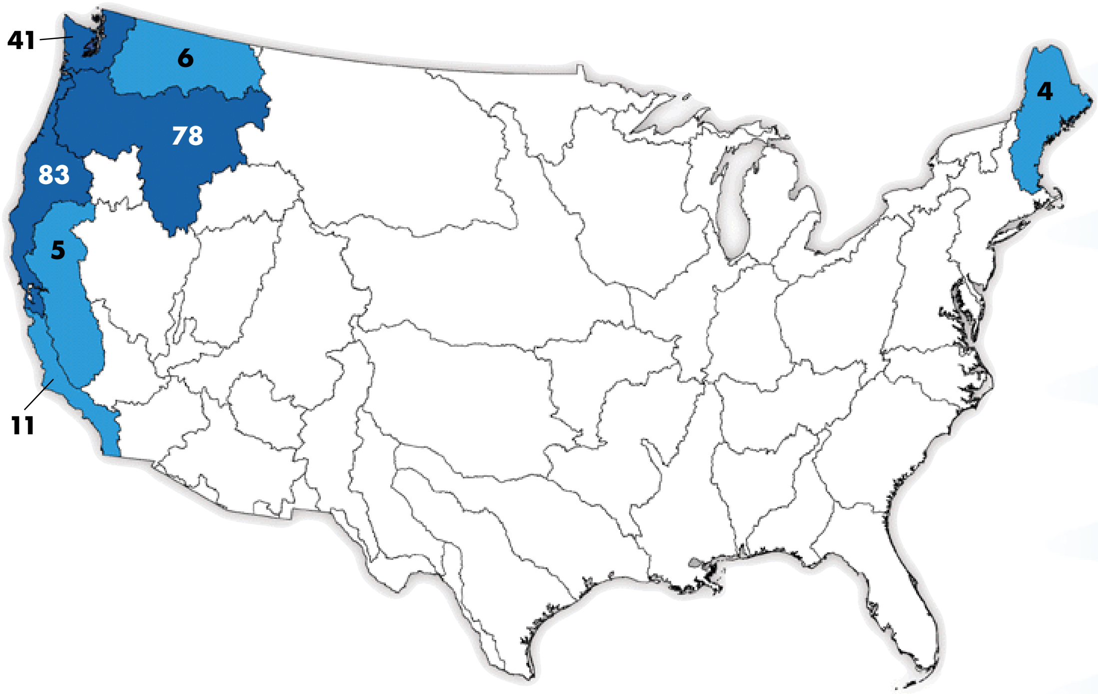
animals spawn in specific watersheds where they return to breed after spending a number of years maturing in the ocean. Possessing remarkable sensory homing abilities, they usually return at a specific season to the river where they hatched. Each of these populations—called "runs" or "stocks"—contains unique genetic diversity because of limited breeding with other stocks and adaptations to local environmental conditions. The loss of a stock results in an irreplaceable loss of genetic diversity for the species as a whole.

When salmon species are viewed at the level of individual stocks, two parts of the country emerge as areas with many imperiled groups at the subspecies or population level (Figure 4). In the Pacific Northwest, at least 106 major populations of salmon and steelhead trout have already been extirpated. In California, Oregon, Idaho, and Washington, 214 salmon and steelhead stocks are at risk of extinction, representing seven species: chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*Oncorhynchus kisutch*), sockeye salmon (*Oncorhynchus nerka*), chum salmon (*Oncorhynchus keta*), pink salmon (*Oncorhynchus gorbuscha*), steelhead trout (*Oncorhynchus mykiss*), and sea-run cutthroat trout (*Oncorhynchus clarki*).[22] In New England waters another species, the Atlantic salmon (*Salmo salar*), has four stocks that are at risk.

As important as salmon are to the economy and ecology of the nation, the remainder of this report focuses on the less-recognized but even larger number of other freshwater species whose future is in question.

Figure 4. Regional Concentrations of At-Risk Salmon Stocks

Although full species of imperiled freshwater fishes and mussels are concentrated in the Southeast, salmonid stocks at risk are clustered in the Pacific Northwest and New England (number indicates at-risk salmon, steelhead, and sea-run cutthroat stocks by region).



© Charlie Ott, TNC

Sockeye salmon (Oncorhynchus nerka) *spawn in small, clear streams from Alaska to California. Twenty-nine stocks of sockeye are considered extinct and an additional 70 sockeye stocks are at risk in the Pacific Northwest (parts of four U.S. states plus British Columbia and the Yukon). This is primarily due to the estimated loss of 96 percent of their habitat in the Columbia River basin.*[22,36]

Threats to Freshwater Species and Systems

Because rivers integrate everything in their landscapes, the living organisms found in rivers tell us about the status and quality of their watersheds. Unfortunately, the story told in North America's rivers today is one of damaged landscapes and the historical tendency to undervalue our rivers.[37]

James R. Karr, professor,
University of Washington, 1997

Although the Southeast and West stand out as epicenters of endangerment, as noted previously, freshwater organisms are under stress throughout the United States. Among the many significant threats to freshwater species and their habitats, three stand out nationwide:[38]

- **Nonpoint source pollution** comes from diffuse sources and is usually carried in rainwater and snowmelt to surface and subsurface waters. This pollution often includes a variety of chemical and nutrient contaminants that degrade water quality. Of special concern are the sediments from uncontrolled soil erosion, which can smother stream bottoms and render them unsuitable for many aquatic creatures. Agriculture, some forestry activities, urban and suburban development, and highway construction all contribute to erosion.

- **Non-native species,** accidentally or purposely introduced into aquatic systems, interfere with native species by competing with them for limited resources and by directly preying upon them.

Dams and their associated operations seriously alter the flow, temperature, and nutrient content of waterways. The impounded water upstream and the altered downstream flows physically change stream channels, while the dam itself poses a barrier to species dispersal. The downstream and upstream effects of a single dam can alter the character of an entire watershed. In the United States, some 75,000 dams larger than six feet and 2.5 million smaller dams have widespread and pervasive effects on freshwater life.[39,40] Only 42 free-flowing rivers longer than 125 miles remain in the United States—less than 2 percent of the country's 3.1 million miles of rivers and streams.[3,41]

Human disturbance of freshwater systems can have devastating and unexpected costs. Nutrient enrichment of stream systems has catalyzed toxic outbreaks of *Pfiesteria piscicida*, a microscopic aquatic organism linked to fish kills numbering in the hundreds of thousands. First discovered in 1988, this one-celled species enters the deadly phase of its life cycle when it is stimulated by fish waste or nutrient enrichment of water bodies—through infusions of fertilizer, sewage, or livestock waste. *Pfiesteria* not only kills fishes but harms human health: People exposed to *Pfiesteria*-filled waters experience memory loss, impaired cognitive function, and skin lesions. In the wake of *Pfiesteria* fish kills and resulting public alarm, state authorities in North Carolina and Maryland closed rivers to human use, harming the regions' fishery and tourism industries.[42]

NONPOINT SOURCE POLLUTION

The Clean Water Act has been more effective in controlling "end of pipe" (point source) industrial and municipal discharges than the diffuse, nonpoint sources of sediments and pollution that are now the greatest cause of degraded water quality.

Agricultural lands are critical for protection of water quality and streamlife because fields and pastures can deliver vast quantities of sediments, chemicals, and nutrients to receiving waters. The President's Council on Environmental Quality reports total soil erosion losses at 2.1 billion tons nationwide, or 5.6 tons per acre per year. Approximately 65 percent of the sediment washed into U.S. streams, rivers, and lakes comes from cropland, pastures, and rangeland.[43] Often bound to this eroded sediment is phosphorus, the nutrient primarily responsible for eutrophication in freshwater systems. Eutrophication can cause "blooms" of algae that virtually kill lakes and clog freshwater supply intakes. Well-tested and readily available management practices can greatly limit losses of valuable topsoil and nutrients from agricultural areas while reducing farmers' investments in chemical additives.

Urban and residential areas not only contribute nonpoint source pollutants but alter natural water flows within watersheds by increasing the percentage of roads, driveways, parking lots, and other impermeable ground surfaces. Pollution in residential areas is caused by failing septic systems, septic system additives, improper disposal of household chemicals, stormwater runoff, construction activities, and inappropriate use of fertilizers and pesticides. More than 30 studies have found that stream systems become significantly degraded when 10 to 12 percent of the watershed is made impermeable.[44] For example, in one study, trout were lost when watershed impermeability reached 12 percent.[45] Stormwater runoff from impermeable surfaces carries large amounts of sediment, heavy metals, oil, and oxygen-demanding organic matter. Moreover, an increase in impermeable surfaces increases the intensity of stormwater runoff, hastening the erosion of streambanks and further degrading stream systems.

© Brian Richter, TNC

Taylor Draw Dam on the White River in Colorado is among the 26 major dams built in the upper Colorado River system. These dams have seriously altered the natural habitat of the region's native fishes, including endangered species such as the Colorado squawfish (Ptychocheilus lucius) *and razorback sucker* (Xyrauchen texanus).

Valuing Our Fresh Waters

> *Human survival has always been dependent on our ability to recognize, understand, and utilize biological diversity. However much we learn to manipulate our environment, we cannot escape our dependency on biodiversity for food, medicines, and materials or for the ecological services provided by healthy, diverse ecosystems.*[46]
>
> Stephen Blackmore, Keeper of Botany,
> The Natural History Museum, London, 1996

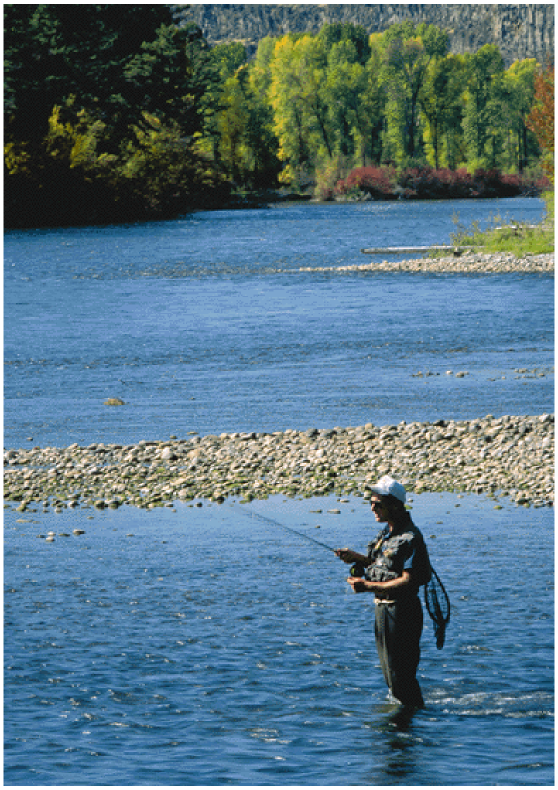
Clean water is essential to life. Both humans and all the other animals profiled in this report depend on an adequate supply of clean water. Stream-dwelling insects, mollusks, and crustaceans are indicators of environmental quality. Like the fishes that have succumbed to *Pfiesteria* outbreaks, these species provide warning signs of problems with water quality and ecosystem stability when their numbers drop. Many state agencies monitor fishes and aquatic insects not only to assess the condition of freshwater habitats but to evaluate water quality for decisions about water supply and land management.[47]

Freshwater habitats provide for many of our fundamental needs: water for drinking and irrigation; food in the form of fishes and waterfowl; and in-stream services such as flood control, transportation, recreation, and water quality protection. Healthy river systems and wetlands retain water and buffer the effects of storms, reducing the loss of life and property to floods. Naturally vegetated streamside riparian zones help trap sediments and break down nonpoint source pollutants. And, rivers, lakes, streams, and wetlands have long inspired artists and musicians, enriching the human spirit with their beauty.

Freshwater species offer a wealth of goods and services. Aquatic filter-feeding animals like mussels remove nutrients and toxic substances from water, keeping it cleaner for drinking and recreation. Fishes are an integral part of aquatic food webs, intricately linked to ecosystem health. Around the world, some 950 million people rely on fishes as their primary source of protein. In 1990, the total harvest of freshwater fish worldwide was valued at $8.2 billion. Surprisingly, the value of the freshwater sport fishery in the United States alone is twice that of the global commercial harvest, with direct expenditures in 1991 totaling approximately $16 billion.[48,49] The total global value of fishes, mollusks, crustaceans, waterfowl, and other goods extracted from freshwater systems is estimated at more than $100 billion per year, and may be several times that amount.[50,51] Aside from food and income value, people also care about the very survival of rare and endangered fish species. Economic valuation studies show that people are willing to pay up to $60 per household per year to ensure that imperiled species continue to exist.[52]

Still-undiscovered genetic and chemical resources of aquatic species hold potential value for medical, agricultural, and industrial applications. Fishes are frequently used as experimental models for studies in neurobiology, developmental biology, endocrinology, aquatic toxicology and carcinogenesis, and biochemical and genetic adaptation.[53] Certain chemicals found in freshwater species have been worth millions of dollars to the companies that identified their pharmaceutical uses, but their value is immeasurable to the people who benefit from these biomedical advances. To gain from the storehouse of information that remains hidden in freshwater species, we must preserve them and their natural habitats.

Perhaps most important, rivers are "crucibles of evolution."[54] Freshwater species are the product of millions of years of evolution, and we have an obligation to them, to ourselves, and to our descendants to ensure that they do not go the way of the Snake River sucker, the silver trout, the Tennessee riffleshell, and the other aquatic species once found in the United States that live no more.



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Native bull trout (Salvelinus confluentus) *can be found in Idaho's Snake River, a popular sportfishing destination.*

Challenges of Aquatic Conservation

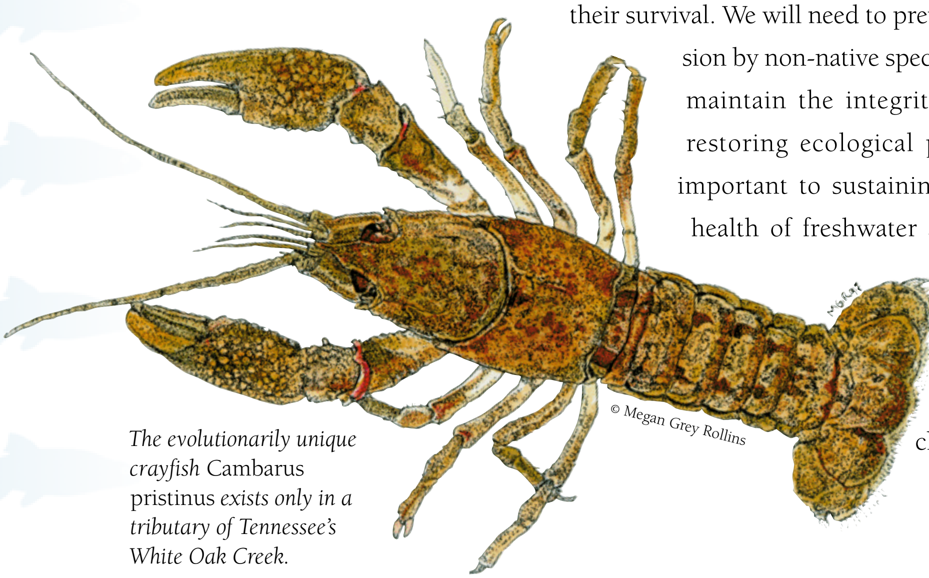
To protect your rivers, protect your mountains.

Emperor Yu of China, 1600 B.C.E.

Protecting streamlife is a complicated business. Because water flows downhill, freshwater species are affected by activities taking place anywhere upstream or uphill in the watershed, even many miles away. Conservation actions must therefore address threats to water quantity and quality over large areas that are upstream from imperiled species and habitats.

Human activities in watersheds can pose a host of threats to freshwater species. Yet, it is often difficult to pinpoint the stresses on streams, species, and habitats. Even when these stresses are correctly identified, the sources of water quality and quantity problems can be difficult to control. Too often human activities within the watershed are incompatible with conservation objectives for freshwater species and habitats.

To protect freshwater species and systems, we will need to counter the threats that jeopardize their survival. We will need to prevent pollution and invasion by non-native species. We will also need to maintain the integrity of these systems by restoring ecological processes. Particularly important to sustaining biodiversity and the health of freshwater systems is retaining or restoring the natural variability in stream flows: timing, duration, frequency, and rate of change.[55,56]



The evolutionarily unique crayfish Cambarus pristinus *exists only in a tributary of Tennessee's White Oak Creek.*

Hope for the Future

Watersheds are a logical landscape unit for focusing freshwater conservation efforts.[6,29,57] The small watershed areas highlighted in the following section of this report offer hope for the future of the nation's imperiled streamlife. Despite decades of abuse, the United States still has places that harbor incredibly diverse assemblages of freshwater species, many of them found nowhere else. These critical watersheds for conservation—"hot spots" of globally imperiled and vulnerable species—should be targeted by all who have a stake in our freshwater heritage: local citizens; local watershed groups; local, state, and national governments; private corporations; and conservation organizations.

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The Santa Margarita River flows through the Camp Pendleton Marine Base and the rapidly urbanizing landscape of Southern California, making protection of its aquatic species a complex and challenging endeavor.

Critical Watersheds for Conservation

Setting Conservation Priorities

The precarious state of freshwater organisms across the country makes clear the need for concerted efforts to protect our rich and globally significant aquatic heritage. The scale of this need, however, far outstrips the resources currently available for this task. Setting priorities for freshwater conservation activities thus becomes an important step in effectively designing and carrying out protection strategies at national as well as local levels.

The Nature Conservancy has adopted an ecoregion-based approach to setting priorities and protecting biological diversity.[58] This involves identifying priority conservation sites within each of the nation's ecological regions, or ecoregions. Ecoregions are large geographically defined areas, each with particular environmental conditions, such as climate and geology, that support distinctive groupings of species and ecological communities.[59,60] Priority sites within ecoregions generally are those that reflect the best examples of characteristic ecological communities, or that encompass species and communities that are rare or otherwise at risk of disappearing. Protecting a well-designed suite of priority sites can help ensure the conservation of the ecoregion's entire complement of species, along with the genetic variability that is critical for these species' long-term survival.[61]

Because conservationists are only just beginning to identify and classify aquatic communities consistently,[62] freshwater conservation priorities must still largely be defined based on species-level information. There are several species-oriented approaches to selecting sets of areas where conservation would most efficiently protect biological diversity. One strategy is to identify hot spots, areas with the greatest total diversity of species or, preferably, the greatest number of species at risk.[63-65] Another approach combines additional criteria to ensure that all target species are represented in the selected portfolio. In identifying the following critical watersheds for conservation, we employ both of these strategies.

Hot Spots for Freshwater Species at Risk

Of the more than 2,000 small watershed areas found across the continental United States, about 1,300 support one or more fish or mussel species at risk. In turn, 87 of these stand out as hot spots, harboring 10 or more imperiled species (Figure 5). These hot spots of aquatic diversity are largely concentrated in the Southeast: four river basins alone, the Tennessee, Ohio, Cumberland, and Mobile, contain 18 of the top 19 watersheds. The upper Clinch River on the Virginia-Tennessee border surpasses all other small watershed areas in the country, with 48 imperiled and vulnerable fish

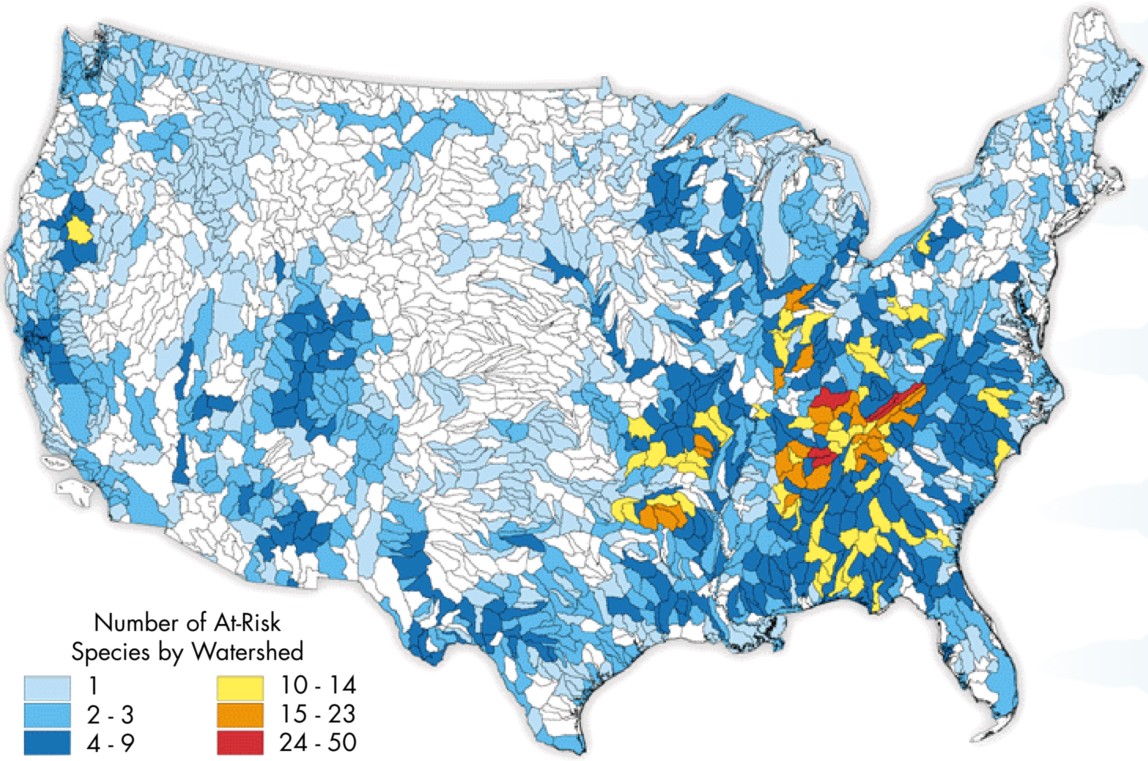

Figure 5. Hot Spots for At-Risk Fish and Mussel Species

Watersheds with 10 or more at-risk fish and mussel species are concentrated in the Southeast, reflecting the extraordinary species diversity of rivers and streams in this region.

HOT SPOTS ANALYSIS METHODOLOGY

This hot spots analysis is based on precise location data collected by the Natural Heritage Network for 307 vulnerable or imperiled fish species and 158 mussel species. These data were supplemented with information from the scientific literature.

Using geographic information system (GIS) computer mapping technology, analysts assigned fish and mussel species to the small watershed areas or subbasins (U.S. Geological Survey eight-digit Hydrologic Cataloging Units) where they are known to occur. Experts in all states reviewed the data to refine the small watershed area distributions of imperiled and vulnerable fish and mussel species.

Alaska was excluded from the analysis because it has no freshwater fish or mussel species that are currently considered to be at risk. Because of its distance from North America, Hawaii was also excluded from the analysis,although its islands are home to four vulnerable freshwater fishes, each occurring on five islands: Hawaii, Maui, Molokai, Oahu, and Kauai.

Only full species and not subspecies, populations, or stocks were included in this analysis. Other freshwater species groups (such as snails, crayfishes, or aquatic insects) were not included because location information on these species is not as well developed as the information on fish and mussel species. Including these species would have biased the results to areas with more complete inventory data rather than to indicate areas that are actually home to the highest numbers of species at risk.

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Conservationists, farmers, and state and federal agencies are working together to restore and maintain critical streamside corridors along Ohio's Big and Little Darby Creeks, a refuge for 103 fish and 38 mussel species.

and mussel species—including 21 that are federally listed as endangered or threatened. Three of the top eight rivers—the upper Clinch, the upper Green (Kentucky), and the Conasauga (Tennessee-Georgia)—are profiled later in this report. Appendix B lists the 87 small watershed hot spots with 10 or more species at risk.

For hot spots to be useful in defining conservation priorities, they must be defined at the right scale. For many species, the small watershed unit used in this analysis is the appropriate scale. In certain circumstances, however, conservation activities may be effectively employed on a larger scale (for example, in several adjacent watershed areas) or a smaller scale (such as in a small headwater stream or a single spring within the watershed), depending on the nature of the threats and the species of concern. Looking beyond small watershed boundaries is also essential when vulnerable streamlife regularly moves between drainages, such as sturgeons, squawfishes, and anadromous fishes like salmon and shad. On the other hand, viable populations of at-risk fish and mussel species may be found only in a small portion of the watershed, not its entire area. And threats to the continued existence of at-risk species may only be manageable in a small area of the subbasin. Some threats may require attention upstream, such as the effects of large dams and water withdrawals, while other threats may (surprisingly) require abatement downstream, such as dams that block fish passage, or channelization and gravel extraction that can cause destructive upstream-progressing river channel erosion.[66]

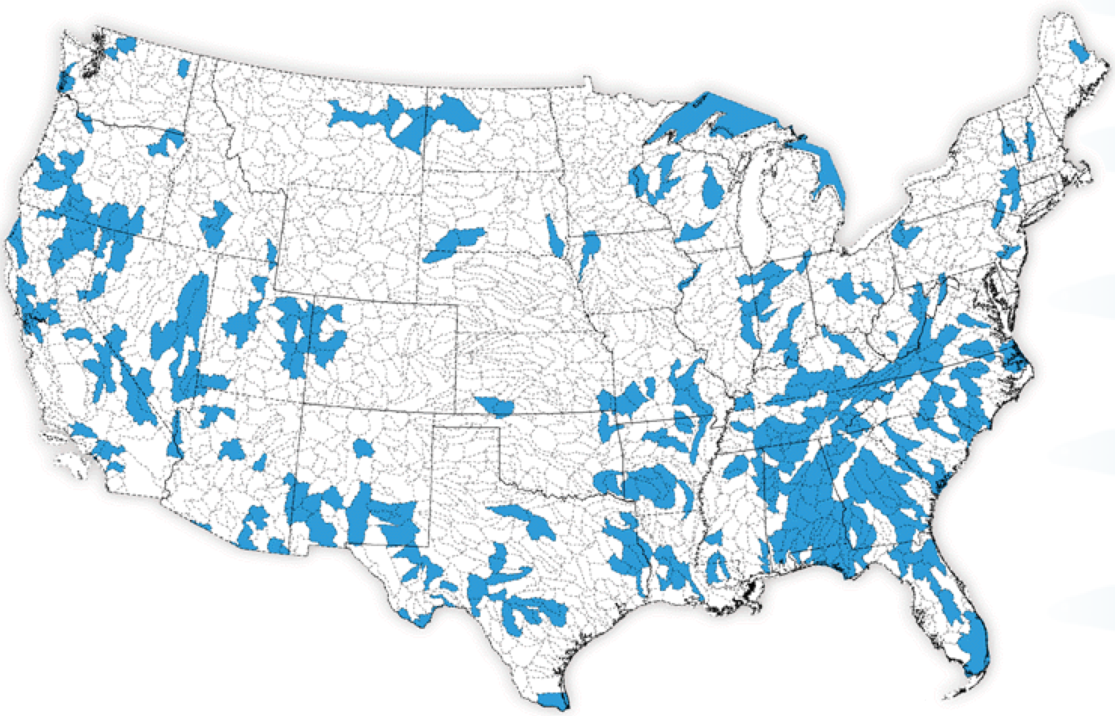
An Aquatic Portfolio: Critical Watersheds for Conservation

While the watershed hot spots highlighted in the previous section harbor the greatest diversity of imperiled species, some at-risk fish and mussel species exist only outside of these areas. Conservation strategies based solely on hot spots would leave these species out in the cold. An extension of this hot spots approach is thus needed that identifies a suite of watersheds that comprehensively could protect these imperiled organisms. The following analysis of critical watersheds for conservation suggests that a relatively small number of watershed areas could conserve much of the nation's rich aquatic diversity.

Protection of the 327 small watershed areas displayed below (Figure 6) would conserve populations of all known imperiled and vulnerable fish and mussel species in the United States—and thereby a significant portion of the world's freshwater biodiversity. Representing only 15 percent of the total number of watersheds in the continental United States, this portfolio includes one or more watersheds in each U.S. ecoregion (see box, page 22). Watersheds and ecoregions can be used in a complementary way for resource management;[60] by incorporating ecoregional representation into this watershed-based analysis, the portfolio should reflect a significant portion of the nation's freshwater genetic and ecological variability. And while designed around fishes and mussels, conservation activities in these watersheds would also benefit the many other aquatic and terrestrial co-inhabitants of these ecosystems.

Figure 6. Critical Watersheds to Conserve Fish and Mussel Species

Protecting and restoring 327 watersheds—15 percent of the total—would conserve populations of all at-risk freshwater fish and mussel species in the United States.



WATERSHED SELECTION PROCESS

The small watersheds highlighted in Figure 6 were selected on the basis of a rarity-weighted richness index (RWRI) for each eight-digit hydrologic unit (subbasin).[67] The index is developed by giving each species a score that is calculated as 1 divided by the number of subbasins in which the species currently occurs (h_i). If a species is now found in only one subbasin, the species gets a score of 1/1, or 1.0; if a species currently occurs in 20 subbasins, it receives a score of 1/20, or 0.05. The individual species scores are then summed for the component G1-G3 fish and mussel species in each subbasin to yield a rarity-weighted index for the subbasin. (The mathematical equation for this index is as follows:

$$RWRI = \Sigma_{i=1}^{n} 1/h_i$$

where n = the number of species found within a subbasin. In the case of a subbasin with one endemic species and one species occurring in 19 other subbasins, the RWRI=1.05. This score may be thought of as an index of irreplaceability of the subbasin.)

Watersheds were selected in a stepwise fashion. Within each of the 63 ecoregions currently recognized by The Nature Conservancy,[61] which are a refinement of ecoregions originally developed by the U.S. Forest Service[59], the subbasin with the highest index value was selected. Additional subbasins were then added in nationally where indices were ≥1.5 or where G1-G3 fish and mussel diversity was >14 species. Then, subbasins that have at least two G1-G3 fish or mussel species and that are already known to be the focus of conservation efforts aimed at some of the component fresh-water species were added. Additional subbasins were then added to ensure that all 465 G1-G3 fish and mussel species were captured at least twice (with the exception of species restricted to a single subbasin, which were necessarily captured only once). Finally, conservation practitioners and scientists reviewed the subbasins selected to eliminate those with known non-viable populations or insurmountable threats. The resulting 327 subbasins constitute 15 percent of the 2,111 subbasins or small watershed areas in the lower 48 states.

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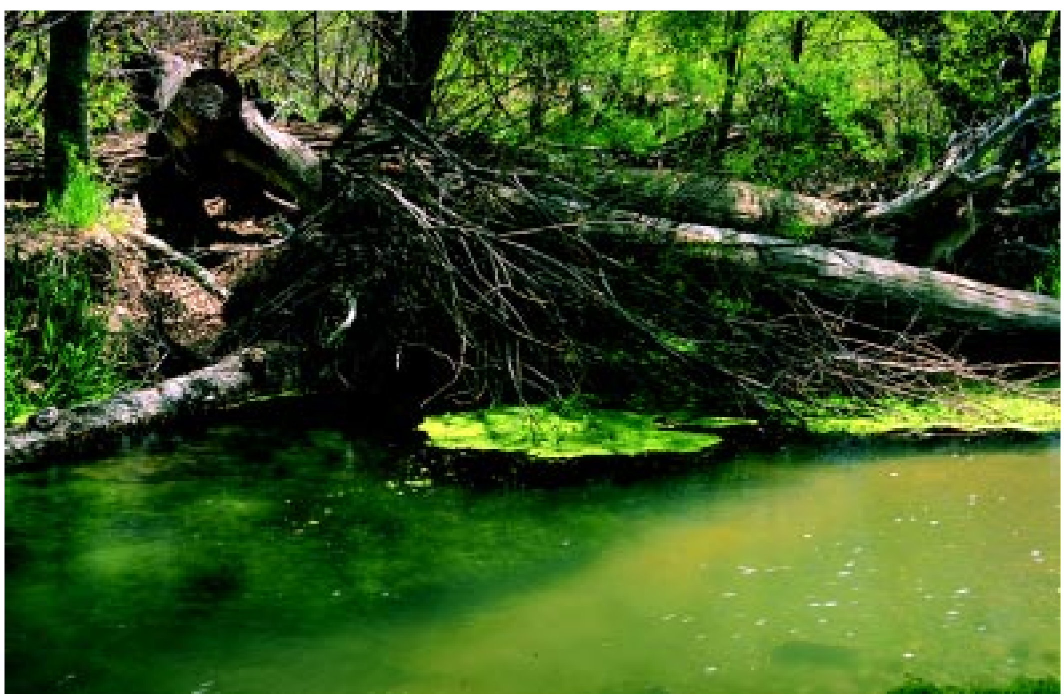


The Mimbres River of New Mexico, a critical watershed to conserve at-risk fish and mussel species, provides habitat to the Chihuahua chub (Gila negrescens).

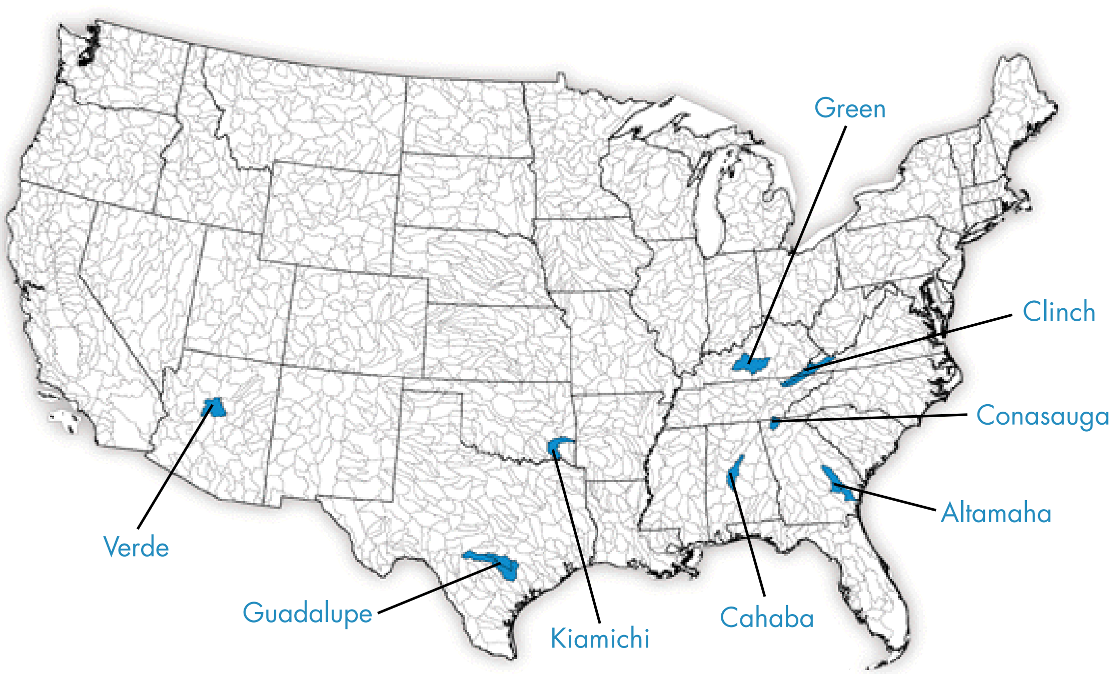
This set of watersheds is not a definitive list to protect all freshwater biodiversity, but it does provide a starting point for conservation action. Although the analysis is based on the best currently available scientific information, it represents only the species groups for which complete information is available. Such analyses should be repeated in the future as more is learned about other freshwater groups (such as crayfishes, snails, and aquatic insects), subspecies or stocks (such as salmon or cutthroats), and newly recognized species (for instance, more than 100 new U.S. freshwater fishes have been identified in the past quarter century).

In some parts of the country, information may be available that will point to additional watersheds (beyond this set of 327) that are critical to the survival of imperiled streamlife other than fish and mussel species. For example, the Wood-Pawtucket watershed in Rhode Island has no fish or mussel species at risk, but is home to 8 species of globally imperiled and vulnerable dragonflies and damselflies.[68] Similarly, Eagle Lake in California has no fish or mussel species at risk but is home to genetically distinct populations of rainbow trout and tui-chub, as well as a number of endemic snail species.[69]

Conserving the 327 watersheds represented in Figure 6 will protect at least two populations of nearly all at-risk fishes and mussels, but ultimately this may not be enough to ensure the long-term survival of those species. Species require the protection of multiple populations to achieve that objective. Looking beyond a species perspective, even watersheds and streams without imperiled species deserve the best possible care and stewardship that we can give them, because human health and quality of life are tied to their well-being.

Rivers of Life: Working to Protect Freshwater Hot Spots

Many of the critical watershed areas highlighted in this report are already benefiting from concerted efforts to conserve their imperiled freshwater life. We feature here eight watersheds included on the preceding list of critical watersheds that currently are the focus of protection efforts. These profiles highlight the many ways individuals, organizations, and agencies are working together to conserve hot spots of freshwater biodiversity, and illustrate the challenges and opportunities inherent in freshwater conservation efforts.



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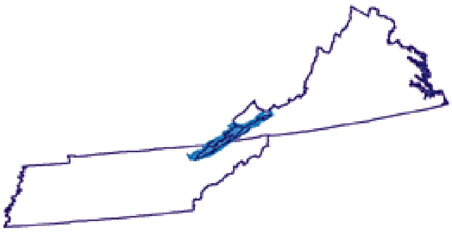
Clinch River
Virginia and Tennessee

Imagine playing a game of environmental "Jeopardy!" The category is rare species. Answer: This unsung region has the highest number of globally imperiled and vulnerable freshwater species in the United States. Question: What is the Clinch River watershed? With its 29 rare mussel species and 19 rare fish species, the Clinch River above Tennessee's Norris Reservoir is home to a remarkable level of aquatic diversity. In fact, the Clinch and Powell rivers harbor a collection of freshwater mussels unmatched anywhere in the world. These unglamorous animals are known by vividly descriptive common names: spectaclecase, Tennessee heelsplitter, Appalachian monkeyface, snuffbox.

The nation's leading hot spot of aquatic diversity is found in one of the most unlikely places: the mist-shrouded Appalachian Mountains of southwestern Virginia and northeastern Tennessee. Here, streams meander amid ridges and valleys to form the upper Clinch and Powell rivers, the only undammed and ecologically intact headwaters of the Tennessee River system. The region's limestone bedrock is honeycombed by some 1,250 caves and uncounted underground springs and streams. In addition to the diversity in the rivers, this mostly unexplored world is filled with a menagerie of rare beetles, isopods, and other insects—creatures just as dependent on good water quality as are mussels and fishes. In all, 28 species found in the Clinch and Powell valleys are federally listed as threatened or endangered.



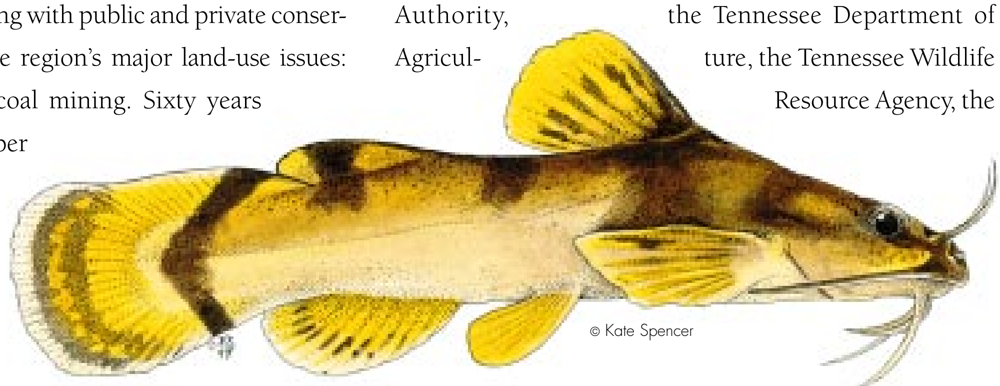
Unfortunately for these fascinating creatures, their survival prospects resemble a real-life game of jeopardy played out each day. In the past century, the region has suffered deep ecological losses. Where once there were 60 kinds of freshwater mussels, only about 40 remain. A history of natural resource exploitation has damaged parts of southwest Virginia's environment, poisoning stretches of some rivers. Declining water quality—a legacy of coal mining and ecologically unsound agricultural practices—is the primary threat to the rivers today.

To succeed in the Clinch Valley and elsewhere, conservation must include people. In Russell County, Virginia, for example, a citizens' initiative known as the Russell County Vision Forum is planning for sustainable development to protect the environment and the local way of life. The county chamber of commerce, the county board of supervisors, the Planning District Commission, The Nature Conservancy, and the National Association of Counties jointly sponsor the forum.

Throughout the Clinch Valley, local landowners and other partners are working with public and private conservationists to address the region's major land-use issues: forestry, farming, and coal mining. Sixty years after the last major timber harvest in the region, second-growth forests are again ready to be harvested. Economic pressures will soon lead to more logging. Whereas poor logging practices can pollute streams and degrade wildlife habitat, environmentally sound timber harvesting could create a sustainable local industry that protects streams and supports local communities. In response, local entrepreneurs are leading a revival of the traditional craft of low-impact horse-logging. The Conservancy is helping local landowners who are making their once-in-a-lifetime timber harvesting decisions by exploring innovative financial mechanisms that will provide incentives for long-term sustainable forestry (such as the development of a forest bank, described in the following Green River case study).

Farmers always show a knack for getting things done, and those living along the upper Clinch and Powell rivers are no exception. Since 1989, dozens of farmers have voluntarily protected creeks and sensitive caves on their property to improve local water quality, taking advantage of government and Nature Conservancy incentive programs. In places like Hancock County in Tennessee and Scott County in Virginia, this includes practical solutions such as streambank fencing, reestablishment of riparian buffers, off-stream water sources for cattle, and carefully selected heavy-use areas. The Conservancy provides farmers with guidance and financial assistance.

To succeed, these programs require long-term partnerships with dozens of groups and agencies, including county officials, Virginia Tech, the Virginia Department of Conservation and Recreation's Natural Heritage and Soil and Water Conservation programs, the Virginia Department of Game and Inland Fisheries, the Tennessee Valley Authority, the Tennessee Department of Agriculture, the Tennessee Wildlife Resource Agency, the Clinch-Powell Resource Conservation and Development Council, the U.S. Department of Agriculture, the U.S. Environmental Protection Agency, and the U.S. Fish and Wildlife Service.



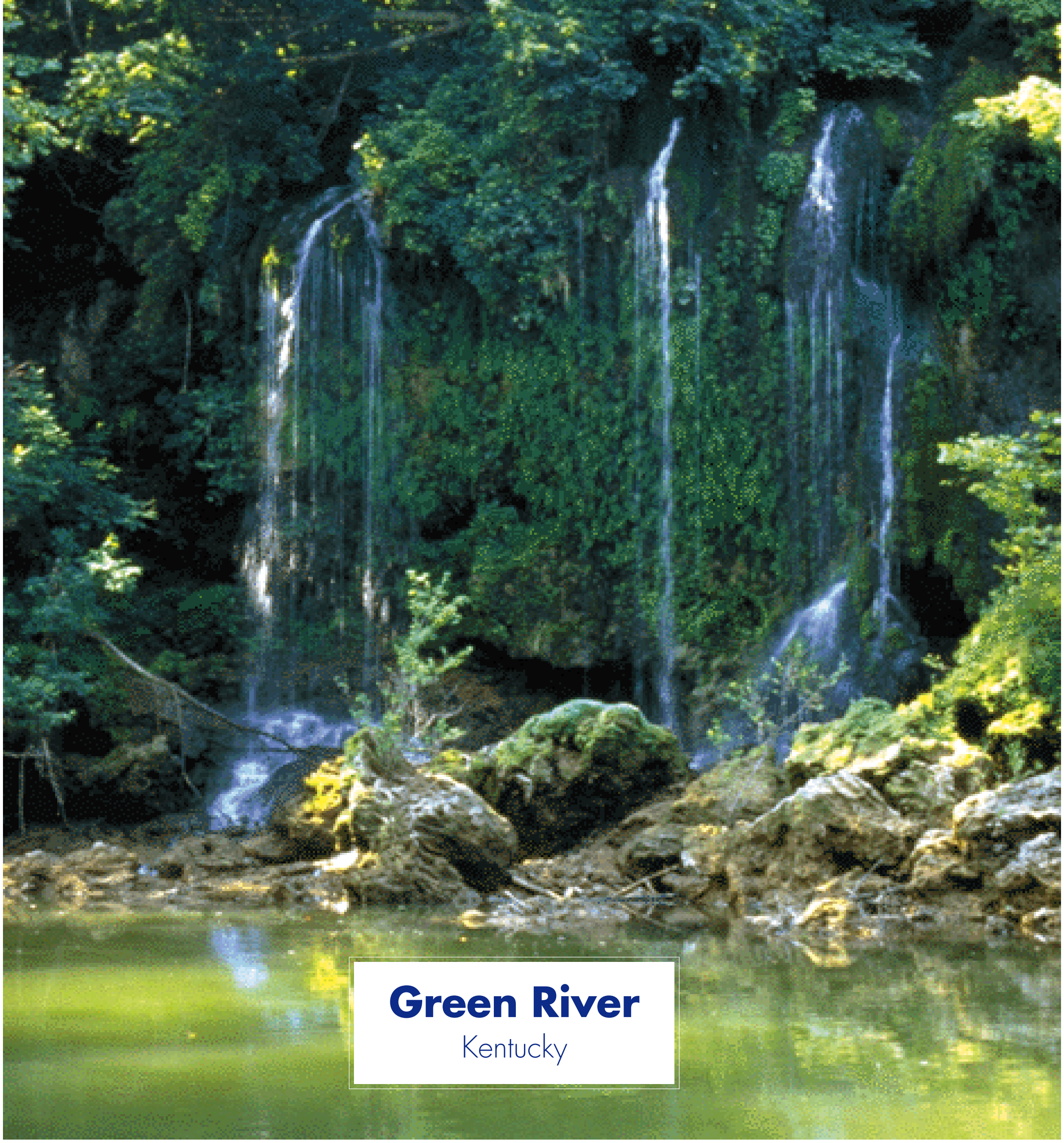
*Scientists who first described the yellowfin madtom (*Noturus flavipinnis*) believed the species to be extinct, but this secretive, nocturnal fish persists in the Clinch and Powell river system.*

The coal re-mining initiative, a partnership among the coal industry, state and federal regulatory agencies, and the Conservancy, is tackling the complex issue of abandoned mine lands. In a pilot project on Black Creek, a coal company is using new technologies to re-mine, clean

The Clinch River supports an unrivaled diversity of freshwater mussel species.

up, and restore a stream heavily degraded from acid mine drainage. The urgency of working with the coal industry to solve such problems was brought home in 1996 when a coal waste holding pond on a tributary of the Powell River burst, sending a black plume through 30 miles of streams and killing at least 11,000 fishes.

Although conservation groups can help protect rivers by providing resources, information, and expertise, lasting conservation takes the commitment of people who live and work there. That commitment is the tie that binds the varied conservation efforts on the Clinch and Powell rivers.



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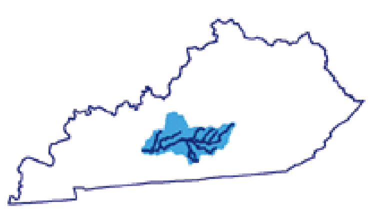
Green River

Kentucky

Kentucky's upper Green River is the most biologically rich branch remaining of the Ohio River system. Although its upper headwaters are impounded, the river flows unhindered for a 100-mile stretch through eight counties and Mammoth Cave National Park, the world's largest cave system. This 100-mile reach is where the river's great aquatic diversity is concentrated. It also stands to benefit from an innovative forest management approach that would preserve water quality and species diversity by preventing siltation.



The primary land use in the Green River watershed is agriculture, yet extensive forests remain in the riparian zone and in the watershed. Intact forests keep soil where it should be: on the ground, not in the river. With increased timber harvesting in the Green watershed, the risk of land degradation and river siltation rises. This could harm water quality and reduce habitat value for imperiled aquatic species.

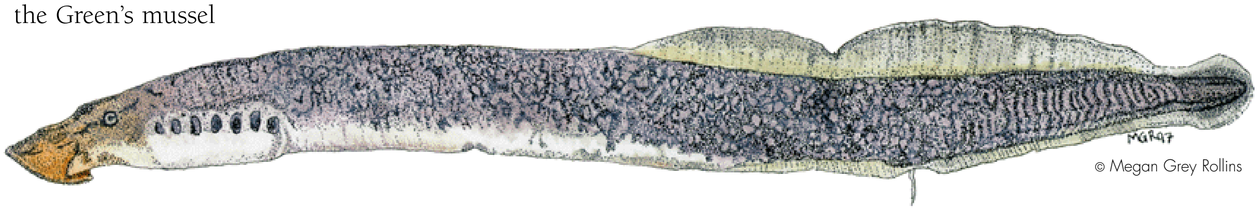
The development of a forest bank—a market-based approach to sustainable forest management—holds great promise for the Green watershed, as well as the Clinch watershed and Big Brushy Creek in Ohio. This newly conceived conservation tool encourages local landowners to turn over their timber rights to a "bank" in exchange for a steady rate of return on their forest resources. The bank places the dedicated forestland under a sustainable management regime, and then actively markets its "green" harvested wood products. This arrangement ensures that as timber is harvested, water quality is maintained. It also ensures steady income flow for the forest owners who entrust their land to the bank.

Both people and other species will benefit from efforts to manage forest resources sustainably and in a manner that maintains water quality in the watershed. The Green River boasts 71 mussel species and more than 150 fish species, including the rare northern cavefish (*Amblyopsis spelaea*), spotted darter (*Etheostoma maculatum*), and tippecanoe darter (*Etheostoma tippecanoe*). Twenty-nine of the Green's mussel and fish species are imperiled or vulnerable, and seven are listed as endangered under the U.S. Endangered Species Act. The upper Green River is also rich in crayfishes, with both the rare cave-dwelling eyeless crayfish (*Orconectes pellucidus*) and the endemic bottlebrush crayfish (*Barbicambarus cornutus*).

Some of the Green's greatest biological resources are not just underwater but underground. Mineral dissolution of the watershed's underlying limestone bedrock has created sinkhole plains, sinking streams, and numerous springs throughout the area. Although this underground wonderland harbors countless species still undiscovered, one subterranean gem, Mammoth Cave National Park, has been well studied. Because of its great size and abundance of small, specialized habitats, the Mammoth Cave system supports one of the world's richest collections of cave species, including the federally listed endangered Mammoth Cave shrimp (*Palaemonias ganteri*), found nowhere else in the world.

The Green's unique aquatic and subterranean species are threatened not only by poor forest management practices but by pollution from inadequate industrial and residential sewage treatment, siltation from improper agricultural techniques, and streamflow regulation. Although the Green is still free of the non-native zebra mussel, invasion by this exotic species could be devastating to the river's native mussel life. Preventing the invasion of non-native fish and mussel species is a high priority in the Green.

Many partners are working together to minimize threats to the Green River. The U.S. Fish and Wildlife Service has committed to carrying out a stress analysis of the watershed, to identify the highest-priority activities to reduce threats to the river. The agency will work with private landowners to define the best environmentally sound and economically beneficial management practices. The U.S. Army Corps of Engineers is working to regulate streamflow releases from the river's headwater dam to meet both human and wildlife needs. To acquire land in strategic places along the Green, Kentucky's Department of Fish and Wildlife Resources and Nature Preserves Commission plan to collaborate with The Nature Conservancy. Creative approaches and partnerships like the Green River forest bank will help protect the long-term health of the watershed's aquatic, cave, and terrestrial species and communities.

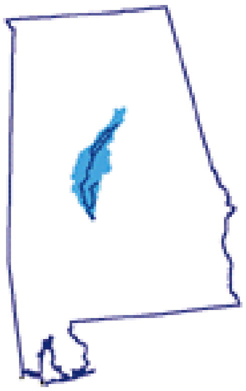


© Megan Grey Rollins

Lampreys, like the Green River's vulnerable, prehistoric-looking mountain brook lamprey (Ichthyomyzon greeleyi)*, are the only living freshwater representatives of a group evolved from jawless fishes that lived 500 million years ago.*

Cahaba River
Alabama

Almost 50 percent of all documented U.S. species extinctions since European settlement have occurred during this century in the Mobile River basin.[70] Alabama, through which this vast river system courses, has the unfortunate distinction of being the most extinction-prone state in the continental United States, with 98 species extinct. Most of Alabama's many rivers have been impounded for hydropower or dredged for barge transport, resulting in the disappearance of many riverine habitats and species. Within this landscape of species loss, the Cahaba River remains the state's longest essentially free-flowing river, and one of its most biologically rich.



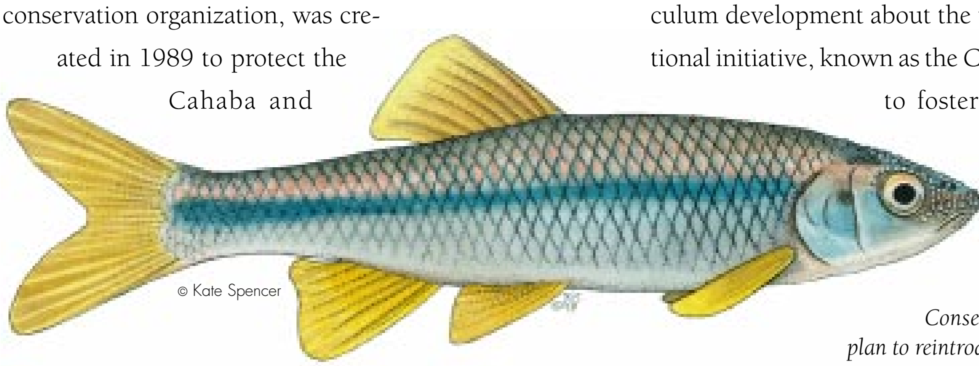
The Cahaba River basin supports 69 rare and imperiled species, including 10 fish and mussel species that are listed under the U.S. Endangered Species Act. It has more fish species, 131, than any river its size in North America. One of these fish is the Cahaba shiner (*Notropis cahabae*), one of the few endangered fish species confined to the mainstem of only one river. Although the number of freshwater mussels and snails has declined sharply from historical numbers, many species are still well represented in the river, including pearly mussels like the critically imperiled orangenacre mucket (*Lampsilis perovalis*).

The Cahaba watershed is a treasure trove of botanical life as well. As the river flows southward into rural Bibb County, it shelters the largest known stand of the imperiled shoals lily (*Hymenocallis coronaria*). Celebrated locally as the Cahaba lily, this spectacular and surprisingly delicate flower grows in the middle of the river, wedging its bulbs into crevices in the limestone rock. Bibb County is also home to a unique terrestrial plant community, the Bibb County glades, mostly found immediately adjacent to the Little Cahaba River, a major tributary. In 1992, botanist Jim Allison counted eight new species of plants on limestone outcrops along the Cahaba's banks—a discovery befitting expeditions to uncharted tropical wildernesses.

Until recently, the steep-sided Appalachian ridges of the Cahaba's headwater tributaries kept streamside development to a minimum. However, population growth is pushing residential and commercial development from Birmingham into the Cahaba River watershed, resulting in increased toxic stormwater runoff, sedimentation, and municipal wastewater discharges. At the same time, domestic drinking water withdrawals from the Cahaba divert virtually its entire flow during drought periods. Although threats in the upper watershed are growing, the lower half of the watershed, where the Cahaba's biodiversity is most remarkable, is somewhat healthier.

To prevent degradation of this rich biological resource, government agencies, conservation groups, and citizens' groups are working together to protect the Cahaba's rare and endemic aquatic species and natural communities. The Cahaba River Society, a nonprofit conservation organization, was created in 1989 to protect the Cahaba and promote river stewardship in the state of Alabama. To safeguard water quality in the Cahaba, the group participates on a citizen's advisory committee on stormwater management. It is also helping to develop a citizen-based, basin-wide plan for water quality protection, pioneering a new approach for the state environmental management agency. The resulting Cahaba River Basin Plan may serve as a model for other basin plans throughout the state.

The Cahaba River Society is also promoting habitat conservation and environmental education in the Cahaba watershed. It is helping Jefferson County, the source of the Cahaba's headwaters, to allocate a $30 million commitment to development of greenways. Much of this money will go to Cahaba River greenways. The Cahaba River Society is also working with Bibb County, the National Fish and Wildlife Foundation, and The Nature Conservancy to acquire a piece of land adjacent to the river that will protect several globally significant species. To develop broad-based public support for Cahaba River protection, the group was awarded an environmental education grant from the Chesapeake Bay Foundation and Toyota Motors Corporate Services of North America. Through children's field trips, teacher training, and curriculum development about the river, the resulting educational initiative, known as the CLEAN program, will work to foster long-term commitment to conservation of the Cahaba and its rich freshwater diversity.



Conservationists are considering a plan to reintroduce the threatened blue shiner (Cyprinella caerulea)*, last seen in the Cahaba River in 1971.*

Conasauga River

Tennessee and Georgia

On the steep, forested slopes of the Blue Ridge Mountains in northwest Georgia, the clean, cool waters of the Conasauga River descend rapidly through the mountains toward Tennessee. Crossing the state line, the river pauses in deep pools, dropping now and then through a number of small rapids.

The Conasauga River supports 24 rare and imperiled aquatic species, including 12 that are federally listed under the U.S. Endangered Species Act. Its clear waters are home to a colorful array of rare fishes, including the holiday darter (*Etheostoma brevirostrum*), the blue shiner (*Cyprinella caerulea*), and the endangered Conasauga logperch (*Percina jenkinsi*). Flowing farther through Tennessee and back into Georgia, the river harbors other rare fishes, including the frecklebelly madtom (*Noturus munitus*) and the amber darter (*Percina antesella*). Some of the rarest river inhabitants live quietly at the bottom of the river: a half dozen species of freshwater mussels. These animals, including the endangered southern pigtoe (*Pleurobema georgianum*) and triangular kidneyshell (*Ptychobranchus greenii*), filter the river's waters for nourishment. There is even fresh evidence that three species of mussels believed to be extinct may actually be surviving in the Conasauga.

The Conasauga River supports more rare species and is in better condition than most of the other rivers draining through the Coosa River system of northwestern Georgia and eastern Alabama into Mobile Bay.

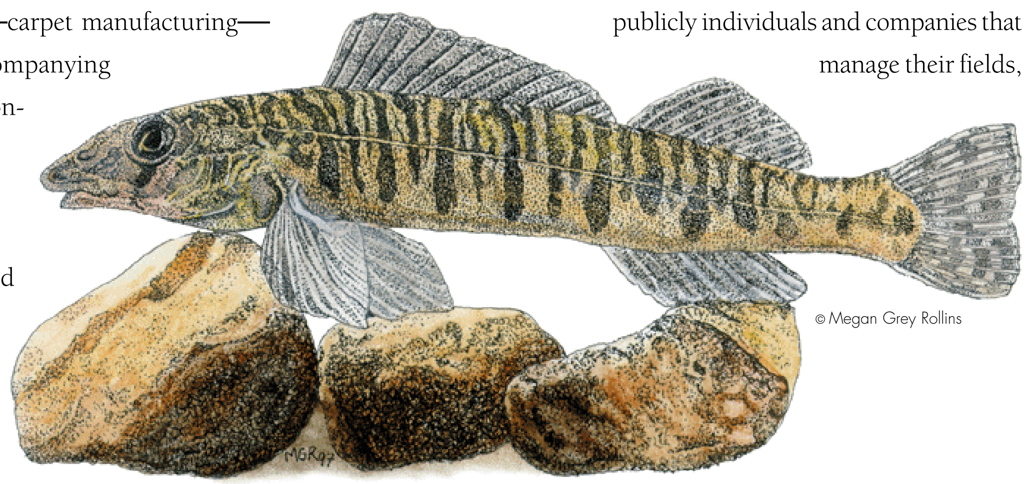
Surrounded by extensive wilderness and national forestland, the upper third of the river is in almost pristine condition. No dams block fish movements or disturb the river's hydrology. Many of the watershed's farmers and other landowners have managed their land well, and the river's native species have benefited from their careful land use. Local citizens have also benefited from the river's health: It provides them with recreational opportunities, outstanding fishing, and, most important, water for agricultural, residential, and industrial use.

The Conasauga River is not without problems, however. Siltation threatens to smother the river bottoms where endangered fishes feed and mussels live. Excess nutrients and toxic chemicals may also degrade water quality. To varying degrees, these pollutants come from crop agriculture, cattle, timber harvest practices, poultry operations, and the assorted effects of residential and industrial development.

One industry—carpet manufacturing—and the growth accompanying it pose a particular concern for the Conasauga's distinctive freshwater species. Dalton, Georgia, and other nearby towns are reported to produce two-thirds of the country's wall-to-wall carpets. Many carpet mills rely on the waters of the Conasauga River for production. As the carpet industry prospers, residential and industrial development may spread farther in the watershed. Without appropriate conservation action, the Conasauga River may become significantly degraded, and many of its rare fishes and mussels could be driven to extinction.

To address these concerns about the future of the Conasauga River, local citizens, conservation groups, and government agencies joined together to create the Conasauga River Alliance. This effort began as an ecosystem-based assistance study, which was initiated by the Limestone Valley Resource Conservation and Development Council and funded through the Natural Resources Conservation Service of the U.S. Department of Agriculture. It has since blossomed into a consolidated effort that now includes a growing number of local citizens and more than 20 federal and state agencies.

Within the alliance, district conservationists with the Natural Resources Conservation Service are working with farmers on streambank stabilization and restoration, and local governments and local citizens are organizing river cleanups. Through its many partners, the alliance is also sponsoring field trips to educate people about best management practices for forestry, residential development, and other land uses. Other alliance members are developing signs that will be posted to recognize publicly individuals and companies that manage their fields, forests, and industries in a "river-friendly" manner. Through these and other cooperative efforts, the Conasauga River Alliance is taking the first steps to achieve its vision of maintaining "a clean and beautiful Conasauga River—forever."



© Megan Grey Rollins

The endangered Conasauga logperch (Percina jenkinsi) *is restricted to a stretch of river barely 12 miles long.*

Altamaha River

Georgia

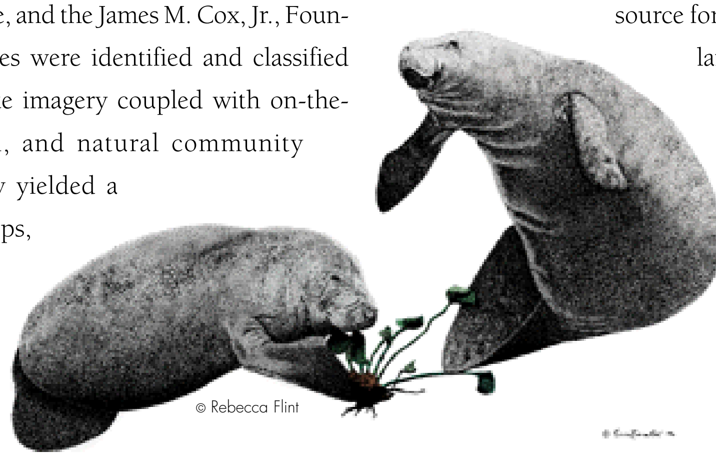
New technologies can advance conservation in old places where unique species have evolved. In Georgia's Altamaha River basin, a geographic information system (GIS)—a computer application used to overlay and analyze biological, social, and physical data—is being wielded as a powerful tool for conservation planning. Ecological inventory and GIS analysis have provided valuable information to define conservation and management priorities in the lower Altamaha watershed.

The Altamaha River drains more than one-quarter of Georgia's land surface, making it the third-largest river basin along the Atlantic seaboard. With limited development, a sparse human population, and landowners strongly attached to their natural heritage, the Altamaha and its floodplain remain fairly undisturbed. In its entirety, the Altamaha is among the most biologically rich river systems draining into the Atlantic Ocean. It sustains globally rare natural communities and 11 imperiled and vulnerable pearly mussel species, 7 of which are found nowhere else in the world. In total, at least 130 species of rare or endangered plants and animals are found in the Altamaha River watershed.

Although the Altamaha is still relatively intact, management practices within the watershed threaten to reduce water quality and quantity and cause habitat destruction and degradation. Natural communities in the floodplain are being lost to timber production, agriculture, and land development. The introduction of non-native species like the flathead catfish (*Pylodictis olivaris*) and Asiatic clam (*Corbicula fluminea)* has caused native fish and mussel species to decline.

To protect the river's biological riches and counter mounting threats, The Nature Conservancy initiated an ecological inventory of the lower Altamaha River watershed in 1991. This inventory was funded by the Woodruff Foundation, the Georgia Power Company, the U.S. Fish and Wildlife Service, and the James M. Cox, Jr., Foundation. Land-cover types were identified and classified using aerial and satellite imagery coupled with on-the-ground plant, animal, and natural community surveys. The inventory yielded a set of 18 landcover maps, significantly increasing resource managers' understanding of the biological condition of lands adjacent to the river. The landscape-scale land-cover classification methodology developed at the Altamaha became a model for other Conservancy efforts around the country.

Building upon this analytical work, the U.S. Environmental Protection Agency funded the Georgia Department of Natural Resources and the Conservancy's effort to carry out the Lower Altamaha River Watershed Demonstration Project. The goal of this initiative was to develop a management plan and conservation strategy for the lower Altamaha River watershed. The project also identified the stresses that affect the health of the lower watershed in order to curb wetland loss and plan for critical area protection. Using GIS software, conservationists overlaid the Altamaha's land-cover maps with data on imperiled species occurrences, river hydrology, point sources of pollution, landownership, and political boundaries. The GIS analysis revealed which lands were natural or converted, who owned important areas for conservation and threat abatement, and where conservation and management actions should be focused.



The productive estuarine environment where the lower Altamaha River meets the Atlantic Ocean is habitat to the endangered West Indian manatee (Trichechus manatus) *during the summer months.*

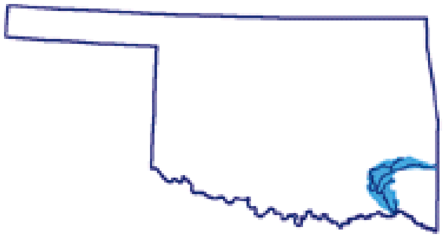
The Altamaha GIS database is a rich information source for local decision makers and landowners. It is being used to give landowners individualized data on the biological resources on their properties, such as what types of species and natural communities are found on their land, what their global and statewide rarity is, and what areas may be important for protection. Supported by the database, the Georgia Department of Natural Resources and The Nature Conservancy are helping hundreds of local landowners learn how they can support conservation on their properties using a variety of tools: conservation easements, enrollment of their property in the Georgia Natural Areas Registry, and adoption of beneficial management practices, such as leaving vegetation buffers intact around streams. The extensive database is helping to make protection of the Altamaha more focused, targeted, and efficient—benefiting natural and human communities alike.

© Caryn Vaughn

Kiamichi River

Oklahoma

One of the rarest mussels in North America occurs in Oklahoma's Kiamichi River: the Ouachita rock pocketbook (*Arkansia wheeleri*). This animal is the world's sole representative of the genus *Arkansia*, making it evolutionarily distinctive and a high priority for conservation. The only remaining viable population of Ouachita rock pocketbooks exists in the clean waters of the Kiamichi River, home to another 28 mussel species, including 7 imperiled or vulnerable species and more than half the mussels known from the entire state of Oklahoma. Harboring more than 100 native fish species, the river is also extremely rich in freshwater insects.



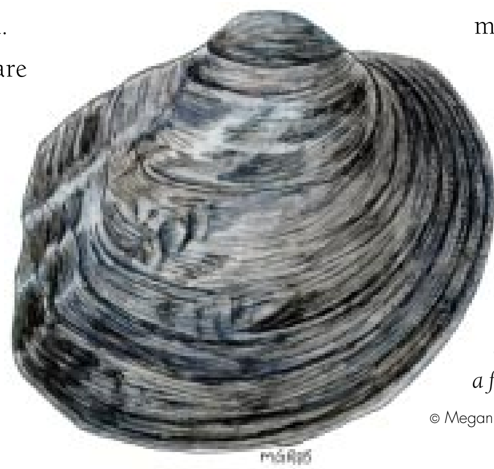
The key to the Kiamichi's biological significance may be that it traverses ecologically distinct regions: mountains, prairie, and coastal plain. The river originates on the south slope of Rich Mountain, only a stone's throw from Arkansas. It flows to the west through the Ouachita Mountains, then south across the Gulf Coastal Plain and Central Plains to join the Red River on the Oklahoma-Texas border. The Kiamichi is one of the few tributaries of the Red River that has not been significantly influenced by major land-use changes or water diversion. But that may change soon.

Plans are under consideration to sell the Kiamichi's high-quality water across state boundaries to Texas. Burgeoning population growth in the Dallas–Fort Worth metropolis has heightened water demand in the Lone Star State, creating a willingness to buy Kiamichi water at above-market value. This decision would have ripple effects throughout the Kiamichi watershed, potentially spurring development that would be detrimental to the diversity of life that inhabits the river. Many people living near the river want to keep their water in the Kiamichi and oppose the trans-state water sale.

At this time, the Kiamichi remains one of the few ecologically intact river basins in the region. Only one main-stem impoundment exists on the lower river. Land ownership in the watershed is largely private, and historically these landowners have done a good job of protecting the river, through actions like leaving riparian borders around pastures. The narrow watershed is heavily forested, and until recently land use was limited primarily to forestry and cattle grazing. The river has no protected status, however, and it also now faces the threats of potentially poorly managed chicken and hog farm development, gravel mining, increased timber harvesting, and additional water impoundment.

State and federal agencies are spearheading efforts to understand and protect the Kiamichi. They are gathering information to assess the status of rare species and environmental conditions in the river basin. The U.S. Fish and Wildlife Service plans to use this newly collected information as a tool for education and outreach with local citizens. The agency is also interested in establishing a volunteer, community-based water quality program. This program would equip schools, community groups, and area residents with water quality test kits—a means of collecting data and connecting people with the river.

While the issue of interstate water diversion remains unresolved, public and private entities are adopting conservation-friendly management practices to minimize other threats to the river. With the move toward increased timber extraction and development in the watershed, best management practices are being adopted to minimize environmental disturbances from streamside construction, forestland management, and other activities. The Natural Resources Conservation Service may support programs in the watershed to protect water quality and control erosion. Many of the Kiamichi conservation efforts will rely on public involvement and cooperative agreements with private landowners to protect critical areas of the watershed, addressing both the economic needs of the local people and the long-term viability of the river.



The Kiamichi River hosts the world's sole remaining viable population of the Ouachita rock-pocketbook (Arkansia wheeleri)*, a federally listed endangered mussel.*

© J. Fries

Guadalupe River

Texas

The Guadalupe River in Texas is a classic example of contrast. The upper quarter of the river, called the upper and middle segments, cuts through the rocky limestone of the Edwards Plateau and is rich in rare species. Four endemic fishes occur in this reach: the Guadalupe bass (*Micropterus treculi*), the endangered fountain darter (*Etheostoma fonticola*), the greenthroat darter (*Etheostoma lepidum*), and the gray redhorse (*Moxostoma congestum*). The lower three-quarters of the river roll gently through a wide, shallow floodplain to San Antonio Bay, harboring only one of the river's unique species—the threatened Cagle's map turtle (*Graptemys caglei*).

Most of the watershed surrounding the upper and middle segments is relatively undeveloped rangeland and woodland. Except for municipal use from Canyon Lake, this portion of the river has only limited water diversion for small streamside communities, riparian orchards, and nut groves. Conversely, land use in the river's lower three-quarters is dominated by pastureland and agricultural cultivation, with more extensive water diversion for crop irrigation. These downstream water uses have helped keep upstream water from being diverted from the biologically rich upper and middle Guadalupe segments.

Hidden beneath the surface of the Edwards Plateau also lives an astounding diversity of species—163 rare and imperiled animals that exist only in subterranean caves and waters. More than one-third of these species are aquatic, including two fish and four salamander species. Land- and water-use activities that cause pollution or withdraw water from the underground aquifer could cause a mass extinction of these unique and vulnerable animals.

Fortunately, the large areas of relatively undeveloped land in the watershed, excellent water quality, numerous pristine springs, and periodic extremes of flood and drought have helped maintain the upper and middle Guadalupe's diversity of life. Despite one major surface impoundment and numerous low-water dams, the upper and middle Guadalupe rank among the highest-quality waters in Texas.

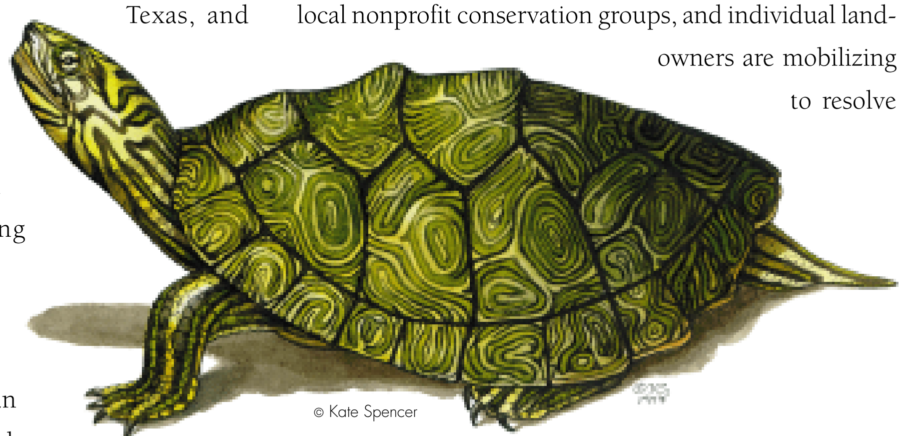
Ironically, the presence of the human-made dam and the introduced trout that thrive in its cool downstream tailwaters has galvanized a major constituency of support for river protection: trout anglers. The Guadalupe is one of only two trout streams in Texas, and the river has been regularly stocked with the fishes since the late 1970s. According to the Texas Department of Parks and Wildlife, trout are reproducing successfully in this substantially altered section of the river. Because trout have even higher water quality requirements than many native fish species, trout anglers have become advocates of pollution prevention in the watershed.

The upper and middle Guadalupe are also a mecca for recreationists, and some portions of the river have such dense concentrations of pleasure-seekers that water quality, shoreline habitat, and underground aquatic life are being damaged. Because people from throughout the state flock to the Guadalupe to enjoy its clear waters, recreationists and recreational businesses share with trout fishers a concern for water quality. Without clean water, recreational opportunities will dry up.

Recreational overuse is not the only threat to the Guadalupe. As in other parts of the country, the Guadalupe faces human population growth, an attendant rise in water demand, and residential and recreational development in the watershed. Increased water demand may lead to the construction of new in-stream impoundments, further disturbing the river's natural flows. Continued clearing of riparian forest for development along the expanding I-35 and I-10 highway corridors could alter the river's water quality and flows. Pollution from municipal wastewater treatment facilities, on-site wastewater systems, livestock waste, and vegetation clearing could also degrade water quality. Additional intentional and accidental introductions of non-native plants and animals, including fishes and snails, could further harm the river's native species.

State and local government agencies, national and local nonprofit conservation groups, and individual landowners are mobilizing to resolve current and emerging threats and to help conserve the biological diversity of the upper and middle Guadalupe River. The main strategies include:

- wisely managing the basin's water resources, including practicing conservation and developing alternative surface water supplies,
- reducing and controlling point and nonpoint sources of pollution through enhanced municipal and individual wastewater treatment, and expanded siting

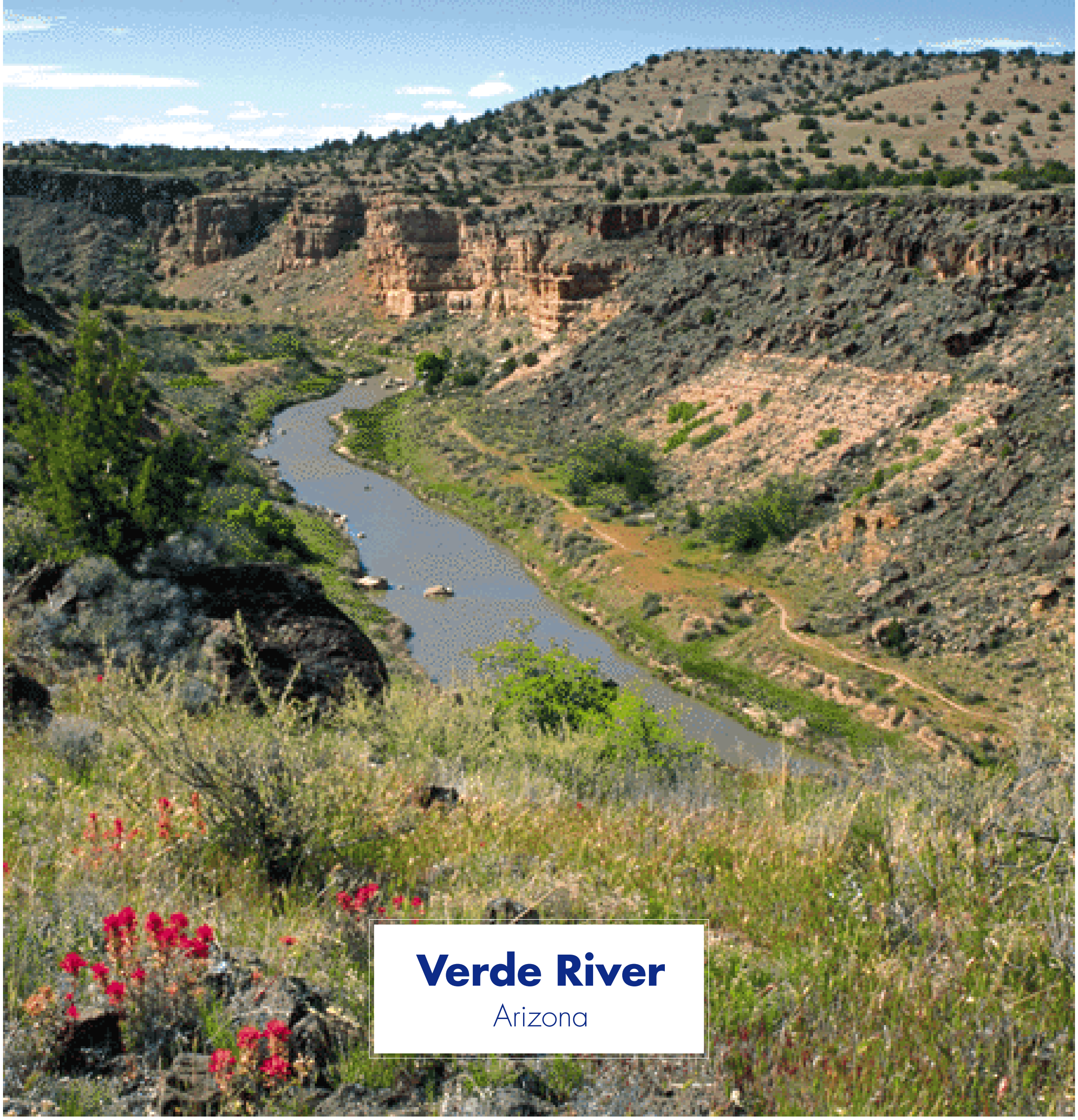


The imperiled Cagle's map turtle (Graptemys caglei) *rarely ventures on land except to deposit its eggs. It is found in Texas's Guadalupe River system and nowhere else in the world.*

and construction standards for development,

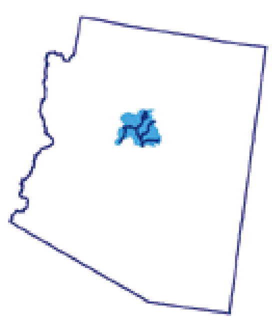
- limiting use within the riparian zone and restoring natural communities in upland areas and along the river and its tributaries,
- managing recreational uses of the river,
- selectively removing or reengineering in-stream impoundments to restore natural hydrologic variability,
- providing incentives to maintain landownership in large unfragmented blocks, and
- developing locally based conservation trusts to work with communities and individuals committed to protecting the riparian corridor and other sensitive locations.

All of these conservation strategies will require the active involvement of the private landowners, government agencies and officials, conservation organizations, business leaders, and citizens who live, work, and vacation in the upper and middle segments of the Guadalupe River in Texas.



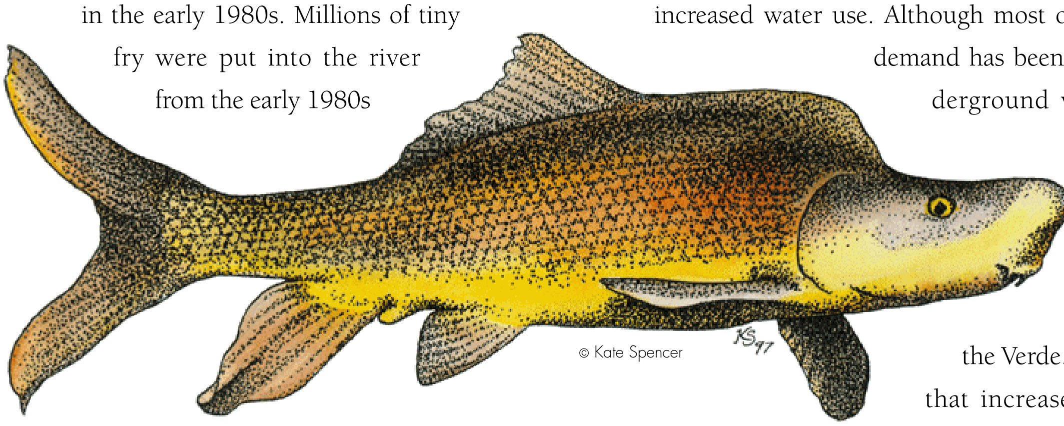
© Harold E. Malde

At least 110 species have gone extinct in North America since the arrival of European colonists.[21] Seventeen of those extinctions have been freshwater fishes. Potentially joining their ranks are the endangered razorback sucker (*Xyrauchen texanus*) and Colorado squawfish (*Ptychocheilus lucius*), whose populations have been ravaged by predatory non-native fishes, changes in stream flow and water temperature, and river habitat loss. These fishes are 2 of 18 native fish species historically known from the Gila River basin, which covers nearly two-thirds of Arizona and is the largest tributary of the lower Colorado River. Of the 18 Gila basin fish species, 1 is extinct and 10 are federally listed as endangered or threatened. In total, 78 percent of the Gila's fish species are either extinct or imperiled.



Arizona's Verde River is one of the largest tributaries to the Gila River system. The portion above the town of Camp Verde—the "upper" Verde—is especially noteworthy as a stronghold for native fish species. Twelve native fish species historically occurred in the upper Verde River; thanks to reintroduction efforts, nine species can still be found in the main-stem Verde and its major tributaries. One segment of the upper Verde is considered to be the second most important native fishery in Arizona, after Aravaipa Creek. This part of the river flows through some of the least accessible parts of the Prescott National Forest. It is particularly good habitat for native fishes because it has remained relatively free of the non-native fish species that have harmed many native Gila fish populations. Although 5 of the historic 12 species had been extirpated from the Verde watershed, 2 of these, the Colorado squawfish and the razorback sucker, are now the subject of intensive recovery efforts.

The Arizona Department of Fish and Game and the U.S. Fish and Wildlife Service began reintroducing razorback suckers and Colorado squawfishes to the Verde River in the early 1980s. Millions of tiny fry were put into the river from the early 1980s



The state of Arizona and the U.S. Fish and Wildlife Service are working to reintroduce the endangered razorback sucker (Xyrauchen texanus) *into the upper Verde River to counteract the loss of populations from hydrologic alteration and introductions of non-native fishes.*

through the early 1990s, but none survived. Because the immature fishes were so small, they were easy prey for introduced species like the flathead catfish (*Pylodictus olivarus*). Since 1993, the agencies have been restocking the river with larger fishes, which are showing better signs of surviving. The state agency is also considering eliminating fishing restrictions on non-native species in the Verde River. Ultimate success of species reintroduction can be claimed if the native fishes are able to survive to maturity and reproduce successfully. Fortunately, razorback suckers and Colorado squawfishes are long-lived animals, and established individuals can live for up to 60 years. If conditions within the river improve in coming decades, the reintroduced fishes may have a shot at reproducing successfully. At the very least, species reintroduction efforts may ensure that the endangered fishes' genetic diversity is preserved in a natural environment.

The fish recovery program will be for naught, though, if the other threats to the Verde River are not managed. The upper Verde River watershed covers 2,600 square miles, parts of which are experiencing rapid population growth without any coordinated water resource planning. The population living in towns in the Verde River basin is projected to increase by 143 percent between 1994 and 2040. With such rapid population growth comes increased water use. Although most of the area's water demand has been met through underground water extraction, scientists are concerned because this groundwater supply feeds into the Verde. There is a danger that increased pumping will reduce river flows, further imperiling fishes and other biological resources.

In response to the lack of water resource planning, the Verde Natural Resource Conservation District and the Cocopai Resource Conservation and Development Area formed a local watershed-based planning group, the Verde Watershed Association (VWA), in 1993. The goal of the VWA is to protect the Verde River watershed while promoting sustainable use of the basin's resources. Relying heavily on public participation, the association adopted a three-phase approach to water resources planning: 1) developing a high-quality, shared information base; 2) forming alternative future water-use scenarios and possible strategies for managing water resources; and 3) seeking agreement on a long-term water management plan. The VWA and the Natural Resources Conservation Service conducted a cooperative river basin study and built a comprehensive, publicly accessible database. The association also hosted a series of watershed conferences to review the results of the basin study and develop a plan for river and riparian habitat protection.

Many partners are involved in the VWA's water resources management initiative. The Bureau of Reclamation is working with a local irrigation district to manage streamflow diversion so that it minimizes habitat disturbance and maintains adequate river flows. Together with the VWA and the Verde Natural Resources Conservation District, the bureau is also sponsoring springtime river float trips in which several hundred community members learn firsthand about the river's cultural and natural resources. Through a grant from the U.S. Environmental Protection Agency, the Verde Natural Resource Conservation District has developed a nursery for restoration of native riparian plant species along the river. These restoration, management, and educational initiatives will help instill local commitment to protecting the upper Verde River, its watershed, and its species diversity.

Elements of Success

Knowing is not enough; we must apply. Willing is not enough; we must do.

Goethe

How does successful conservation happen? The preceding case studies illustrate positive actions that will help protect freshwater systems from further decline. They demonstrate how groups of concerned citizens, public agencies, and private organizations can work together toward conserving critical watersheds. In each example, several key elements characterize effective local efforts.

A Catalyzing Event

Whether it is the listing of an endangered species, a proposed water diversion, or an accidental toxic spill, most conservation activities are ignited in response to an immediate problem in a watershed. In some cases, federal or state agencies are mandated to begin addressing the problem; in other cases, the people who live in the watershed perceive a threat to their livelihood or quality of life. To be stirred to action, watershed residents must become aware that they live in a watershed, that their well-being is affected by its health, that it is a priority area for conservation, and that they can do something to help protect it.

Fight, Flee, or Cooperate?

Whether people support or oppose the activities that will affect their watershed, the best watershed management efforts are characterized by people, businesses, and public agencies willing to work together to identify problems and solutions. Cooperation begins with all parties believing they have a role to play, power to influence the outcome, and a sense of responsibility. Everyone who owns land, lives, or makes a living in the watershed can influence the ultimate fate of its water resources. Therefore, their willing participation is critical to success. It is a spirit of cooperation that leads private landowners to apply voluntary conservation practices along Oklahoma's Kiamichi River to minimize sedimentation from agriculture and forestry activities.

Also essential is working on a scale at which people can understand the cause and effect of their actions. For conservation of freshwater biodiversity, the small watershed is a logical rallying point, both geographically and biologically. This report identifies those critical small watershed areas—a mere 15 percent of the country's total—whose protection will include all U.S. freshwater fish and mussel species at risk.

Nature Conservancy and U.S. Fish and Wildlife Service researchers collaborate on a stream study in Oregon's Twelvemile Creek.

Create a Forum for Discussion and Action

Most people in a watershed are too busy to work full time solving problems by themselves. In addition, the probability of success is low when only one voice is represented. Most watersheds cross multiple political districts (such as townships, counties, and states) and affect many constituencies. If no local watershed association exists to serve as a catalyst for river conservation, an organization like Alabama's Cahaba River Society can be formed. Ideally, such an organization should have staff dedicated to addressing the complexity of issues and the long-term nature of river conservation activities.

Success is often tied to creating a forum in which all constituents in a watershed can be heard. In Virginia's Clinch Valley, it was the Russell County Vision Forum—formed by the local chamber of commerce, board of supervisors, and planning district commission, along with The Nature Conservancy and the National Association of Counties—that set the stage for Russell County residents and businesses to create a blueprint for the future of their county. For the Conasauga River, on the Tennessee-Georgia border, it was the Conasauga River Alliance.

Identify the Issues and Get the Facts

Identifying the real issues facing the watershed, and getting the best information available to analyze those issues, is essential for success. Good scientific information is required to identify the *actual* threats to the resource or imperiled species. For example, several private and public entities jointly funded a scientific study of the Altamaha River in Georgia. The information generated by that analysis led to the development of a credible, broadly accepted set of conservation actions to address threats to the river.

What is degrading the river—agricultural runoff, lack of municipal sewage treatment, unchecked residential growth, poor forestry practices, or a combination of these problems? Figuring out the real threats and targeting solutions to address them saves time and money.

Assemble the Resources to Solve the Problem

Numerous federal and state agencies offer financial and technical assistance to help address water quality and endangered species issues. For example, the Natural Resources Conservation Service of the U.S. Department of Agriculture has staff in almost every county who are dedicated to helping private landowners solve environmental problems created by agriculture. The agency administers programs that provide a cost-share for the installation or implementation of conservation practices, such as fences for livestock and buffer strips to reduce erosion from farm fields. Most counties also have soil and water conservation districts that include local residents who help define conservation needs and develop solutions. Other federal agencies, such as the Environmental Protection Agency and the Army Corps of Engineers, can conduct or fund scientific studies to analyze particular problems.

One way to attract the interest and support of a public agency is to identify or create a local entity committed to solving environmental problems. It helps to have designated full-time staff, because working with agencies and applying for program support can be time-consuming. The work gets easier as conservation activities in a watershed result in positive outcomes. Maintaining a positive, problem-solving approach is one of the most important elements of an effective program.

Finally, all elected officials should be kept fully informed of the activities in the watershed. These people are responsible for maintaining the programs and funding that can make a difference. They also have staff who can direct local residents to the help they need.

Safeguarding Our Rivers of Life

The United States is a world center of freshwater biodiversity. Yet, many species inhabiting our freshwater ecosystems are in serious trouble and are far more imperiled than terrestrial species. The decline in freshwater species reflects the widespread degradation of water quality and quantity in the United States—a siren call to all Americans who value clean water for drinking and recreation.

This report argues that concerted efforts to protect a small number of key watershed areas in the United States will make a significant contribution to the conservation of the world's freshwater biodiversity. These watershed areas, eight of which are profiled in this report, offer many opportunities to protect our rich freshwater biodiversity. Success will depend on the extent to which conservationists, landowners, corporations, and municipalities work cooperatively in these places to ensure good water quality and to maintain or restore natural water flows.

Beyond its role in promoting site-based conservation activities, The Nature Conservancy is taking other steps to protect the nation's freshwater resources. The Conservancy is establishing an organization-wide Freshwater Initiative. This crosscutting program will promote the gathering of biological information, the creation of freshwater conservation demonstration sites, and the development of an Internet-based learning network to share lessons and best management practices. In addition, the Conservancy will be establishing a freshwater conservation center in Chattanooga, Tennessee, to focus activities in the Southeast—arguably the most biologically rich and imperiled region in the world for freshwater species.

Protecting water quality and quantity in the critical watersheds identified in this report will do much to secure the future of America's fish and mussel species and many other associated freshwater organisms. However, many freshwater species are not directly included in these analyses, and their conservation will require additional watersheds to be protected. Ultimately, we should safeguard *all* the "rivers of life" that flow through our nation. By maintaining or restoring the health of all our nation's watersheds we not only will help ensure the survival of our aquatic biodiversity, but will help protect our own well-being and quality of life.

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Additional Resources

For more information on freshwater life, and what you can do to help protect our nation's rivers and waterways, contact or visit the Web sites of the following organizations. Your local library may be able to provide Internet access if you do not have personal access.

Association for Biodiversity Information (ABI): http://www.abi.org/abi

ABI helps Natural Heritage Programs to operate as a network by sharing technologies, promoting the exchange of knowledge and experiences, and facilitating the development of information products and services.

American Fisheries Society (AFS): http://www.esd.ornl.gov/societies/AFS/

AFS promotes scientific research and enlightened management of fisheries resources for optimum use and enjoyment by the public. It publishes some of the world's leading fisheries research journals.

American Rivers: http://www.amrivers.org

American Rivers is a national river-saving organization. Its web site tracks recent and upcoming national river policies, including the American Heritage Rivers Initiative and America's Most Endangered Rivers nominations.

American Society of Ichthyologists and Herpetologists: http://www.utexas.edu/depts/asih/

The primary goals of the Society are to increase knowledge about fishes, amphibians, and reptiles and to disseminate that knowledge through conferences and publications, such as the journal *COPEIA*.

Desert Fishes Council: http://www.utexas.edu/depts/tnhc/.www/fish/dfc/dfc_top.html

The Council's mission is to preserve the biological integrity of desert aquatic ecosystems and their associated life forms.

Environmental Defense Fund (EDF): http://www.edf.org/

EDF is a leading advocate of economic incentives as a new approach to solving environmental problems. It maintains a Member Action Network to influence national environmental policy.

Global Rivers Environmental Education Network (GREEN): http://www.igc.apc.org/green/

GREEN works with business, government, community, and educational organizations across the United States and Canada, and with GREEN Country Coordinators in 135 countries, to support local efforts in watershed education and sustainability.

International Rivers Network: http://www.irn.org/

This Web site provides activists with important in-depth background and current information on river campaigns.

Izaak Walton League: http://www.iwla.org/iwla/

The League uses a grassroots approach to protecting U.S. soil, air, woods, waters, and wildlife and has a nationwide river conservation program called "Save Our Streams."

Metropolitan Washington Council of Governments (MWCOG): http://www.mwcog.org/index.html

MWCOG provides a series of reports on topics such as watershed restoration, controlling urban runoff, and riparian buffer strategies in urban settings that can be ordered through its Web site.

National Oceanic and Atmospheric Administration (NOAA): http://www.noaa.gov

The mission of NOAA is to describe and predict changes in the Earth's environment, and to conserve and manage wisely the nation's coastal and marine resources.

National Park Service: http://www.nps.gov/

The primary mission of the National Park Service is to regulate the use of the national parks to conserve the scenery and natural and historic objects and wildlife therein and to provide for their enjoyment in a manner that will leave them unimpaired for the enjoyment of future generations.

Natural Resources Conservation Service: http://www.nrcs.usda.gov/

The mission of the Natural Resources Conservation Service is to provide leadership and administer programs to help people conserve, improve, and sustain our natural resources and environment.

Potential Priority Watersheds for Protection of Water Quality from Nonpoint Sources Related to Agriculture: http://www.nhq.nrcs.usda.gov/land/env/wqpost2.html/

National maps developed to assist decisionmakers in identifying priority watersheds for water quality protection from nonpoint sources due to agriculture.

Rivers, Trails, and Conservation Assistance (RTCA): http://www.cr.nps.gov:80/rtca/

The RTCA program helps communities protect rivers, trails, and greenways on lands not owned or managed by the federal government.

Natural Heritage Network: http://www.heritage.tnc.org/

Natural Heritage Programs collectively represent the largest ongoing effort to gather standardized data on imperiled plants, animals, and ecosystems.

Natural Resources Defense Council (NRDC): http://www.nrdc.org/nrdc/

NRDC's mission is to preserve the environment, protect public health, and ensure the conservation of wilderness and natural resources.

NCSU Water Quality Group, WATERSHEDSS: A decision support system for nonpoint source pollution control: http://h2osparc.wq.ncsu.edu/

WATERSHEDSS (Water, Soil, and Hydro-Environmental Decision Support System) is designed to help watershed managers identify their water quality problems and select best management practices.

North American Benthological Society: http://www.benthos.org/

The Society works to promote better understanding of benthic communities—groups of species living on or in lake or sea bottoms.

River Network: http://www.teleport.com/~rivernet/index.html

This Web site includes resources for watershed protection and management of nonprofit organizations, and a directory of river organizations.

River Watch Network: http://www.riverwatch.org/

River Watch Network brings together people to monitor, restore, and protect their rivers, helping communities develop scientific studies and river conservation strategies.

Southeastern Fishes Council (SFC): http://www.flmnh.ufl.edu/fish/sfc/

This Web site presents SFC publications including *PROCEEDINGS,* a biannual journal of peer-reviewed science papers, and other regional reports.

The Nature Conservancy: http://www.tnc.org/

The Conservancy's mission is to preserve plants, animals, and natural communities that represent the diversity of life on Earth by protecting the lands and waters they need to survive.

The Watershed Management Council: http://watershed.org/wmchome/index.html

The Watershed Management Council is a nonprofit educational organization dedicated to advancing the art and science of watershed management.

U.S. Environmental Protection Agency (EPA): http://www.epa.gov/

The EPA has a variety of programs and offices that focus on improving the nation's water quality, and watershed health. Among them are:

Office of Wetlands, Oceans, and Watersheds (OWOW): http://www.epa.gov/owow/
A general directory to the EPA's extensive Wetland, Ocean, and Watershed programs.

Nonpoint Source Pollution Control Program: http://www.epa.gov/OWOW/NPS/
Basic questions and answers about nonpoint source pollution, and a bulletin dealing with the condition of aquatic ecosystems.

Watershed Protection: A Statewide Approach: http://www.epa.gov/OWOW/watershed/state/
A publication detailing OWOW's approach to water resources management within watersheds. The EPA is using this approach to focus on hydrologically defined resource areas, watersheds, and aquifers.

The Watershed Academy: http://www.epa.gov/OWOW/watershed/wacademy.html
Training courses and related materials about watershed processes, functions, and management techniques.

Surf Your Watershed: http://www.epa.gov/surf/
Index of Watershed Indicators: http://www.epa.gov/surf/iwi/
Information on 15 measures of watershed "health" compiled for 2,111 watersheds in the contiguous 48 states.

American Heritage Rivers: http://www.epa.gov/OWOW/heritage/rivers.html
Detailed description and comments on President Clinton's American Heritage Rivers Initiative.

U.S. Fish and Wildlife Service: http://www.fws.gov

This Web site describes the agency's regional divisions and their major responsibilities, including endangered species, freshwater and anadromous fishes, wetlands, migratory birds, and the National Wildlife Refuge System.

U.S. Geological Survey: http://www.usgs.gov/

USGS—Water Resources of the United States: http://h2o.er.usgs.gov/
Water data, publications, and programs provided by the USGS.

USGS—Hydrologic Unit Maps: http://water.usgs.gov/public/GIS/huc.html
Maps of U.S. hydrologic units at several scales. Each hydrologic unit is identified by a unique hydrologic unit code (HUC).

USGS—National Water Quality-Assessment (NAWQA) Program: http://wwwrvares.er.usgs.gov/nawqa/nawqa_home.html
A resource that defines water quality status and trends in the nation's ground and surface water resources.

USGS—Biological Resources Division: http://www.nbs.gov/
The Biological Resources Division of USGS provides scientific information and technologies to support the sound management and conservation of U.S. biological resources.

USGS—Nonindigenous Aquatic Species: http://nas.nfrcg.gov/
This site is a central repository for spatially referenced biogeographic accounts of non-native aquatic species.

World Wildlife Fund: http://www.wwf.org/

The World Wildlife Fund (WWF) conducts worldwide efforts to protect threatened wildlife and the habitats it needs to survive.

Appendix A:

Numbers of At-Risk Fish and Mussel Species In Freshwater Regions[33] of the United States

Freshwater Region	Number of Fish Species at Risk	Number of Mussel Species at Risk	Total of Fish and Mussel Species at Risk
Tennessee-Cumberland	57	47	104
Mobile	42	23	65
Interior Highlands	28	26	54
South Atlantic	25	22	47
Florida Gulf	17	23	40
Old Ohio	13	25	38
Teays	19	17	36
Mississippi Embayment	21	13	34
Central Prairie	17	15	32
Middle Mississippi	8	16	24
Pamlico-Ablemarle Sound	13	8	21
Florida	5	14	19
Pacific Mid-Coastal	17	1	18
West Texas Gulf	11	6	17
East Texas Gulf	6	9	15
Lower Rio Grande	12	3	15
Upper Mississippi	6	8	14
Pecos	13	1	14
Erie-Ontario	5	8	13
Chesapeake Bay	4	8	12
Michigan-Huron	6	5	11
Bonneville	10	0	10
Vegas-Virgin	10	0	10
California Central Valley	8	2	10
Gila	8	0	8
Little Colorado	8	0	8
Middle Missouri	6	2	8
Lahontan	8	0	8
Upper Colorado	7	0	7
Lower Colorado	6	0	6
Pacific Coastal	6	0	6
Columbia Unglaciated	4	2	6
Death Valley	5	0	5
Oregon Lakes	5	0	5
Long Island Sound	2	3	5
Southern Plains	5	0	5
Pacific North Coastal	3	2	5
Superior	5	0	5

Freshwater Region	Number of Fish Species at Risk	Number of Mussel Species at Risk	Total of Fish and Mussel Species at Risk
Lower St. Lawrence	4	0	4
Upper Snake	4	0	4
Upper Rio Grande	4	0	4
South Coastal	4	0	4
Upper Missouri	3	0	3
Gulf of Maine	2	1	3
Guzman	3	0	3
Columbia Glaciated	1	1	2
English-Winnipeg Lakes	2	0	2
Upper Saskatchewan	1	0	1

Appendix B:

U.S. Watershed Hot Spots with 10 or More At-Risk Freshwater Fish and Mussel Species

Small Watershed Area (subbasin, or USGS Hydrologic Cataloging Unit)	**States**	**Number of Fish and Mussel Species at Risk**	**Number of Fish and Mussel Species with U.S. Endangered Species Act Status**
Upper Clinch	VA,TN	48	21
Upper Duck	TN	33	6
Powell	VA,TN	30	13
Upper Green	KY	29	7
Upper Elk	TN	27	9
South Fork Cumberland	TN,KY	22	7
Wheeler Lake	AL,TN	22	9
Conasauga	GA,TN	21	10
Tippecanoe	IN	21	6
Upper Ouachita	AR	20	3
Holston	TN	20	12
Spring [Upper White basin]	AR,MO	20	1
Lower Wabash	IN,IL	20	8
Nolichucky	TN,NC	19	6
South Fork Holston	VA,TN	19	4
Lower Little Tennessee	TN,NC	19	7
Watts Bar Lake	TN	19	8
Upper Cumberland-Lake Cumberland	KY,TN	18	5
North Fork Holston	VA,TN	18	4
Lower Little	AR,OK	17	3
Middle Wabash-Deer	IN	17	7
Lower Tennessee-Beech	TN,MS	16	8
Little Missouri	AR	16	1
Lower East Fork White	IN	16	5
Pickwick Lake	AL,TN	15	4
Lower Duck	TN	15	6
Lower Cumberland-Old Hickory Lake	TN	15	10
Strawberry	AR	15	0
Buttahatchee	AL,MS	15	6
Barren	KY,TN	15	3
Hiwassee	TN,NC,GA	15	2
Upper Tombigbee	MS,AL	14	7
Ouachita Headwaters	AR	14	1
Buffalo	TN	14	4
Upper Little	OK	14	2
Lower Clinch	TN	14	11
Middle Tennessee-Chickamauga	TN,GA	14	6
Current	MO,AR	14	1
Middle Wabash-Little Vermilion	IN,IL	14	6

Small Watershed Area (subbasin, or USGS Hydrologic Cataloging Unit)	**States**	**Number of Fish and Mussel Species at Risk**	**Number of Fish and Mussel Species with U.S. Endangered Species Act Status**
Middle Wabash-Busseron	IN,IL	14	6
Caney	TN	13	5
Altamaha	GA	13	2
Sipsey	AL	13	6
Upper Saline	AR	13	1
Spring [Neosho basin]	MO,KS,OK	13	3
Middle White	AR	13	1
Upper White	IN	13	3
Waccamaw	NC,SC	12	2
Cahaba	AL	12	4
Apalachicola	FL,GA	12	4
Upper Flint	GA	12	2
Yellow	FL,AL	12	0
Rockcastle	KY	12	3
Beaver Reservoir	AR,MO	12	1
French	PA,NY	12	2
Etowah	GA	11	3
Collins	TN	11	4
Lower Ocmulgee	GA	11	2
Escambia	AL,FL	11	2
Middle Chattahoochee-Walter F. George Reservoir	GA,AL	11	1
Pea	AL,FL	11	2
Lower Choctawhatchee	FL,AL	11	2
Lower Conecuh	AL	11	1
Upper Tar	NC	11	2
Emory	TN	11	4
Kinchafoonee-Muckalee	GA	11	3
Upper Neuse	NC	11	1
Kiamichi	OK	11	1
Upper Cumberland-Cordell Hull	TN	11	3
Lower French Broad	TN	11	4
Upper Black	MO,AR	11	1
Elk	WV	11	3
Lost	CA,OR	10	2
Little Red	AR	10	1
Lower Tallapoosa	AL	10	2
Upper Little Tennessee	NC	10	3
Sepulga	AL	10	0
Middle Alabama	AL	10	3
Luxapallila	AL,MS	10	3
Red	TN,KY	10	1
Buffalo	AR	10	0
Illinois	OK,AR	10	2
Lower Ohio	KY,IL	10	3
Licking	KY	10	2
Muskingum	OH	10	2
Ohio Brush-Whiteoak	OH,KY	10	1
Little Muskingum-Middle Island	WV,OH	10	2

Appendix C:

Critical Watersheds to Conserve At-Risk Fish and Mussel Species

Small Watershed Area (subbasin, or USGS Hydrologic Cataloging Unit)	**States**	**Primary Ecoregion**	**Number of At-Risk Fish and Mussel Species**
Wheeler Lake	AL, TN	Cumberlands & Southern Ridge & Valley	23
Buttahatchee	AL, MS	Upper East Gulf Coastal Plain	15
Sipsey	AL	Upper East Gulf Coastal Plain	15
Pickwick Lake	AL, TN	Interior Low Plateau	15
Cahaba	AL	Upper East Gulf Coastal Plain	14
Lower Tallapoosa	AL	Upper East Gulf Coastal Plain	12
Pea	AL, FL	East Gulf Coastal Plain	11
Lower Conecuh	AL, FL	East Gulf Coastal Plain	11
Escambia	AL, FL	East Gulf Coastal Plain	11
Middle Coosa	AL	Cumberlands & Southern Ridge & Valley	11
Sepulga	AL	East Gulf Coastal Plain	10
Middle Alabama	AL	Upper East Gulf Coastal Plain	10
Luxapallila	AL, MS	Upper East Gulf Coastal Plain	10
Sipsey Fork	AL	Cumberlands & Southern Ridge & Valley	9
Upper Conecuh	AL	East Gulf Coastal Plain	8
Lower Coosa	AL	Cumberlands & Southern Ridge & Valley	8
Mobile-Tensaw	AL	East Gulf Coastal Plain	8
Upper Choctawhatchee	AL	East Gulf Coastal Plain	7
Lower Alabama	AL	East Gulf Coastal Plain	7
Middle Tombigbee-Lubbub	AL, MS	Upper East Gulf Coastal Plain	7
Locust	AL	Cumberlands & Southern Ridge & Valley	7
Upper Black Warrior	AL	Cumberlands & Southern Ridge & Valley	7
Patsaliga	AL	East Gulf Coastal Plain	6
Middle Tallapoosa	AL	Piedmont	6
Upper Alabama	AL	Upper East Gulf Coastal Plain	6
Lower Tombigbee	AL	East Gulf Coastal Plain	5
Upper Ouachita	AR	Upper West Gulf Coastal Plain	20
Little Missouri	AR	Upper West Gulf Coastal Plain	16
Strawberry	AR	Ozarks	16
Ouachita Headwaters	AR	Ouachita Mountains	14
Upper Saline	AR	Upper West Gulf Coastal Plain	13
Buffalo	AR	Ozarks	10
Little Red	AR	Ozarks	10
Bayou Bartholomew	AR, LA	Mississippi River Alluvial Plain	7
Lower Ouachita-Smackover	AR	Upper West Gulf Coastal Plain	6
Cache	AR	Mississippi River Alluvial Plain	3
Little Colorado Headwaters	AZ, NM	Arizona-New Mexico Mountains	4
Chevelon Canyon	AZ	Arizona-New Mexico Mountains	4

Small Watershed Area (subbasin, or USGS Hydrologic Cataloging Unit)	**States**	**Primary Ecoregion**	**Number of At-Risk Fish and Mussel Species**
Lower San Pedro	AZ	Sonora Desert	4
San Bernardino Valley	AZ, NM	Apache Highlands	4
Grand Canyon	AZ	Colorado Plateau	3
Upper Verde	AZ	Apache Highlands	3
Upper Santa Cruz	AZ	Apache Highlands	2
Whitewater Draw	AZ	Apache Highlands	2
Rio Sonoyta	AZ	Sonora Desert	1
Rio De La Concepcion	AZ	Apache Highlands	1
Lower Pit	CA	West Cascades and Coastal Forests	6
Upper Pit	CA	Modoc Plateau and East Cascades	5
Suisun Bay	CA	Great Central Valley	5
San Pablo Bay	CA	California Central Coast	5
San Francisco Bay	CA	California Central Coast	5
Lower Sacramento	CA	Great Central Valley	4
Lower Cosumnes-Lower Mokelumne	CA	Great Central Valley	3
Santa Clara	CA	California South Coast	3
Mad-Redwood	CA	California North Coast	2
Lower Eel	CA	California North Coast	2
Russian	CA	California North Coast	2
Upper Cache	CA	California North Coast	2
Mill-Big Chico	CA	Great Central Valley	2
Upper King	CA	Sierra Nevada	2
San Gabriel	CA	California South Coast	2
Santa Ana	CA	California South Coast	2
Santa Margarita	CA	California South Coast	2
Crowley Lake	CA, NV	Great Basin	2
Owens Lake	CA	Mohave Desert	2
Death Valley-Lower Amargosa	CA, NV	Mohave Desert	2
Upper Cow-Battle	CA	West Cascades and Coastal Forests	1
Upper Kern	CA	Sierra Nevada	1
Upper Tuolumne	CA	Sierra Nevada	1
Colorado Headwaters-Plateau	CO, UT	Colorado Rocky Mountains	5
Lower Yampa	CO	Utah-Wyoming Rocky Mountains	5
Lower White	CO, UT	Wyoming Basins	4
Lower Gunnison	CO	Colorado Rocky Mountains	3
Apalachicola	FL, GA	East Gulf Coastal Plain	13
Lower Choctawhatchee	FL, AL	East Gulf Coastal Plain	11
Yellow	FL, AL	East Gulf Coastal Plain	10
Lower Ochlockonee	FL, GA	East Gulf Coastal Plain	9
Chipola	FL, AL	East Gulf Coastal Plain	9
Lower Suwannee	FL	East Gulf Coastal Plain	8
Santa Fe	FL	Florida Peninsula	7
Lower St. Johns	FL	Florida Peninsula	6
St. Andrew-St. Joseph Bays	FL	East Gulf Coastal Plain	4
Oklawaha	FL	Florida Peninsula	3
Choctawhatchee Bay	FL	East Gulf Coastal Plain	3
Everglades	FL	Tropical Florida	2
Kissimmee	FL	Florida Peninsula	1

Small Watershed Area (subbasin, or USGS Hydrologic Cataloging Unit)	**States**	**Primary Ecoregion**	**Number of At-Risk Fish and Mussel Species**
Lower Ocmulgee	GA	South Atlantic Coastal Plain	13
Altamaha	GA	South Atlantic Coastal Plain	13
Middle Chattahoochee-Walter F. George Reservoir	GA, AL	East Gulf Coastal Plain	13
Upper Flint	GA	Piedmont	12
Kinchafoonee-Muckalee	GA	East Gulf Coastal Plain	12
Etowah	GA	Piedmont	12
Ohoopee	GA	South Atlantic Coastal Plain	10
Lower Chattahoochee	GA, AL	East Gulf Coastal Plain	9
Upper Coosa	GA, AL	Cumberlands & Southern Ridge & Valley	9
Lower Oconee	GA	South Atlantic Coastal Plain	8
Little Ocmulgee	GA	South Atlantic Coastal Plain	8
Ichawaynochaway	GA	East Gulf Coastal Plain	8
Upper Tallapoosa	GA, AL	Piedmont	8
Lower Flint	GA	East Gulf Coastal Plain	7
Coosawattee	GA	Southern Blue Ridge	7
Upper Suwannee	GA, FL	South Atlantic Coastal Plain	6
Oostanaula	GA	Cumberlands & Southern Ridge & Valley	6
Upper Ocmulgee	GA	Piedmont	4
Upper Ochlockonee	GA	East Gulf Coastal Plain	4
Upper Ogeechee	GA	South Atlantic Coastal Plain	3
Upper Oconee	GA	Piedmont	3
Satilla	GA	South Atlantic Coastal Plain	2
Little Sioux	IA, MN	Northern Tallgrass Prairie	1
Bear Lake	ID, UT	Utah-Wyoming Rocky Mountains	5
Upper Snake-Rock	ID	Columbia Plateau	1
Big Wood	ID	Idaho Batholith	1
Little Wood	ID	Columbia Plateau	1
Middle Wabash-Little Vermilion	IL, IN	North Central Tillplain	14
Vermilion	IL, IN	Central Tallgrass Prairie	9
Embarras	IL	Interior Low Plateau	7
Kankakee	IL, IN	Central Tallgrass Prairie	7
Tippecanoe	IN	North Central Tillplain	21
Lower East Fork White	IN	Interior Low Plateau	16
St. Joseph	IN, OH, MI	North Central Tillplain	8
Driftwood	IN	North Central Tillplain	7
Blue-Sinking	IN, KY	Interior Low Plateau	7
Crooked	KS, OK	Central Shortgrass Prairie	3
Upper Cimarron-Bluff	KS, OK	Central Mixed-Grass Prairie	3
Middle Neosho	KS	Osage Plains/Flint Hills Prairie	3
Upper Green	KY	Interior Low Plateau	29
South Fork Cumberland	KY, TN	Cumberlands & Southern Ridge & Valley	22
Upper Cumberland-Lake Cumberland	KY, TN	Interior Low Plateau	18
Barren	KY, TN	Interior Low Plateau	15
Rockcastle	KY	Cumberlands & Southern Ridge & Valley	12
Licking	KY	Interior Low Plateau	10
Lower Tennessee	KY	Upper East Gulf Coastal Plain	9
Upper Cumberland	KY, TN	Cumberlands & Southern Ridge & Valley	4
Bayou De Chien-Mayfield	KY	Upper East Gulf Coastal Plain	2

Small Watershed Area (subbasin, or USGS Hydrologic Cataloging Unit)	**States**	**Primary Ecoregion**	**Number of At-Risk Fish and Mussel Species**
Bayou Teche	LA	Mississippi River Alluvial Plain	8
Upper Calcasieu	LA	Piney Woods	6
Lower Red-Lake Iatt	LA	Piney Woods	3
Mermentau Headwaters	LA	Gulf Coast Prairies and Marshes	2
Cacapon-Town	MD, PA, WV, VA	Central Appalachian Forest	2
Mattawamkeag	ME	Northern Appalachian/Boreal Forest	1
Lake Superior	MI, WI, MN	Great Lakes	2
Dead-Kelsey	MI	Great Lakes	1
Lake Huron	MI	Great Lakes	1
Spring	MO, AR	Ozarks	19
Lower Little	MO, OK	Upper West Gulf Coastal Plain	17
Current	MO, AR	Ozarks	14
Spring	MO, KS, OK	Ozarks	13
Upper Black	MO, AR	Ozarks	11
Meramec	MO	Ozarks	8
Lower Gasconade	MO	Ozarks	6
Sac	MO	Ozarks	5
Niangua	MO	Ozarks	5
Upper Tombigbee	MS, AL	Upper East Gulf Coastal Plain	15
Pascagoula	MS	East Gulf Coastal Plain	7
Tangipahoa	MS, LA	East Gulf Coastal Plain	7
Lower Chickasawhay	MS, AL	East Gulf Coastal Plain	6
Amite	MS, LA	East Gulf Coastal Plain	6
Bayou Pierre	MS	Upper East Gulf Coastal Plain	3
Little Tallahatchie	MS	Upper East Gulf Coastal Plain	2
Yocona	MS	Upper East Gulf Coastal Plain	1
Fort Peck Reservoir	MT	Northern Great Plains Steppe	3
Prairie Elk-Wolf	MT	Northern Great Plains Steppe	3
Charlie-Little Muddy	MT, ND	Northern Great Plains Steppe	3
Lower Yellowstone	MT	Northern Great Plains Steppe	3
Upper Tar	NC	Piedmont	11
Upper Neuse	NC	Piedmont	11
Waccamaw	NC, SC	Mid-Atlantic Coastal Plain	11
Upper Little Tennessee	NC, GA	Southern Blue Ridge	10
Fishing	NC	Piedmont	8
Lower Yadkin	NC	Piedmont	7
Deep	NC	Piedmont	6
Rocky	NC, SC	Piedmont	6
Lower Cape Fear	NC	Mid-Atlantic Coastal Plain	4
Black	NC	Mid-Atlantic Coastal Plain	4
Lumber	NC, SC	Mid-Atlantic Coastal Plain	4
Little Pee Dee	NC, SC	Mid-Atlantic Coastal Plain	4
Albemarle	NC	Mid-Atlantic Coastal Plain	2
Lake Sakakawea	ND	Northern Great Plains Steppe	3
Upper Connecticut-Mascoma	NH, VT	Lower New England/Northern Piedmont	2
Lower Delaware	NJ, PA	North Atlantic Coast	2
Upper Pecos-Black	NM, TX	Chihuahua Desert	8
Upper Gila	NM	Arizona-New Mexico Mountains	7
Upper Gila-Mangas	NM, AZ	Apache Highlands	7

Small Watershed Area (subbasin, or USGS Hydrologic Cataloging Unit)	**States**	**Primary Ecoregion**	**Number of At-Risk Fish and Mussel Species**
San Francisco	NM, AZ	Arizona-New Mexico Mountains	6
Upper Pecos-Long Arroyo	NM	Chihuahua Desert	5
Mimbres	NM	Chihuahua Desert	3
Rio Hondo	NM	Arizona-New Mexico Mountains	3
Rio Grande-Santa Fe	NM	Colorado Rocky Mountains	2
Elephant Butte Reservoir	NM	Arizona-New Mexico Mountains	2
Rio Felix	NM	Chihuahua Desert	2
Tularosa Valley	NM, TX	Chihuahua Desert	1
Lower Virgin	NV, UT, AZ	Mohave Desert	5
White	NV	Great Basin	5
Muddy	NV	Great Basin	3
Havasu-Mohave Lakes	NV, AZ, CA	Mohave Desert	3
Meadow Valley Wash	NV	Great Basin	2
Spring-Steptoe Valleys	NV	Great Basin	2
Fish Lake-Soda Spring Valleys	NV, CA	Great Basin	2
Upper Amargosa	NV, CA	Great Basin	2
Lower Quinn	NV	Great Basin	1
Massacre Lake	NV	Columbia Plateau	1
Thousand-Virgin	NV, OR	Columbia Plateau	1
Truckee	NV, CA	Columbia Plateau	1
Pyramid-Winnemucca Lakes	NV	Columbia Plateau	1
Long-Ruby Valleys	NV	Great Basin	1
Hot Creek-Railroad Valleys	NV	Great Basin	1
Middle Delaware-Mongaup-Brodhead	NY, PA, NJ	High Allegheny Plateau	2
Lake George	NY, VT	Great Lakes	1
Middle Hudson	NY	Lower New England/Northern Piedmont	2
Hudson-Wappinger	NY	Lower New England/Northern Piedmont	2
Muskingum	OH	Western Allegheny Plateau	10
Upper Scioto	OH	North Central Tillplain	8
Upper Little	OK	Ouachita Mountains	14
Kiamichi	OK	Ouachita Mountains	11
Lower Neosho	OK, AR	Ozarks	2
Lost	OR, CA	Modoc Plateau and East Cascades	10
Upper Klamath Lake	OR	West Cascades and Coastal Forests	9
Sprague	OR	Modoc Plateau and East Cascades	8
Williamson	OR	Modoc Plateau and East Cascades	7
Upper Klamath	OR, CA	Klamath Mountains	7
Upper Grande Ronde	OR	Idaho Batholith	3
Lower Grande Ronde	OR, WA	Idaho Batholith	3
Middle Fork Willamette	OR	West Cascades and Coastal Forests	2
Mckenzie	OR	West Cascades and Coastal Forests	2
South Umpqua	OR	Klamath Mountains	2
Umpqua	OR	West Cascades and Coastal Forests	2
Alvord Lake	OR, NV	Columbia Plateau	2
Warner Lakes	OR, CA, NV	Columbia Plateau	1
Guano	OR, NV	Columbia Plateau	1
Goose Lake	OR, CA	Modoc Plateau and East Cascades	1
French	PA, NY	Western Allegheny Plateau	12
Middle Allegheny-Tionesta	PA	High Allegheny Plateau	8

Small Watershed Area (subbasin, or USGS Hydrologic Cataloging Unit)	**States**	**Primary Ecoregion**	**Number of At-Risk Fish and Mussel Species**
Lynches	SC, NC	Mid-Atlantic Coastal Plain	8
Lower Catawba	SC, NC	Piedmont	8
Middle Savannah	SC, GA	South Atlantic Coastal Plain	7
Saluda	SC	Piedmont	5
Broad-St. Helena	SC	South Atlantic Coastal Plain	4
Edisto	SC	Mid-Atlantic Coastal Plain	3
Stevens	SC	Piedmont	2
Upper White	SD, NE	Northern Great Plains Steppe	1
Middle White	SD	Northern Great Plains Steppe	1
Vermillion	SD	Northern Tallgrass Prairie	1
Upper Duck	TN	Interior Low Plateau	32
Upper Elk	TN	Interior Low Plateau	27
Conasauga	TN, GA	Cumberlands & Southern Ridge & Valley	24
Holston	TN	Cumberlands & Southern Ridge & Valley	21
Nolichucky	TN	Southern Blue Ridge	20
Watts Bar Lake	TN	Cumberlands & Southern Ridge & Valley	19
Lower Little Tennessee	TN, NC	Southern Blue Ridge	19
Lower Tennessee-Beech	TN, MS	Upper East Gulf Coastal Plain	17
Lower Duck	TN	Interior Low Plateau	15
Hiwassee	TN, NC, GA	Southern Blue Ridge	14
Buffalo	TN	Interior Low Plateau	14
Caney	TN	Interior Low Plateau	13
Collins	TN	Interior Low Plateau	11
Emory	TN	Cumberlands & Southern Ridge & Valley	11
Red	TN, KY	Interior Low Plateau	10
Lower Elk	TN, AL	Interior Low Plateau	9
North Fork Forked Deer	TN	Upper East Gulf Coastal Plain	2
Big Bend	TX	Chihuahua Desert	7
Lower Devils	TX	Chihuahua Desert	7
Middle Sabine	TX, LA	Upper West Gulf Coastal Plain	6
San Saba	TX	Edwards Plateau	6
Black Hills-Fresno	TX	Chihuahua Desert	6
Upper Devils	TX	Edwards Plateau	6
Toledo Bend Reservoir	TX, LA	Upper West Gulf Coastal Plain	5
South Llano	TX	Edwards Plateau	5
Medina	TX	Edwards Plateau	5
Lower Neches	TX	Piney Woods	4
Middle Brazos-Millers	TX	Southern Shortgrass Prairie	4
San Marcos	TX	Crosstimbers &Southern Tallgrass Prairie	4
Upper San Antonio	TX	Crosstimbers &Southern Tallgrass Prairie	4
Reagan-Sanderson	TX	Chihuahua Desert	4
Lower Pecos-Red Bluff Reservoir	TX, NM	Chihuahua Desert	4
Middle Colorado-Elm	TX	Southern Shortgrass Prairie	3
Concho	TX	Edwards Plateau	3
Upper Guadalupe	TX	Edwards Plateau	3
Middle Guadalupe	TX	Crosstimbers &Southern Tallgrass Prairie	3
Upper Frio	TX	South Texas Plains	3
Caddo Lake	TX, LA	Upper West Gulf Coastal Plain	2
Middle Neches	TX	Piney Woods	2

Small Watershed Area (subbasin, or USGS Hydrologic Cataloging Unit)	**States**	**Primary Ecoregion**	**Number of At-Risk Fish and Mussel Species**
Lower Angelina	TX	Piney Woods	2
Middle Brazos-Palo Pinto	TX	Southern Shortgrass Prairie	2
South Laguna Madre	TX	South Texas Plains	2
Toyah	TX	Chihuahua Desert	2
Independence	TX	Chihuahua Desert	2
Lower Rio Grande	TX	South Texas Plains	1
Westwater Canyon	UT, CO	Colorado Plateau	5
Upper Colorado-Kane Springs	UT	Colorado Plateau	5
Lower Green-Diamond	UT, CO	Wyoming Basins	5
Lower Green-Desolation Canyon	UT	Utah High Plateaus	5
Upper Virgin	UT	Colorado Plateau	5
Duchesne	UT	Utah-Wyoming Rocky Mountains	4
Lower Green	UT	Colorado Plateau	4
Utah Lake	UT	Great Basin	2
Lower Sevier	UT	Great Basin	2
Lower Weber	UT	Utah-Wyoming Rocky Mountains	1
Upper Clinch	VA, TN	Cumberlands & Southern Ridge & Valley	50
Powell	VA, TN	Cumberlands & Southern Ridge & Valley	30
South Fork Holston	VA, TN	Central Appalachian Forest	18
North Fork Holston	VA, TN	Central Appalachian Forest	17
Upper Roanoke	VA	Piedmont	9
Nottoway	VA, NC	Piedmont	9
Upper James	VA, WV	Central Appalachian Forest	8
Upper Dan	VA, NC	Piedmont	8
Meherrin	VA, NC	Piedmont	6
Upper New	VA, NC	Southern Blue Ridge	6
Middle James-Buffalo	VA	Piedmont	5
Pamunkey	VA	Cheaspeake Bay Lowlands	4
Lower Columbia-Sandy	WA, OR	West Cascades and Coastal Forests	3
Willapa Bay	WA	West Cascades and Coastal Forests	3
Colville	WA	Canadian Rocky Mountains	2
Grays Harbor	WA	West Cascades and Coastal Forests	2
North Umpqua	WA	West Cascades and Coastal Forests	2
Upper Skagit	WA	North Cascades	2
Stillaguamish	WA	Puget Trough and Willamette Valley	2
Lower St. Croix	WI, MN	Superior Mixed Forest	9
Copperas-Duck	WI, IL	Central Tallgrass Prairie	9
Lower Chippewa	WI	Prairie-Forest Border	7
Wolf	WI	Superior Mixed Forest	6
Lower Wisconsin	WI	Prairie-Forest Border	5
Upper Chippewa	WI	Superior Mixed Forest	3
Upper Kanawha	WV	Cumberlands & Southern Ridge & Valley	7
Middle New	WV, VA	Central Appalachian Forest	5
Greenbrier	WV	Central Appalachian Forest	5
Cheat	WV, PA, MD	Central Appalachian Forest	2
Tygart Valley	WV	Central Appalachian Forest	1

Appendix D:

U.S. State and Regional Natural Heritage Data Centers

The Nature Conservancy
Conservation Science Division
1815 N. Lynn St.
Arlington, VA 22209
(703) 841-5300

Association for Biodiversity Information
3220 N St., NW #205
Washington, DC 20007

Alabama Natural Heritage Program
Huntingdon College
Massey Hall
1500 East Fairview Avenue
Montgomery, AL 36106-2148
(334) 834-4519

Alaska Natural Heritage Program
University of Alaska Anchorage
707 A Street
Anchorage, AK 99501
(907) 257-2780

Arizona Heritage Data Management System
Arizona Game & Fish Department
WM-H
2221 W. Greenway Road
Phoenix, AZ 85023
(602) 789-3612

Arkansas Natural Heritage Program
Research Section
Arkansas Natural Heritage Commission
Suite 1500, Tower Building
323 Center Street
Little Rock, AR 72201
(501) 324-9150

California Natural Heritage Division
Department of Fish & Game
1220 S Street
Sacramento, CA 95814
(916) 322-2493

Colorado Natural Heritage Program
Colorado State University
254 General Services Building
Fort Collins, CO 80523
(970) 491-1309

Connecticut Natural Diversity Database
Natural Resources Center
Department of Environmental Protection
79 Elm Street, Store Level
Hartford, CT 06106-5127
(860) 424-3540

Delaware Natural Heritage Program
Division of Fish & Wildlife
Dept of Natural Resources & Environmental Control
4876 Hay Point Landing Road
Smyrna, DE 19977
(302) 653-2880

District of Columbia Natural Heritage Program
13025 Riley's Lock Road
Poolesville, MD 20837
(301) 427-1302

Florida Natural Areas Inventory
1018 Thomasville Rd., Suite 200-C
Tallahassee, FL 32303
(850) 224-8207

Georgia Natural Heritage Program
Wildlife Resources Division
Georgia Department of Natural Resources
2117 U.S. Highway 278 S.E.
Social Circle, GA 30025
(706) 557-3032

Hawaii Natural Heritage Program
The Nature Conservancy of Hawaii
1116 Smith Street, Suite 201
Honolulu, HI 96817
(808) 537-4508

Idaho Conservation Data Center
Department of Fish & Game
600 South Walnut Street, Box 25
Boise, ID 83707-0025
(208) 334-3402

Illinois Natural Heritage Division
Department of Natural Resources
524 South Second Street
Springfield, IL 62701-1787
(217) 785-8774

Indiana Natural Heritage Data Center
Division of Nature Preserves
Department of Natural Resources
402 West Washington Street, Room W267
Indianapolis, IN 46204
(317) 232-4052

Iowa Natural Areas Inventory
Department of Natural Resources
Wallace State Office Building
East 9th/Grand, 4th Floor
Des Moines, IA 50319-0034
(515) 281-5918

Kansas Natural Heritage Inventory
Kansas Biological Survey
2041 Constant Avenue
Lawrence, KS 66047-2906
(913) 864-3453

Kentucky Natural Heritage Program
Kentucky State Nature Preserves Commission
801 Schenkel Lane
Frankfort, KY 40601
(502) 573-2886

Louisiana Natural Heritage Program
Department of Wildlife & Fisheries
P.O. Box 98000
Baton Rouge, LA 70898-9000
(504) 765-2821

Maine Natural Areas Program
Department of Conservation
93 State House Station
Augusta, ME 04333-0093
(207) 287-8044

Maine Endangered Species Program
Department of Inland Fisheries & Wildlife
650 State Street
Bangor, ME 04401-5654
(207) 941-4466

Maryland Heritage & Biodiversity
Conservation Programs
Department of Natural Resources
Tawes State Office Building, E-1
Annapolis, MD 21401
(410) 260-8540

Massachusetts Natural Heritage & Endangered
Species Program
Division of Fisheries & Wildlife
Route 135
Westborough, MA 01581
(508) 792-7270 ext. 200

Michigan Natural Features Inventory
Mason Building, 8th floor
Box 30444
Lansing, MI 48909-7944
(517) 373-1552

Minnesota Natural Heritage & Nongame Research
Department of Natural Resources
500 Lafayette Road, Box 25
St. Paul, MN 55155
(612) 296-2835

Mississippi Natural Heritage Program
Museum of Natural Science
111 North Jefferson Street
Jackson, MS 39201-2897
(601) 354-7303

Missouri Natural Heritage Database
Missouri Department of Conservation
P.O. Box 180
Jefferson City, MO 65102-0180
(573) 751-4115

Montana Natural Heritage Program
State Library Building
1515 E. 6th Avenue
Helena, MT 59620
(406) 444-3009

Navajo Natural Heritage Program
Navajo Fish & Wildlife Department
P.O. Box 1480
Window Rock, AZ 86515-1480
(520) 871-6472

Nebraska Natural Heritage Program
Game and Parks Commission
2200 North 33rd Street
P.O. Box 30370
Lincoln, NE 68503
(402) 471-5500

Nevada Natural Heritage Program
Department of Conservation & Natural Resources
1550 E. College Parkway, Suite 145
Carson City, NV 89706-7921
(702) 687-4245

New Hampshire Natural Heritage Inventory
Department of Resources & Economic
Development
172 Pembroke Street
P.O. Box 1856
Concord, NH 03302-1856
(603) 271-3623

New Jersey Natural Heritage Program
Office of Natural Lands Management
22 South Clinton Avenue,
P.O. Box 404
Trenton, NJ 08625-0404
(609) 984-1339

New Mexico Natural Heritage Program
University of New Mexico
851 University Blvd. S.E.
Suite 101
Albuquerque, NM 87131-1091
(505) 272-3545

New York Natural Heritage Program
Department of Environmental Conservation
700 Troy-Schenectady Road
Latham, NY 12110-2400
(518) 783-3932

North Carolina Natural Heritage Program
NC Department of Environment, Health & Natural Resources
Division of Parks & Recreation
P.O. Box 27687
Raleigh, NC 27611-7687
(919) 733-4181

North Dakota Natural Heritage Inventory
North Dakota Parks & Recreation Department
1835 Bismarck Expressway
Bismarck, ND 58504
(701) 328-5357

Ohio Natural Heritage Data Base
Division of Natural Areas & Preserves
Department of Natural Resources
1889 Fountain Square, Building F-1
Columbus, OH 43224
(614) 265-6453

Oklahoma Natural Heritage Inventory
Oklahoma Biological Survey
111 East Chesapeake Street
University of Oklahoma
Norman, OK 73019-0575
(405) 325-1985

Oregon Natural Heritage Program
821 SE 14th Avenue
Portland, OR 97214
(503) 731-3070; 230-1221

Pennsylvania Natural Diversity Inventory

PNDI-East
The Nature Conservancy
34 Airport Drive
Middletown, PA 17057
(717) 948-3962

PNDI-West
Western Pennsylvania Conservancy
209 Fourth Avenue
Pittsburgh, PA 15222
(412) 288-2777

PNDI-Central
Bureau of Forestry
P.O. Box 8552
Harrisburg, PA 17105-8552
(717) 783-3444

Rhode Island Natural Heritage Program
Rhode Island Department of Environmental Management
Division of Planning & Development
235 Promenade Street, 3rd Floor
Providence, RI 02908
(401) 277-2776, x4308

South Carolina Heritage Trust
SC Department of Natural Resources
P.O. Box 167
Columbia, SC 29202
(803) 734-3893

South Dakota Natural Heritage Data Base
SD Department of Game, Fish & Parks
Wildlife Division
523 E. Capitol Avenue
Pierre, SD 57501-3182
(605) 773-4227

Tennessee Division of Natural Heritage
Dept. of Environment & Conservation
401 Church St.
Nashville, TN 37243-0447
(615) 532-0431

TVA Regional Natural Heritage Resource Group
Division of Land Management
Tennessee Valley Authority
Norris, TN 37828
(423) 632-1593

Texas Conservation Data Center
P.O. Box 1440
San Antonio, TX 78295-1440
(210) 224-8774

Utah Natural Heritage Program
Utah Division of Wildlife Resources
1594 West North Temple, Suite 2110
Salt Lake City, UT 84114-6301
(801) 538-4700

Vermont Nongame & Natural Heritage Program
Vermont Fish & Wildlife Department
103 S. Main Street, 10 South
Waterbury, VT 05671-0501
(802) 241-3700

Virginia Division of Natural Heritage
Department of Conservation & Recreation
1500 East Main Street, Suite 312
Richmond, VA 23219
(804) 786-7951

Washington Natural Heritage Program
Department of Natural Resources
P.O. Box 47016
Olympia, WA 98504-7016
(360) 902-1340

Natural Areas Program
Department of Natural Resources
P.O. Box 47016
Olympia, WA 98504-7016
(360) 902-1340

West Virginia Natural Heritage Program
Division of Natural Resources
Ward Road, P.O. Box 67
Elkins, WV 26241
(304) 637-0245

Wisconsin Natural Heritage Program
Department of Natural Resources
Endangered Resources/4
101 S. Webster Street, Box 7921
Madison, WI 53707
(608) 266-7012

Wyoming Natural Diversity Database
1604 Grand Avenue, Suite 2
Laramie, WY 82070
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Acknowledgments

The report would not be possible without the work of many state and regional Natural Heritage Program staff, Nature Conservancy staff, and the many scientific collaborators who assisted in developing the specific occurrence data and conservation status data upon which the analyses in this report are based. The Association for Biodiversity Information facilitated the compilation of the occurrence data into a national data set for the analyses.

We also would like to thank the following reviewers for their thoughtful comments: John Alderman, J. David Allan, Nancy Braker, David Braun, Ron Cicerello, Glenn Clemmer, Leslie Colley, Christine A. De Joy, Stephen P. Hall, Jonathan Higgins, Deborah B. Jensen, Lisie Kitchel, Ruth Mathews, Meesh McCarthy, Gary Meffee, Michael Mendelson, Jennie Myers, Christopher Pague, Linda Pearsall, Michael Reuter, Brian Richter, Rob Riordan, Stephen Roble, Charlie Scott, Barbara J. Shapiro, Danielle Shirley, Peggy W. Shute, Thomas Smith, and William Stolzenburg.

Figure 5 (Critical Watersheds) benefited from reviews by Natural Heritage Program staff and Nature Conservancy staff in most states, as well as from reviews by the following individuals: John Alderman, Richard Biggins, Robert Butler, Kevin Cummings, George Cunningham, David Etnier, Jeffrey Garner, John Harris, Paul Hartfield, Robert Howells, Eugene Keferl, Charles Lydeard, Scott Mettee, Peter Moyle, William Pflieger, Tom Watters, Jack Williams, and James Williams.

We gratefully acknowledge the Regina Bauer Frankenberg Foundation for Animal Welfare and the U.S. Environmental Protection Agency for their support of this report. We would also like to acknowledge the U.S. Forest Service and the World Wildlife Fund-U.S. for their support of research that contributed to these analyses.

We gratefully acknowledge Canon U.S.A., Inc., which makes possible publication of this report as part of the Conservancy's NatureServe® program.

Special thanks are due to Publishers Printing Company, Inc. for furnishing paper and printing for this report.

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PRINTING AND PAPER: Courtesy of Publishers Printing Company, Inc., Shepherdsville, Kentucky