HEALTHY WATERS

A new ecological approach to identifying and protecting healthy waters in Virginia

"… at the mouth of every brook and in every creek
…exceeding good fish of divers kinds"

– Gabriel Archer, Jamestown Colonist, 1607

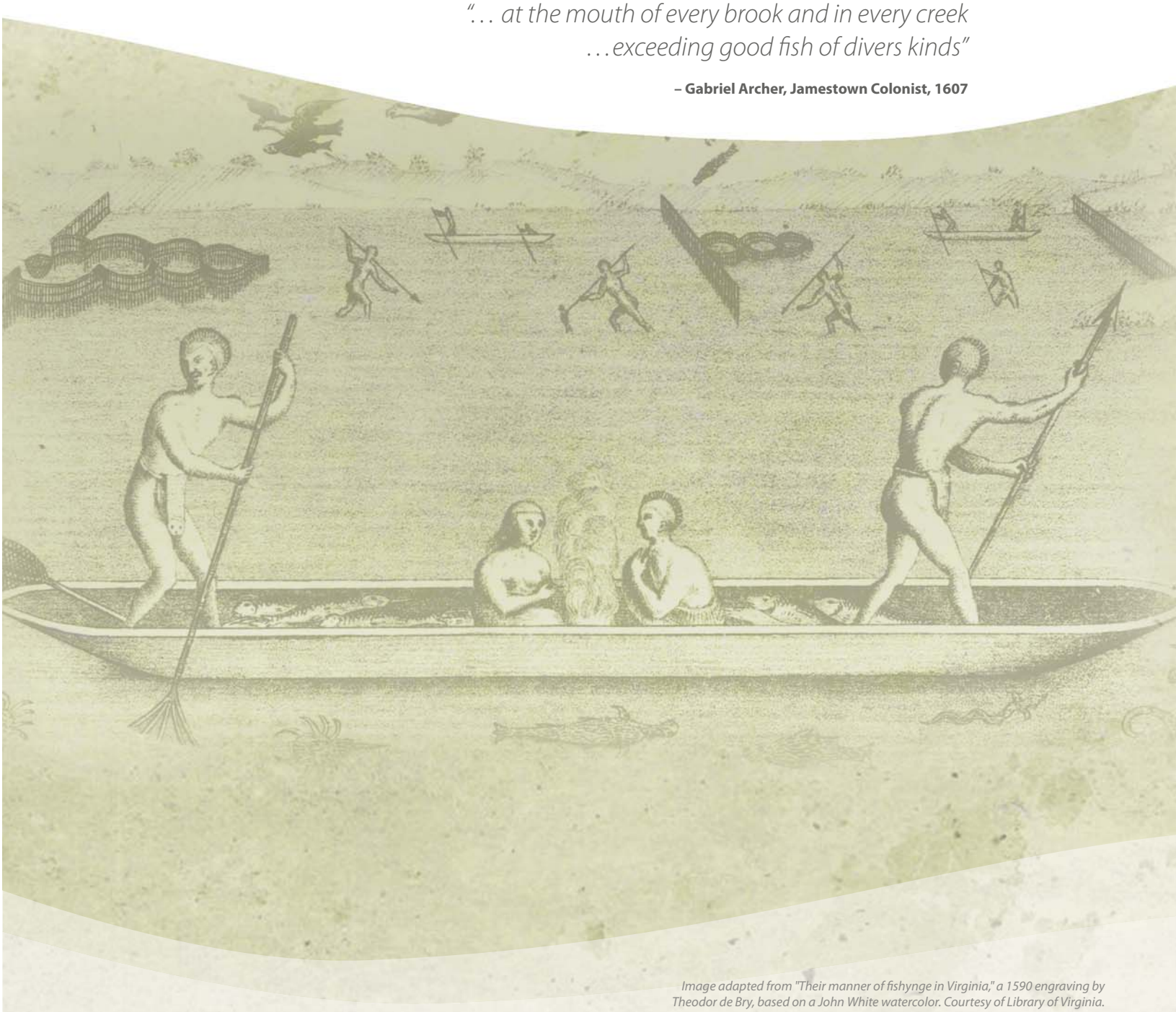

Image adapted from "Their manner of fishynge in Virginia," a 1590 engraving by Theodor de Bry, based on a John White watercolor. Courtesy of Library of Virginia.

HEALTHY WATERS

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Photo courtesy of Irvine Wilson.

HEALTHY WATERS IN VIRGINIA

In recent years, biologists have waded through more than 2,000 creeks and streams in Virginia, counting and analyzing fish, shellfish and aquatic bugs; documenting in-stream habitat; and scrutinizing banks and borders. Surprisingly, at a time when there is so much bad news about the environment, they've found nearly 200 ecologically healthy streams, creeks and rivers throughout the state, and there are more yet to be identified.

Identifying healthy waters is part of Virginia's new Healthy Waters initiative designed to raise awareness about the need to protect streams, creeks and other waters before they become impaired. In addition to water quality programs that focus on repairing degraded streams, Healthy Waters broadens the scope of conservation efforts to include protecting the ecological integrity and diversity of living resources in our healthy waters.

This approach encompasses everything from aquatic insect larvae and bugs hidden in gravelly stream bottoms, to fish and amphibians, to forested buffers alongside streams, to the water we drink. It's all interconnected, and protecting healthy streams requires a holistic approach that addresses in-stream habitat, stormwater runoff, invasive species and natural stream flow to maintain the balance intended by nature.

Although it may seem like common sense, the concept of protecting healthy waters has not received much attention until now, because most water quality programs have focused on rehabilitating degraded waters. By using Healthy Waters stream assessments to prioritize protection efforts where they will do the most good and by integrating protection into land-use decision-making and voluntary conservation efforts, we can reduce the number of streams that will become degraded and have a positive long-term impact on the interconnected health of Virginia's waters from the mountains to the ocean.

By protecting healthy waters, taxpayers will also avoid costly rehabilitation efforts and save millions of dollars. Currently, there are thousands of impaired streams in the state, and the list grows every year. Although the commonwealth has had some success in repairing them, rehabilitation efforts can be expensive, even cost-prohibitive. More importantly, there are very few examples of being able to restore impaired streams to their full ecological integrity.

Compared to degraded or even rehabilitated streams, healthy streams are more resistant to environmental stressors, such as climate change, invasive species, flooding and drought. They can also serve as models for the restoration of degraded streams and rivers.

Once identified and protected, healthy streams, rivers and their living resources become significant local assets that make no demand on

"I see this as complementary to our water quality programs, which emphasize restoring impaired waters. You cannot have one (restoration) without the other (protection)—they work hand in hand. By identifying the healthy watersheds that still remain and taking steps to protect them, we can ensure that they'll be healthy in the future and that the natural infrastructure will remain to support our restoration efforts."

– Laura Gabanski, Aquatic Biologist, U.S. EPA

municipal services and can positively contribute to a community—that includes providing clean drinking water. Healthy streams are essential to the prosperity of economically valuable living resources including fisheries and wildlife dependent on stream and river landscapes for reproduction, habitat and food. Healthy streams also preserve recreation opportunities, such as fishing, boating, hiking and birding, and contribute to tourism. In addition, the intrinsic value of sharing with future generations the beauty of healthy streams and the knowledge that ancient species of fish still live in them is priceless.

Conserving healthy streams requires action that is supported at the federal and state levels. The U.S. Environmental Protection Agency (EPA) is moving forward with a national Healthy Watersheds program, and the EPA Region III office has awarded funding to Virginia to pilot Healthy Waters activities. Protecting healthy waters is also rooted in state and federal law. The pollution prevention or "anti-degradation" language of the Clean Water Act provides a formal and specific basis for stream protection. Conservation of healthy waters is also part of the Chesapeake Bay and Virginia Waters Clean-up and Oversight Act.

Launched in Virginia in 2009 after several years of development, Healthy Waters is a multi-organizational effort developed and managed by the Virginia Department of Conservation and Recreation (DCR) and the Center for Environmental Studies at Virginia Commonwealth University in coordination with the Virginia Department of Environmental Quality (DEQ), the Virginia Department of Game and Inland Fisheries (DGIF), and the Virginia Coastal Zone Management Program.

Pumpkinseed Sunfish. Photo courtesy of VCU.

Stream photo courtesy of Gary P. Fleming.

WHAT DEFINES HEALTHY WATERS?

The Columbian Exchange of flora and fauna between the Old World and the New World began in earnest over 400 years ago after European colonists arrived at Jamestown. Since then, the introduction of exotic species has altered the ecosystem of Virginia and much of North America. In addition, most of the state has also experienced up to three cycles of deforestation and regrowth, triggering pollution and increasing sediment buildup in streams from stormwater runoff. As stormwater flows toward streams over farms, fields and cleared forests, it picks up soil and contaminants and dumps them into the waterways, covering habitat and affecting the species that live there.

Even though there are few truly "pristine" streams remaining in Virginia, there are still many freshwater streams and rivers in the commonwealth that support the same aquatic life that existed in pre-Columbian Virginia and that continue to function much the same way they did centuries ago. Dragon Run in the Piankatank watershed is a well-known example. (See related sidebar page 16.)

Scientists generally define "healthy waters" by characteristics that include: (See table on the right.)

✔	A high number of native species and a broad diversity of species.
✔	Few or no non-native species or at least a low abundance of those that have been established. Non-native species can compete with native species for food and habitat, and sometimes they prey on native species. This can eventually eliminate or significantly reduce native populations. (See Brookie sidebar page 26.)
✔	Occurrence of endemic species, which are found only in a particular region or watershed and specialized for local conditions. (See Roanoke Drainage sidebar page 12.)
✔	Few generalist species that are tolerant of degraded water quality, siltation, etc.
✔	A high number of native predators including both fish and bugs that indicate a complex and stable food chain.
✔	Migratory species whose presence indicates that river or stream systems are not blocked by dams or other impediments or controlled by fish passage structures such as ladders, and that important ecological links upstream and downstream are intact. This applies only to river basins that drain into the ocean. (See Migratory Fish sidebar page 6.)
✔	Low incidence of disease or parasites among individual organisms.
✔	Intact buffers of vegetation in the riparian zone between the land and the water that filter runoff and provide protection against pollution and siltation. (See Riparian Plantings sidebar page 5.)

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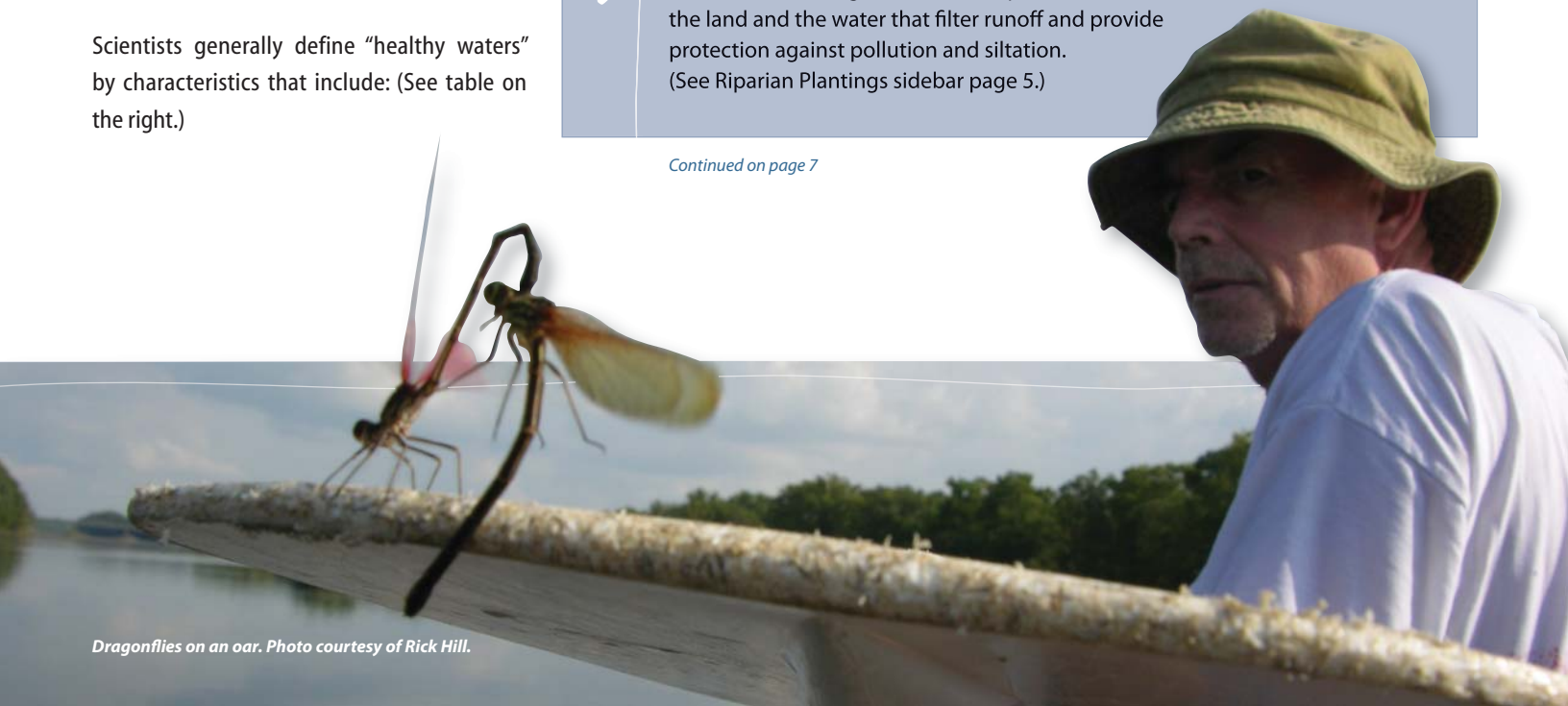


Dragonflies on an oar. Photo courtesy of Rick Hill.

Planting at Presquile National Wildlife Refuge. Photo courtesy of James River Association.

Prothonatory Warbler. Photo courtesy of VCU.

RIPARIAN PLANTINGS
PROVIDE HEALTHY BORDERS

Since 1999, the James River Association (JRA) has successfully planted over 210 acres and 21 miles of shoreline with plants, shrubs and trees to create and expand riparian borders along waterways throughout the James River watershed. These buffers of vegetation between land and water help trap pollutants picked up by rainwater and other runoff as it flows across farms, yards and roads and keep it from entering streams and creeks.

Creating and maintaining riparian buffers is the most effective way to protect healthy streams if resources are limited. Buffers also provide important wildlife habitat.

Amber Foster, manager of the Watershed Restoration Program at JRA, said most of the planting is done by volunteers and partnering organizations, and projects are funded through federal, state and private grants.

One of the largest projects completed so far, is a 100-foot wide buffer along the James River in Chesterfield County at Presquile National Wildlife Refuge, an Important Bird Area designated by the National Audubon Society. The refuge attracts wintering waterfowl, raptors and songbirds including prothonatory warblers, osprey, peregrine falcons, bald eagles and rusty blackbirds.

Mary Elfner, Virginia's Important Bird Area Coordinator for the National Audubon Society, said, "Providing cover, resting areas and food sources is doing the birds a great favor." The society plans to continue planting on the island in collaboration with the U.S. Fish and Wildlife Service.

Until recently, part of the island had been farmed and used as a cattle pasture. But when the cattle stopped grazing there, Foster said the invasive Johnson grass grew "out of control," choking out native vegetation – an important food source for wildlife.

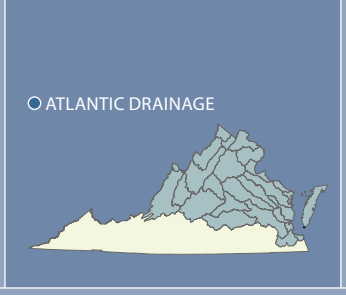
To help solve the problem, the JRA, National Audubon Society, Alliance for the Chesapeake Bay, U.S. Fish and Wildlife Service, and many volunteers joined forces and planted 20 acres of trees in the riparian zone that will eventually shade and block out the invasive grass. The buffer is also expected to slow down erosion.

"We planted 3,500 trees with 200 volunteers in 10 days," Foster said. Two and a half years later, 80 percent of the plantings had survived. "Overall, it was very successful," she said.

The U.S. Fish and Wildlife Service, the organization that manages the refuge, decided what to plant based on trees and shrubs that are native to the area. With a grant from National Fish and Wildlife Foundation and the Water Quality Improvement Fund, they purchased over 20 different species including shad bush, tulip poplar, black walnut, chestnut oak, black oak, sassafras, sourwood, scarlet oak and Virginia pine. "These species will provide habitat and food sources for birds and other wildlife," Foster explained.

Other riparian projects organized by JRA usually involve about half an acre, something 10 volunteers can finish in a few days. They always use native species, which are available from nurseries in Virginia and surrounding states. Ideally, Foster said, they try to plant a 100-foot wide buffer on each side of a stream or river, but sometimes they can plant only a 35-foot wide border. "We'll take what we can get. Any buffer is better than no buffer," she said.

For more information visit JRA, *www.jamesriverassociation.org;* the U.S. Fish and Wildlife Service, *www.fws.gov;* the Center for Watershed Protection, *www.cwp.org;* or Audubon Important Bird Areas, *www.audubon.org/bird/iba*.



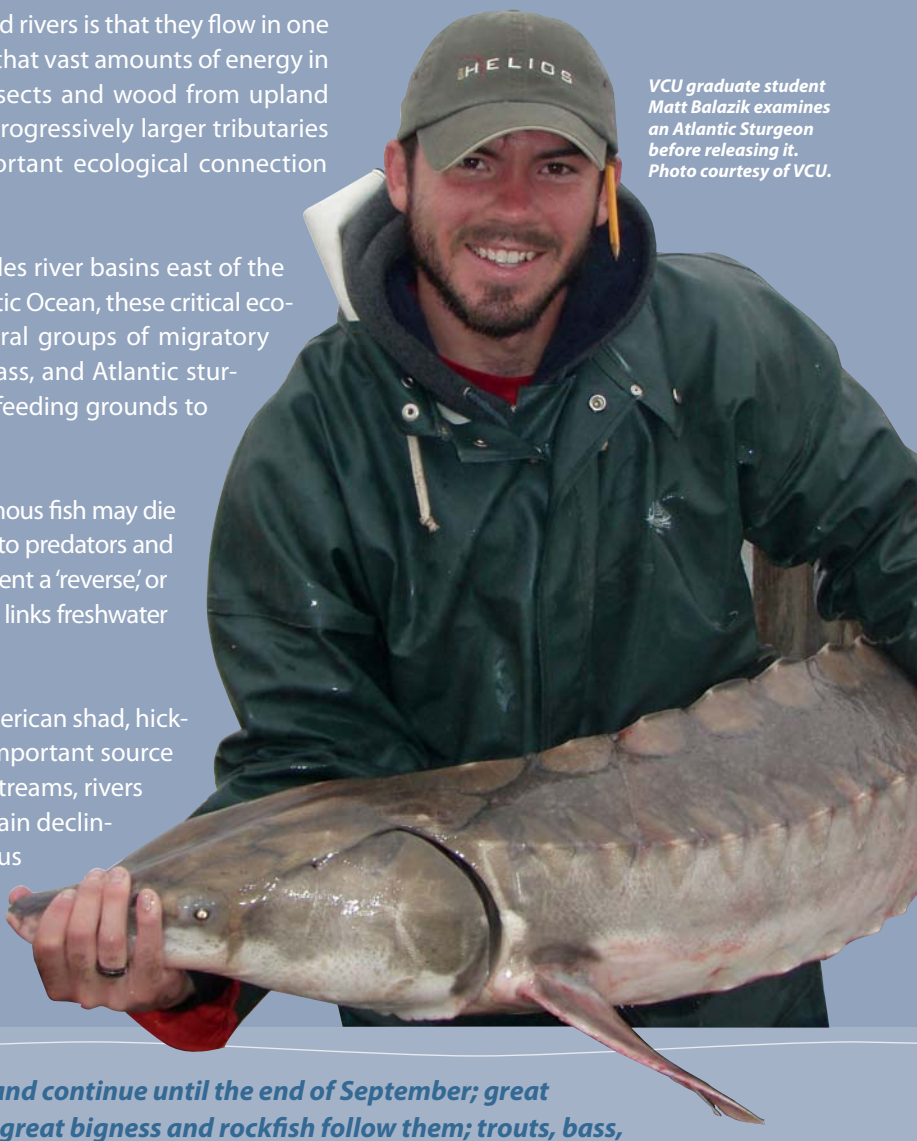
MIGRATORY FISH
LINK INLAND AND COASTAL WATERS

One of the defining characteristics of streams and rivers is that they flow in one direction—downstream. Generally, this means that vast amounts of energy in the form of organic matter such as leaves, insects and wood from upland forests and riparian corridors are supplied to progressively larger tributaries and eventually to estuaries, forming an important ecological connection between inland and coastal landscapes.

But along Virginia's Atlantic Slope, which includes river basins east of the Appalachian Mountains that drain into the Atlantic Ocean, these critical ecological linkages work in both directions. Several groups of migratory fishes, including shads and herrings, striped bass, and Atlantic sturgeon, perform long-distance treks from ocean feeding grounds to streams and rivers to spawn each spring.

Because a significant proportion of these anadromous fish may die during their residence in freshwater, succumbing to predators and the rigors of reproduction, their migrations represent a 'reverse,' or upstream movement of energy and nutrients that links freshwater systems to distant ocean habitats.

Historically, annual migrations by millions of American shad, hickory shad and river herrings were probably an important source of energy, supporting food webs in freshwater streams, rivers and marshes. Current efforts to restore or maintain declining populations of these and other anadromous fishes and to remove dams and other migration impediments will expand Virginia's healthy waters.



VCU graduate student Matt Balazik examines an Atlantic Sturgeon before releasing it. Photo courtesy of VCU.

"The sea fish come into our rivers in March and continue until the end of September; great schools of herrings come in first; shads of a great bigness and rockfish follow them; trouts, bass, flounders, and other dainty fish come in before the other be gone; then come multitudes of great sturgeons…"

– Rev. Alexander Whitaker, Henrico, 1612

HOW ARE HEALTHY WATERS IDENTIFIED AND ASSESSED?

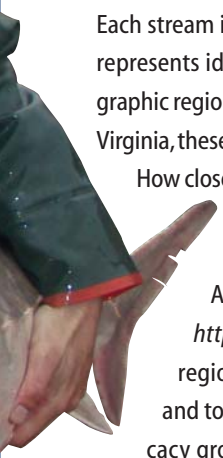
Continued from page 4

Based on healthy water characteristics and other biological stream data, sections of healthy streams in Virginia have been identified and ranked through the Interactive Stream Assessment Resource (INSTAR) as "exceptionally healthy," "healthy " or "restoration candidate."

Developed by the Center for Environmental Studies at Virginia Commonwealth University, INSTAR is an online interactive database application that scientifically identifies healthy streams using biological stream data that includes quantitative and qualitative information about fish communities and bugs, in-stream habitat and riparian borders.

INSTAR generates a Virtual Stream Assessment (VSA) score for each stream studied using data collected by biologists along a 150- to 500-meter length or "reach" of stream, depending on its width. They identify and count fishes and aquatic macroinvertebrates (worms, insects, mollusks, crayfish, etc.) that they collect. They also document in-stream habitat such as vegetation, rocks and fallen logs. In addition, they look for vegetation along stream banks (riparian zones) that can filter and slow runoff and sediment before it pollutes the stream or buries aquatic habitat. (See Stream Assessment sidebar page 8.)

Each stream is then compared statistically to a model reference stream that represents ideal conditions of biology and habitat for streams in that geographic region. Because there are very few truly pristine streams remaining in Virginia, these virtual reference stream models were developed and validated. How closely a stream compares to an appropriate model reference stream determines its VSA score and ranking.



Available to the public through a free, user-friendly website, *http://instar.vcu.edu,* INSTAR was designed primarily to assist regional and local planners with planning and land use decisions, and to help prioritize stream protection and mitigation efforts. Advocacy groups and individuals may also want to use INSTAR to identify healthy streams in their communities and encourage their protection. (See INSTAR sidebar page 10.)

Continued on page 13

Photo courtesy of Gary P. Fleming.

"These tools are easily incorporated into other activities, such as comprehensive plans and zoning. The only thing a locality would change would be to take these healthy resources into consideration when planning. …To protect our healthy waters is more cost effective than trying to correct mistakes later on."

– Bill Street, Executive Director, James River Association

FISHING FOR HEALTHY STREAMS

CONDUCTING AN INSTAR ASSESSMENT

David Hopler and Ricky Davis assess a stream using electrofishing gear. Photo courtesy of VCU.

Using an electrofishing backpack, dressed in chest waders, and armed with nets and buckets, Virginia Commonwealth University biologists looked like the Ghostbusters in camouflage when they began an INSTAR assessment of a creek that drains into the Piankatank River – one of over 1,000 streams they've evaluated since 2005. The information they collect will be used to determine the creek's Virtual Stream Assessment score and how healthy it is.

Trailing an electric cable behind him, David Hopler, fisheries biologist, stepped into the narrow stream and began shocking the water in front of him with a pole connected to his battery-powered backpack. As he waded, he watched for flashes of silver from momentarily stunned fish, netting them quickly before putting them in a bucket of water. Ready with another net, Ricky Davis, a graduate assistant, walked beside him to help spot and capture fish.

"There's a little bit of siltation, but the stream's got a nice flow. The banks and riparian zone are in good shape, so it's pretty good," Hopler said, netting an eel, a crayfish and a tessellated darter. "There's another darter that's rarer – the swamp darter. That would really boost the score if we got one."

Beeping each time it was activated, the shock covered the width of the stream in front of him, but its narcotic effect on the fish wore off quickly. Rubber waders protected the biologists from electrocution.

Staring at the water, Hopler saw another flash and quickly jabbed with the net. "Oh, there's a good fish," he said. "It's one of my personal favorites – a redfin pickerel. One of the things you want to see in a healthy fish population is a native apex predator (at the top of the food chain). He's like an African lion. See the teeth on him? That just upped the score. You have to have a healthy assemblage that it's eating."

Every few yards, he discovered more fish. "There's another tessellated darter. It's the most common darter in the coastal plain. They're actually pretty tolerant. Getting them is not bad, but getting them only would be," he explained.

As he waded, occasionally sinking up to his chest, the backpack measured the amount of shocking time so the effort could be compared to other assessments. When he

Top left: Athericidae: Atherix sp. Larva. Photo by Steve Solado. Courtesy of North American Benthological Society Bottom right: Redfin Pickerel. Photo courtesy of VCU. Stream photo courtesy of DCR.

reached 150 meters, he climbed out and the sampling ended. Davis identified and counted the fish in the bucket, then released them – unharmed – back into the stream.

They had captured nine different species of fish, and only the tail on one warmouth sunfish was abnormal. "We'll have to mark him down because of that, but that's the only bad marker on the whole stream," Hopler said. "We've got all native species, so that's pretty high marks."

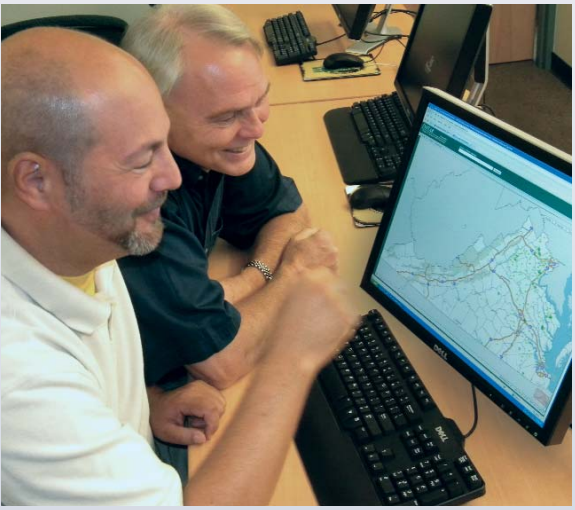
Then he assessed the habitat, using a standardized score sheet. "There are a lot of fallen trees, undercut banks with grasses. … Some root mats and submerged vegetation. … Most of the bends had nice deep areas. … There's definitely sediment deposition, but I've seen a lot worse. … There's no visible channel alteration. There's a lot of bends – excellent natural sinuosity. … No grazing or mowing near the stream, so I'm going to give it [the habitat] a high score."

To finish the assessment, he said another group would come out to study the bugs (macroinvertebrates) in a similar fashion, looking for diversity and intolerant species. Then all the data will be analyzed by INSTAR to determine how this stream compares to a model reference stream.

Based on what he observed, Hopler thinks the creek will probably be in the healthy range, possibly even exceptional.

WHAT IS INSTAR? Q&A With Dr. Greg Garman

Dr. Greg Garman, director of the Center for Environmental Studies at Virginia Commonwealth University, and his staff developed and maintain the Interactive Stream Assessment Resource (INSTAR) to support the Healthy Waters initiative. Here's how he explains it:



Dr. Greg Garman (left) and Dr. Leonard Smock, professor of biology and director of the VCU Rice Center, search for healthy streams with INSTAR. Photo courtesy of VCU.

What is INSTAR and why did you develop it?

GG. If we're going to protect healthy streams, we need to know where they are. The idea behind INSTAR was simply to have a stream database that focused on living aquatic resources, primarily fish and macroinvertebrates (worms, bugs, mollusks, crayfish, etc.) that could be used to objectively identify healthy streams in Virginia and prioritize stream protection and mitigation efforts. We recently launched the fourth version of INSTAR, and it has evolved into a dynamic, interactive, geospatial, decision-support tool. It's available to the public through a free website: *http://instar.vcu.edu*.

Who should use INSTAR?

GG. INSTAR was primarily designed as a tool that regional and local planners can use to assist with planning and land use decisions, and to help prioritize stream protection and mitigation efforts. Advocacy groups and individuals may also want to use INSTAR to identify healthy streams in their communities and encourage their protection.

At the regional level, planning district commissions and regional commissions can use INSTAR to support regional approaches to transportation, priority habitat corridor identification, greenways, zoning and land conservation priorities. It can also be used to identify healthy streams vulnerable to development, as well as those already protected.

Locally, INSTAR can raise awareness about the location of healthy waters and identify priority areas during comprehensive planning. It can serve as the keystone behind environmentally friendly development approaches such as conservation subdivisions and cluster development.

In addition, INSTAR can be used to identify and classify basins or sub-basins within localities that have stricter Better Site Design or required Low Impact Development (LID) elements in land-use planning. A map showing the location of healthy waters can be used to provide ongoing consideration about the impact of development and other activities near healthy waters, which could influence parcel-by-parcel decisions.

Is there anything else like INSTAR?

GG. There's the Maryland Biological Stream Survey (MBSS), and a few other states have similar online, geospatial databases. But INSTAR is the largest, most comprehensive database on streams and rivers in Virginia. It currently has data for over 2,000 stream reaches primarily in the eastern half of the state.

How do you collect stream data?

GG. Our biologists conduct quantitative ecological assessments of measured lengths of streams, between 150 to 500 meters, focusing on assemblages of fishes and aquatic macroinvertebrates, as well as in-stream habitat and riparian corridors. We also integrate archival information collected by several agencies, including DEQ, DGIF and US EPA, whenever possible.

How do you identify which streams are healthy?

GG. There are very few truly pristine streams in Virginia, so we use ecological modeling to determine reference stream

conditions in different river basins and ecoregions based on statistical analysis of 50 different variables, so there's scientific rigor behind it. Then, we compare data collected from actual streams to the appropriate reference virtual streams. This produces a stream assessment score as percent comparability with the virtual reference stream. Streams that score above 70 percent comparable are healthy, and streams that score above 80 percent are exceptional. Streams that score in the 50 to 70 percent range are good restoration candidates; scores below that indicate compromised conditions.

How often do you survey streams and when will information be available for all streams throughout the state?

GG. Most of the streams we've studied so far are in the eastern half of the state where they are more likely to be impacted by development. Funding for assessments is also currently available primarily within the Chesapeake Bay watershed. Eventually, we hope to assess stream health throughout the state on a regular, rotating basis, every few years, as additional funding is secured.

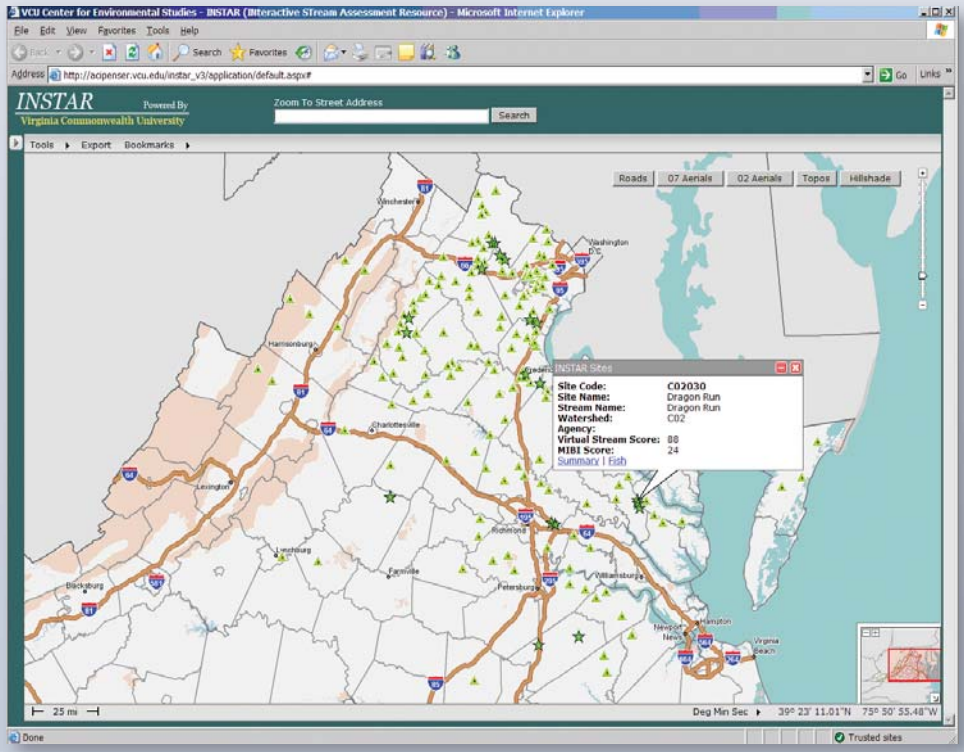
What information do you have about watersheds?

GG. INSTAR also classifies Virginia's 1,275 small watersheds using a modified Index of Biotic Integrity (mIBI), which is based on occurrences of selected aquatic species found in each watershed. In addition to data from VCU's assessments, we use information collected by DGIF, DCR's Virginia Natural Heritage Program and other valuable sources. Watershed assessments differ from stream assessments because they summarize data from an entire watershed, not just from a specific stream reach. They also include fewer stream attributes and are therefore more general predictors of stream health within a region. Scores for mIBI range from 6 to 30, and watersheds with a score greater than 16 are associated with generally high watershed integrity. Until stream assessments are available throughout the state, information about Virginia's watersheds may be the next best indicator of healthy water locations.

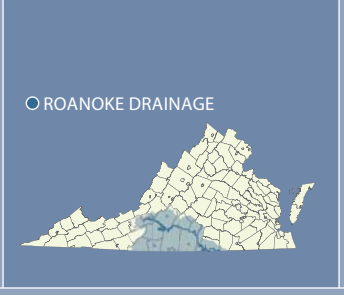
What kind of maps and reports can INSTAR produce?

GG. With INSTAR, it's easy to generate stream data and mapping information at the local, regional or statewide level. You can search by locality, stream name, watershed or drainage area. Specific locations can also be pinpointed using GPS coordinates or street addresses. In addition, you can pull up information about fish, macroinvertebrates and habitat for a specific stream location; turn on topographical views, road maps, wetland overlays and aerial photos. Users can also measure, outline and highlight areas; add and edit text; and generate customized maps and reports.

ⓘ For more information visit Instar at: *http://instar.vcu.edu*.



Click on a stream location on the INSTAR website to find out how healthy it is and to see detailed information about fish and aquatic insects that were identified when the stream was assessed.



ROANOKE DRAINAGE
RICH WITH NATIVE SPECIES

Native fishes in the Roanoke drainage represent one of the most distinctive faunas on the Atlantic Slope of the United States because these communities are so rich in number and diversity, according to "Freshwater Fishes of Virginia", by Robert Jenkins and Noel Burkhead. (The Atlantic Slope includes all river basins east of the Appalachian Mountains that drain into the Atlantic Ocean.)

There are 82 native species in the Roanoke drainage, and five of those are endemic – native forms that live only in the Roanoke drainage. These include the Roanoke hogsucker, *Hypentelium roanokense*; rustyside sucker, *Thoburnia hamiltoni*; orangefin madtom, *Noturus gilberti*; riverweed darter, *Etheostoma podostemone*; and bigeye jumprock, *Moxostoma ariommum*.

The Roanoke logperch, *Percina rex*, and Roanoke bass, *Ambloplites cavifrons*, are also found in the nearby Chowan drainage.

Dr. Jenkins said a diverse assemblage of fish can live here because the rivers are relatively wide and the slope is gentle. He noted that the Roanoke drainage is particularly rich in the diversity of suckers; there are 14 species altogether.

"To have so many native and endemic species is very significant in terms of evolutionary history, dispersal, primitive stocks and the subsequent evolution that gives rise to advanced specialized species in the Roanoke drainage," he said.

For example, he said the Roanoke logperch has an unusual stone-flipping foraging technique. Using its "pig-like" snout, it turns over gravel and small rocks on stream bottoms to find immature insects for food and feeds on midges and caddisflies. It lives to be about six years old, which is longer than other darters.

A federally endangered species, the Roanoke logperch is threatened by pollution and habitat alteration throughout the drainage and is in danger of disappearing. Although it is not abundant, according to "Freshwater Fishes of Virginia", past surveys indicate that the largest population lived in the upper Roanoke River from the city of Roanoke into the lower reaches of its main forks. Smaller populations have also been recorded in the Pigg and Smith rivers.

The Roanoke logperch is considered a healthy water indicator and has also been seen in Stony Creek, a tributary of the Nottoway River, which flows into the Chowan River and ultimately into the Albemarle Sound. Stony Creek has been identified by INSTAR as one of the exceptionally healthy streams in Virginia.

Like other darters, the Roanoke logperch provides an important link between aquatic systems and is part of the food chain. It also provides clues about ancient river-drainage patterns. For example, the Chowan and Roanoke drainages, the only place where the Roanoke logperch has been observed, were probably part of the same drainage system 10,000 years ago, according to Jenkins.

WHERE ARE VIRGINIA'S HEALTHY WATERS?

Continued from page 7

Virginia's healthy streams include well-known natural treasures such as:

- **CLINCH RIVER** Sections of the Clinch River in southwest Virginia, one of the greatest hotspots of biodiversity in North America with more species of endangered and rare freshwater mussels than anywhere else in the world. (See sidebar page 20.)
- **ROANOKE DRAINAGE** Portions of the Roanoke drainage, known for the most distinctive freshwater fish communities on the Atlantic Slope of the United States (rivers and streams east of the Appalachian Mountains that drain into the ocean). (See sidebar page 12.)
- **DRAGON RUN** Dragon Run in the Piankatank watershed—one of the most pristine streams in the Chesapeake area. (See sidebar page 16.)

Based on INSTAR stream assessments, there are many more reaches of healthy streams that are not as well known. About 175 healthy stream reaches have been identified in the eastern half of the state, so far, and we expect to find many more from the mountains to the coast. Some are found in urban and agricultural areas, but most healthy streams flow through forested areas. In general, 10 to 15 percent of streams in the basins sampled exhibit very high ecological integrity – up to 25 percent in some areas. Surprisingly, this occurs in protected pockets in highly developed areas of Northern Virginia, unlike other urban areas where few healthy streams have been identified. (See Fairfax County sidebar page 24.)

Streams throughout the entire state will continue to be assessed and added to the database as resources become available. To supplement stream assessments, information about Virginia's watersheds is also available through INSTAR.

INSTAR classifies watersheds using a modified Index of Biotic Integrity (mIBI), which includes combined information about species collected at various locations within a watershed. This classification is not as geographically specific or as comprehensive as a stream assessment, but it can be used to prioritize watershed protection efforts. Watershed integrity is ranked as "outstanding," "very high," "high" or "moderate."

Continued on page 22

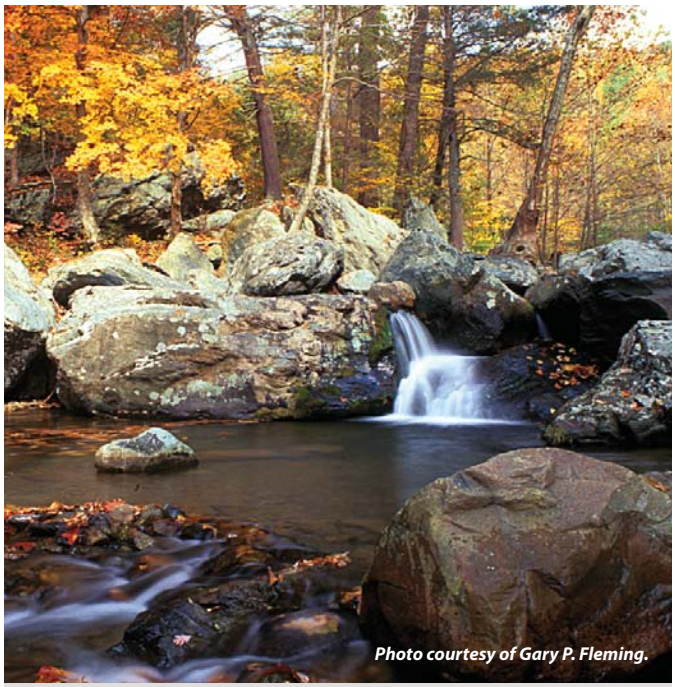


Photo courtesy of Gary P. Fleming.

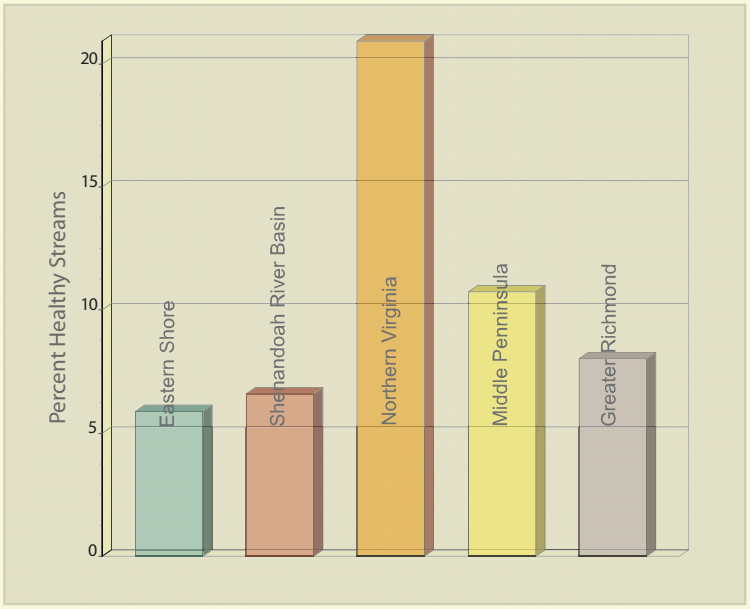
Of the stream sections sampled so far, about 30 are exceptionally healthy, representing the best in Virginia. These include:

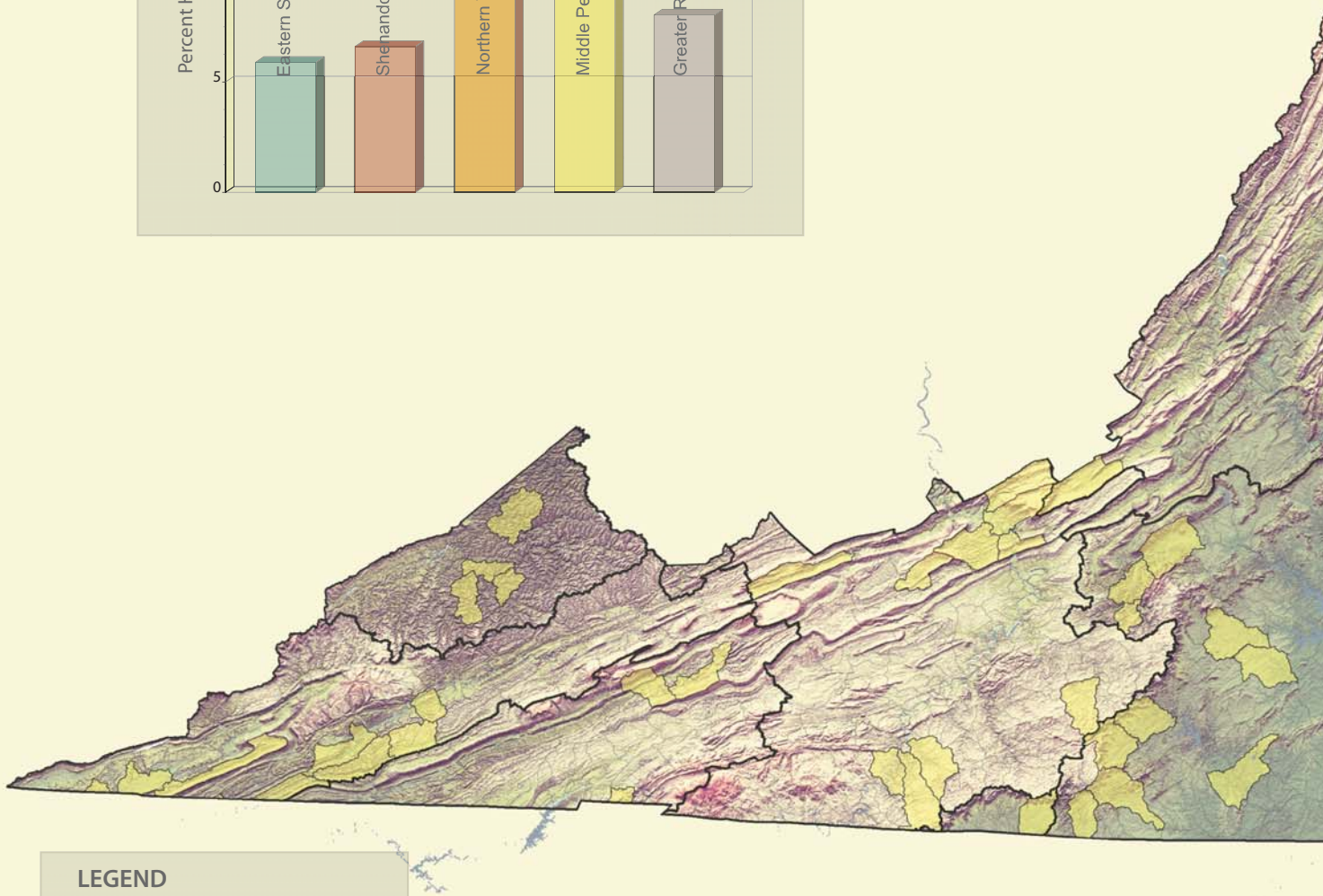
FAUQUIER COUNTY: MILL RUN
FREDERICKSBURG: CLAIBORNE RUN
HANOVER AND HENRICO COUNTIES: CHICKAHOMINY RIVER
KING AND QUEEN COUNTY: DRAGON RUN AND CHENEY BRIDGE SWAMP TRIBUTARY
LOUDOUN COUNTY: LITTLE RIVER AND BULL RUN
MADISON COUNTY: POPHAM RUN
PRINCE WILLIAM COUNTY: SOUTH FORK QUANTICO CREEK
RAPPAHANNOCK COUNTY: HAZEL RIVER
RICHMOND COUNTY: TOTOSKEY CREEK AND NORTH FORK RICHARDSON CREEK
STAFFORD COUNTY: WHITE OAK RUN
SUFFOLK COUNTY: JONES SWAMP TRIBUTARY
SUSSEX COUNTY: STONY CREEK AND HIGGENS CREEK

"An unexpectedly high number of Virginia's stream and river segments assessed by the INSTAR program since 2004 – up to 25 percent in some watersheds – are ecologically and biologically robust. These healthy streams represent a significant natural legacy for the Commonwealth and should be conserved using every tool at our disposal."

– Greg Garman, Director of the Center for Environmental Studies, Virginia Commonwealth University

STATUS OF HEALTHY WATERS IN VIRGINIA





LEGEND

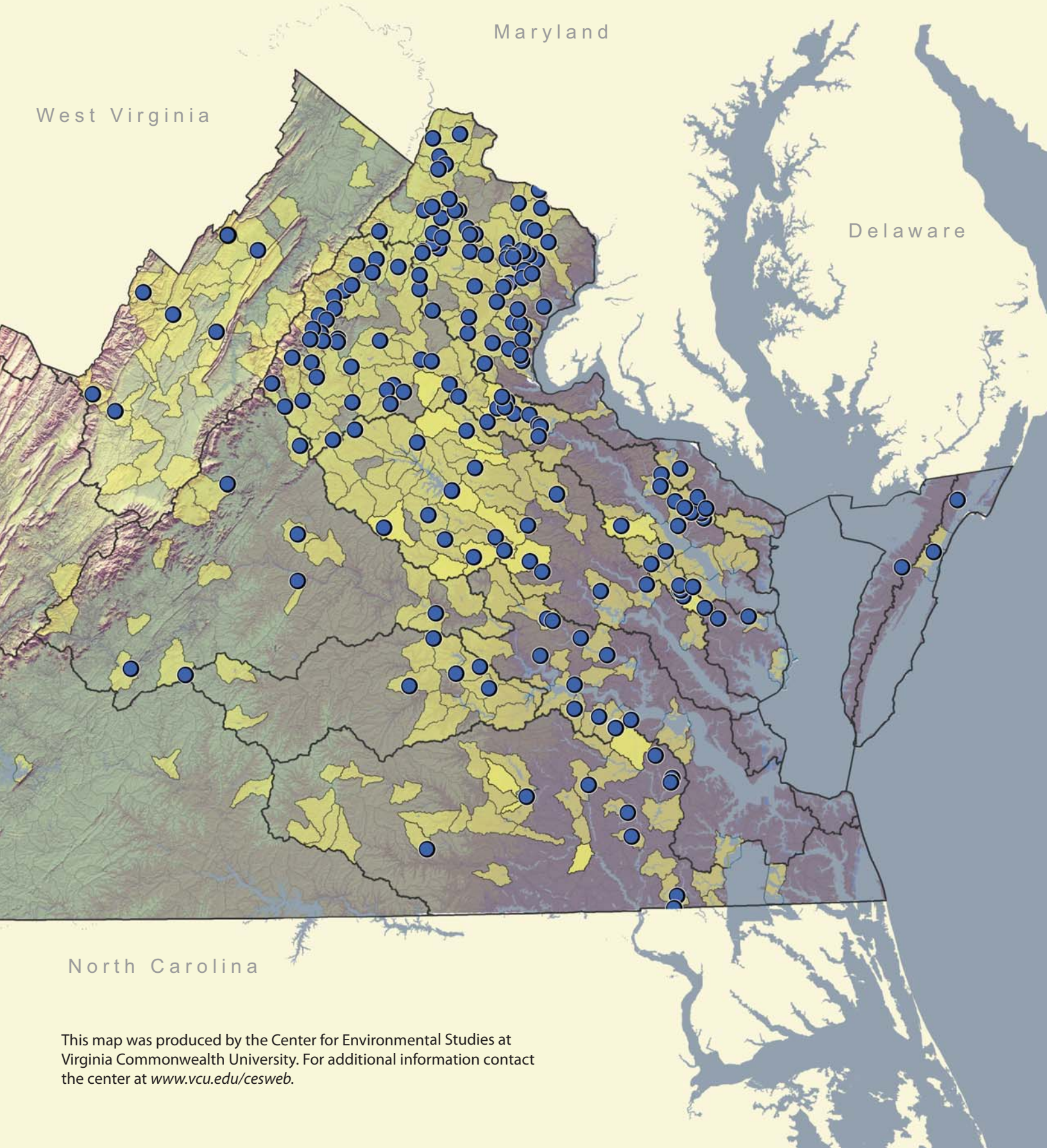
HEALTHY STREAMS

HEALTHY WATERSHEDS

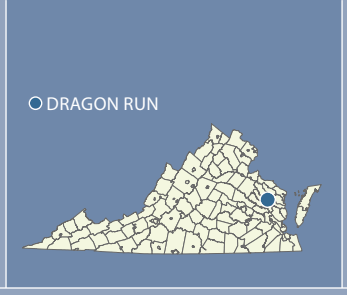
Miles

0 5 10 20 30 40

Based on INSTAR assessments, about 175 healthy stream reaches have been identified in the eastern half of the state so far. Streams throughout the state will continue to be assessed and added to the database as resources become available. Until then, information about Virginia's watersheds may be the next best indicator of healthy water locations. For more information about INSTAR, visit *http://instar.vcu.edu.*



This map was produced by the Center for Environmental Studies at Virginia Commonwealth University. For additional information contact the center at *www.vcu.edu/cesweb*.



DRAGON RUN

PRISTINE WILDERNESS PROTECTED BY FORESTS

Flowing through the largest block of forested land remaining in the Chesapeake Bay, sections of the "wild and beautiful" Dragon Run look much the same today as they did to colonial explorers. Identified by INSTAR as one of the healthiest rivers in Virginia, the river also supports an abundance of fish and wildlife, plants and ancient cypress trees.

"It's about as close to undisturbed as you'll get," according to Andy Lacatell, director of the Chesapeake Rivers Program for The Nature Conservancy. Throughout the watershed there are extensive tidal and nontidal wetlands. It's also the northernmost reach for bald cypress swamps. Some trees here are over 500 years old.

Located in the Middle Peninsula, "the Dragon" winds for 40 miles through King and Queen, Essex, Gloucester and Middlesex counties. Partially tidal, it feeds into the Piankatank River and then into the Chesapeake Bay.

Lacatell said the aquatic biodiversity is exceptional for a watershed the size of Dragon Run. Over 55 fish species have been observed here. These include freshwater game fish such as yellow perch, white perch, redbreast sunfish, chain and redfin pickerel, as well as migratory fish, such as American shad, blueblack herring and striped bass, that live most of the year in the Atlantic Ocean and make spawning runs up the river in the spring. There are very few non-native species and there are several rare species including darters and shiners.

Protecting the river and about 20,000 acres of forest and swamp in its watershed is one of The Nature Conservancy's top priorities for the Chesapeake area. "It's the best forest and one of the best rivers in that ecosystem," Lacatell said. "It's all related – good forest health means good water quality."

The natural ecosystem has survived primarily because the area is largely undeveloped – about 80 percent of the area is forested and the rest is primarily agricultural. Very few people live in the watershed, and there are only a few bridge crossings. However, Lacatell said its proximity to Richmond and Newport News may eventually attract more development, which could threaten its pristine nature.

"The ability to maintain the unfragmented character of the area is important," he said, explaining that "a 50 to 100 foot forested buffer will protect the adjacent waterway from the water quality degrading activities beyond it. But when you increase the buffer to 300 feet or more, you're also providing habitat for a range of species including bear, deer and turkey, and a large block of interior forest will support migratory birds by providing habitat for stopover and foraging."

The Nature Conservancy helps maintain riparian buffers and wildlife corridors primarily by purchasing large tracts of land and placing protective easements on them. "We currently own several properties in the watershed, mostly in forested areas around the tributaries and headwaters of the Dragon Run," Lacatell said. "The core area of the forest we hope to protect and restore encompasses about 20,000 acres."

Along with other conservation-minded groups, such as Friends of the Dragon Run, Virginia Outdoors Foundation

American Bald Eagle. Photo courtesy of VDGIF.

and state agencies, The Nature Conservancy also encourages landowners to voluntarily develop conservation easements that limit development and maintain forested buffers now and in the future, even if the property is sold. As a result of everyone's efforts, about 6,700 acres in the watershed are now protected.

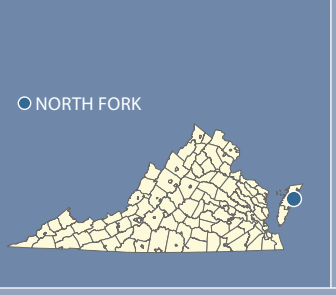
In addition, the Middle Peninsula Planning District Commission has developed a Special Area Management Plan that encourages easements, buffers, and best management practices for landowners. Three of the four counties bordering the river have adopted the plan, which was developed under the guidance of a Dragon Run steering committee that included representatives from the counties and advocacy groups.

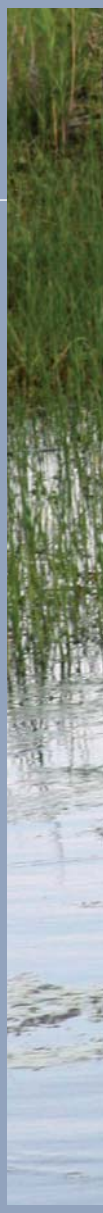
The Nature Conservancy is also collaborating with the Virginia Department of Forestry to return pine forests that were previously managed for pulpwood and saw timber to more natural woodlands. Initially, about 1,000 acres will be restored to a mix of hardwoods, followed by additional plantings in subsequent years. Lacatell said that eventually, the restoration should help to further increase the diversity of species in the watershed.

He noted that another reason the Dragon Run is in such good condition is because the landowners are "great stewards and control access to the river." There are only a few public access points and a small number of private landing areas, but it is possible to get out on the river. The Friends of the Dragon Run provides education-oriented kayak and canoe trips, and the Chesapeake Bay Foundation and the Rappahannock Community College offer trips for students.

ⓘ For more information, visit The Nature Conservancy website, *www.nature.org,* Friends of the Dragon Run, *www.dragonrun.org,* or the Middle Peninsula Planning District Commission, *www.mppdc.com.*

Dragon Run. Photo courtesy of John Hancock Mutual Life Insurance via Chesapeake Rivers Program, The Nature Conservancy.





NORTH FORK PARKERS CREEK

HOME TO RELICT FISH FROM THE ICE AGE

Located on the Eastern Shore of Virginia, North Fork Parkers Creek is a fraction of the size it once was before flooding occurred after the last Ice Age, according to Dr. Stephen McIninch, assistant professor of Environmental Studies at Virginia Commonwealth University.

McIninch explained that rising sea levels submerged much of the original watershed and left behind a relict fish population from ancient species that has survived in a significantly reduced drainage system.

"The fish in North Fork Parkers Creek are also very isolated," he said. "Their reproductive partners have been limited to that drainage for the last 10,000 years." That makes it difficult for the creek to rebound from natural or man related stressors, so it's remarkable that it has been identified by INSTAR as one of the healthiest streams in Virginia, he said.

"With most freshwater streams, if there's a fish kill, the river dries out, or the bugs are wiped out, you usually have fish downstream that can recolonize the population when conditions improve. You don't have that in freshwater streams like North Fork Parkers Creek that flow directly into the sea," he explained.

Since many freshwater species live for only one or two years and there's limited opportunity for recolonization in the creek, species can be eliminated in just a few years if the habitat becomes degraded. "The fact that Parkers Creek has a diverse community with a lot of species indicates that it has been stable for some time," he said.

About 14 species have been seen here, which is at least twice as diverse as other freshwater streams on the Eastern Shore, he said.

The presence of redfin pickerels and tessellated darters also indicates that the water quality is good because they don't tolerate salinity or environmental degradation. McInnich said too much silt from erosion and runoff would bury the darter's creek bottom habitat and affect instream vegetation, which the pickerel needs for spawning.

Other fish that live here include several species of minnows, pumpkinseed sunfish, pirate perch, banded killfish and other species common on the coastal plain.

Scientists are puzzled, however, about the unusual presence of the fat sleeper, first discovered here by McInnich. A small bottom-dwelling fish, its usual range is from North Carolina to Brazil. "It lives in and out of fresh and salt water with relative ease, but it's not built for long distance travel. It's amazing that they showed up in Parkers Creek," McInnich said.

The four-spined stickleback has also been observed in the creek. "That's another fish you don't see much. It can tolerate brackish water, but it doesn't travel long distances, either," he said. Virginia is the southernmost point of its range, which extends north as far as Nova Scotia.

McInnich said threats to North Fork Parkers Creek and other small streams on the Eastern Shore include rising water temperature and the intrusion of saltwater from rising sea levels. Since some freshwater streams on the Eastern Shore are spring fed, potential depletion of the aquifer by excessive water consumption is also a concern.

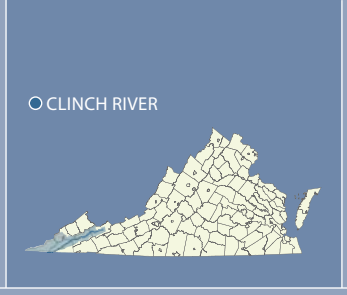
Along sections of creeks farther inland, the water temperature can be too warm for fish during the summer because streams tend to be shallow, and the water isn't shaded if the land is clear-cut to the banks. "Without a

nearby spring, the fish don't have anywhere to go to get to cooler water," he said.

Diverting creeks to irrigate fields and extracting too much water out of a stream also makes the water shallower and increases the water temperature. "The less water there is, the hotter the water gets, and the less likely the creek will be able to support fish and other wildlife," he said, adding that streams will dry up if too much water is lost to irrigation, evaporation or both.

In comparison, along the North Fork of Parkers Creek, trees and vegetative buffers provide shade and help cool the water. Buffers also stop runoff from rainwater that picks up pollutants as it drains over farmland toward waterways, and vegetation in the riparian zone takes up excess fertilizer, pesticides and herbicides before they reach the creek. Landowners along the creek are very conscious of the importance of buffers, he noted.

Fat Sleeper. Photo courtesy of Richard Laparé.
Above: Blue Heron. Photo courtesy of DCR.
Opposite page: Dragonfly. Photo courtesy of Irvine Wilson.



CLINCH RIVER

GLOBAL HOTSPOT FOR BIODIVERSITY AND ENDANGERED SPECIES

One of the greatest hotspots for biodiversity in North America, the Clinch River in southwestern Virginia has more species of endangered and rare freshwater mussels than anywhere else in the world and over 120 species of freshwater fish, according to Dr. Jess Jones, restoration biologist for the U.S. Fish and Wildlife Service.

Draining through the Appalachian Mountains across limestone, the nutrient-rich, well buffered water is home to about 43 species of freshwater mussels, the most endangered group of animals in the United States.

"It's globally important. All of Europe and most of the western states don't have that level of mussel diversity," Jones said.

He said the abundance of species is a result of the last big Ice Age, which peaked about 20,000 years ago. The southern part of the Appalachian Mountains was not glaciated and the ice sheets pushed vegetation and wildlife into the lake and stream valleys that form part of the Tennessee and Cumberland River basins, including the Clinch River.

In addition, species in the Clinch River valley remained relatively undisturbed during the westward expansion of pioneers during the 19th century. "It's a remote, rugged area with limited farmland. There are some industries, mostly mining and timbering, but it was never heavily settled so the streams escaped more serious destruction," he said.

In the last 30 years, however, as the Clinch River and its tributaries have become increasingly degraded by sedimentation and pollutants, 18 species of mussels in the river have significantly declined and are now listed as federally endangered including the dromedary pearlymussel, combshell, oyster mussel and cracking pearlymussel.
Jones explained that the Clinch flows through small mountain towns where at one time, wastewater was dumped unchecked into streams, and runoff from timbering and mining deposited pollutants and sediment into the water.

"Freshwater mussels are very sensitive to pollutants, especially ammonia and chlorine," he said. "They live in the stream bottom for 20 or more years and can't move out of the way of contaminants. … The young are almost microscopic. If water is contaminated, they won't grow."

Mussels can live over 70 years and are vital to stream health. They keep water clean by filtering out suspended particles and pollutants the same way oysters filter water in the Chesapeake Bay. They also convert organic matter into food for bottom-feeding insects, worms and crayfish, which in turn feed fish and other animals. Plus, they increase oxygen levels in the streambed just as earthworms help mix soil to keep it productive and healthy.

"Some of the species of mussels, such as the tan riffleshell in the upper Clinch River, are now found only in about 1,000 meters of stream – that's a really small and critically endangered population," Jones said.

Efforts in recent years to clean up the river are helping, and the situation is beginning to improve, he said. Although some houses in small towns still pipe sewage directly into the river, main sewage lines have been upgraded, and forest industries are providing buffers of trees and vegetation around streams to stop runoff from timbered areas.

In addition, the Virginia Department of Mines, Minerals and Energy and the U.S. Army Corps of Engineers are

A snuffbox mussel lures a logperch into its shell where larvae can attach to it. Photo courtesy of Unio Gallery (http://unionid.missouristate.edu).
Opposite page: Mussels from the Clinch River. Photo courtesy of Virginia Tech Mussel Lab.

working together to remediate abandoned mine sites and coal-refuse piles that continue to leach contaminants into streams. The agencies are constructing passive wetland treatment ponds and riparian buffers along the banks.

"These systems capture contaminants like a sponge and help neutralize them over time," Jones said.

He noted that the lower part of the Clinch is more pristine as it flows into Tennessee, but it is still affected by cattle and agriculture. "If they're not fenced out, cows can damage streams," he said. "They defecate and wallow in them and destabilize gravel beds, which isn't good for fish or mussels. They also trample banks, which allows more sediment into the water and that smothers fish and mussels."

Minimizing the impact of agriculture by encouraging farmers to follow the U.S. Department of Agriculture's best management practices has helped, he said. "Progress is being made, but it's an ongoing effort."

In collaboration with Virginia Tech and the Department of Game and Inland Fisheries, the U.S. Fish and Wildlife Service is trying to restore mussel populations by raising them at two mussel hatcheries – Tech's Freshwater Mussel Conservation Center and the Virginia Aquatic Wildlife Conservation Center near Marion. The facilities propagate eight to 10 species of endangered mussels each year. When they are about one-and-a-half years old, about 200 to 1,000 mussels, depending on the species, are returned each year to streams where water quality and habitat have been improved.

"Some species are harder to propagate than others, and we must also work with captive fish hosts," Jones said.

He explained that after the eggs are fertilized inside the shell, the resulting larvae need to attach to the fins or gills of a host fish. The larvae then burrow into the fish until they reach the juvenile stage and drop off.

The way mussels attract host fish varies. Some simply disperse their larvae into the path of fish and take their chances. Others, such as the critically endangered tan riffleshell mussel, use a more controlled method. Like a Venus flytrap, the riffle shell mussel captures host fish by tricking them into its open shell with a lure that mimics insects wriggling around. The mussel closes its shell around the fish so the larvae can attach to it; then the fish is released.

Different species of mussels use different host fish, and as species of fish in the Clinch River decline because of pollution or loss of habitat, it's more difficult for mussels to reproduce in the wild.

Currently, three species of fish in the Clinch are listed as federally endangered or threatened including the pygmy and yellowfin madtoms and the slender chub. These fish also serve as hosts to some of the endangered mussels.

"It's a tenuous life cycle that can be easily broken," Jones said.

ⓘ For more information visit Virginia Tech *www.fishwild.vt.edu/mussel*, Virginia Aquatic Wildlife Conservation Center *www.dgif.virginia.gov/awcc* and NatureServe Explorer *www.natureserve.org/explorer*

DEFINITIONS

RARE SPECIES Uncommon throughout their range and occur locally at a low density, making them difficult to find. They may or may not be listed as endangered.

THREATENED SPECIES An animal or plant species likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

ENDANGERED SPECIES An animal or plant species in danger of extinction throughout all or a significant portion of its range.

Definitions provided by the U.S. Fish and Wildlife Service.

HOW CAN WE PROTECT OUR HEALTHY WATERS?

Continued from page 13

The number of impaired waters in Virginia increases every year, adding to persistent problems as pollution enters the Chesapeake Bay and crosses state boundaries into North Carolina, Tennessee and Kentucky. To help protect healthy waters before they become degraded, we need to act quickly. Examples of successful efforts to protect streams are included throughout this publication. Local planners, developers, government officials and individuals are critical to the success of this approach and can protect healthy streams by incorporating the following measures into laws, local plans and ordinances, and personal actions:

Expand or create riparian buffers.

Plant or maintain buffers of trees or vegetation at least two to three times the stream width on both sides for as much of the stream length as possible. Vegetative corridors buffer streams from activities in the watershed by intercepting runoff that would otherwise transport sediment and other pollutants to the stream. This is the most effective measure for protecting streams if resources are limited. Buffers also serve as migration paths for semi-aquatic animals, such as frogs and other amphibians, and provide important habitat for other stream-dependent animals, such as the prothonatory warbler. (See James River Association sidebar page 5.)

Focus on headwater protection.

Headwater streams that flow intermittently in the upper reaches of a watershed are often ignored by regulations, but recent research shows that these 'zero-order' stream channels are extremely important to the natural function of downstream waters. Be sure to include them in protection efforts – the entire watershed matters.

Maintain natural stream flow.

Regulatory agencies are recognizing that maintaining natural flow regimes and channel geomorphology, and limiting water withdrawal for off-stream uses such as irrigation is important to stream health. The natural, seasonal pattern of stream flow, the stream's response to storm events, and maintaining minimum flow levels may be as critical to a stream's ecosystem as water quality. (See North Fork Parkers Creek sidebar page 18.)

Avoid biopollution.

Intentionally or unintentionally introducing non-native, exotic and potentially invasive species is "biopollution" and may be just as damaging as chemical toxins to the structure and function of healthy streams. Monitor the distribution of non-native species and develop control programs to keep native species dominant in stream and river communities. Examples of non-native species in Virginia include the European brown trout introduced for recreational anglers, hitch-hiking zebra mussels from the Black Sea, and hydrilla plants from the Amazon. (See Brookie sidebar page 26.)

Keep farm animals and equipment out of streams.

Provide barriers to keep cows and other farm animals out of streams to reduce organic pollution, fecal bacteria and destruction of habitat on stream banks and in stream bottoms. Keep heavy equipment out of streams for the same reasons and to prevent pollution from leaking oil, gasoline and other chemicals.

"While Virginia is deemed to be a water-rich state, less than 1 percent of existing shoreline is publicly accessible. If people can't get to the water resources and can't use them, people won't grow a love for them. When people love what they can use and enjoy, they will want to protect it."

– John Davy, Planning and Recreational Resources Director, Virginia Department of Conservation and Recreation

Control nonpoint source pollution and stormwater runoff.

Manage land use near streams and limit impervious surfaces, such as roads, rooftops and parking lots, to less than 10 percent of the watershed. When stormwater washes off impermeable surfaces, it transports excess sediments, nutrients, hydrocarbons, metals and other pollutants directly into streams. It also increases thermal pollution. Maintaining a high percentage of permeable surfaces, such as forests, can slow down and absorb stormwater. The forest ecosystem can also convert stormwater pollution into less harmful forms and help reduce the amount of damaging energy exerted on the bed and banks of stream channels as excess stormwater courses downstream. There are many other tactics and best management practices (BMPs) for controlling stormwater runoff, but limiting impervious surfaces is one of the most effective methods. (See Fairfax County sidebar page 24.)

Participate in advocacy efforts.

Individuals can use INSTAR and related information tools to identify healthy streams in their communities and voice the need to protect local healthy waters to elected representatives and policymakers at the local city and county levels. Residents can also help by participating in organized stream-walks, riparian plantings and other activities to develop local awareness and stewardship of healthy streams. (See James River Association sidebar page 5.)

Provide access to healthy waters to develop pride and stewardship.

Providing access to healthy streams and encouraging responsible activities in, on and around the water will help build a clientele for healthy waters. Nourishing a sense of ownership, pride and stewardship will help ensure that healthy streams are there for the next generations to enjoy, protect and preserve.

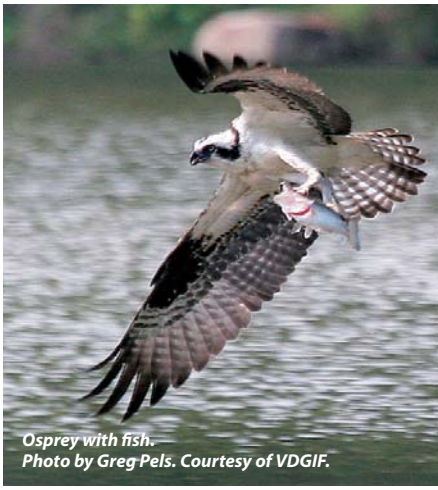
Incorporate healthy waters into regulations and planning efforts.

Local officials and planners can integrate known healthy waters and their conservation into existing codes and regulations and make healthy stream protection a priority in comprehensive planning. They can also adopt and require compliance with Better Site Design principles with special emphasis on penalties for noncompliance or extra requirements for development near designated healthy waters. Better Site Design is a set of model principles to protect streams, lakes and wetlands. It also identifies areas in codes and standards that can be changed to provide better protection for waters by reducing impervious surfaces. (See Fairfax County sidebar page 24.) Additional information is available from DCR, Chesapeake Bay Local Assistance: *www.dcr.virginia.gov/chesapeake_ bay_local_assistance/bsd.shtml.*

Become a healthy water steward.

Individuals can become healthy water stewards through landscaping and proper use of fertilizer and lawn chemicals and by encouraging their neighbors to do the same. For other suggestions and ideas, see the list of resources in the back of this publication and visit the Healthy Waters website at *www.dcr.virginia.gov/healthywaters.*

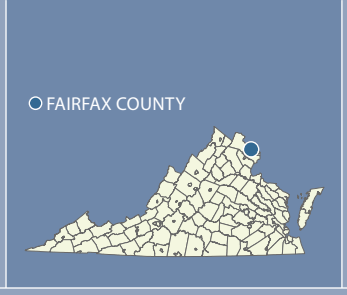
Providing access to healthy streams is important. Photo courtesy of Bill Crabtree Jr., Virginia Tourism Corp.



Osprey with fish. Photo by Greg Pels. Courtesy of VDGIF.

"Friends of the Rappahannock successfully worked with Stafford County on a code revision process that incorporated measures to strengthen the protection of streams and their riparian areas. . . .It was a three-year process that involved developing a relationship with the locality, understanding the path of development that the locality wished to establish, and then working together to develop the appropriate code language."

– John Tippett, Executive Director, Friends of the Rappahannock



FAIRFAX COUNTY
SUCCEEDS IN PROTECTING HEALTHY STREAMS

Fairfax County, the most populous county in Virginia, has a surprising number of healthy streams for an urban area, according to biological studies recently conducted through INSTAR, an Interactive Stream Assessment Resource developed by the Center for Environmental Studies at Virginia Commonwealth University.

Dr. Greg Garman, center director, said that when the Fairfax streams were compared to model reference streams, over 15 percent of the streams evaluated were ecologically healthy in terms of habitat and the number and diversity of fish and bugs. (See related sidebar page 10.)

Garman said, "The percentage of healthy streams in many parts of Northern Virginia is unexpectedly high, compared to other urbanized regions of the state, including Tidewater and Metro Richmond."

At least part of the explanation, according to Fred Rose, Chief of the Watershed Planning and Assessment Branch for Fairfax County, is that the county adopted land-use restriction measures and stringent water quality requirements over 20 years ago to protect and clean up its creeks, streams and lakes, which ultimately provide drinking water for more than 1 million residents.

Bryant Thomas, Regional Water Permits and Planning Manager for the Virginia Department of Environmental Quality, agreed. "Fairfax is at the forefront nationally for water quality and stormwater management practices," he said.

Another factor, according to Thomas, is the Upper Occoquan Sewage Authority (UOSA), an advanced regional sewage treatment facility that opened in 1978 and eliminated 11 major sources of pollution from older sewage treatment plants. He noted that since then, UOSA has maintained state-of-the-art levels of effluent – treated water discharged into the Bull Run River.

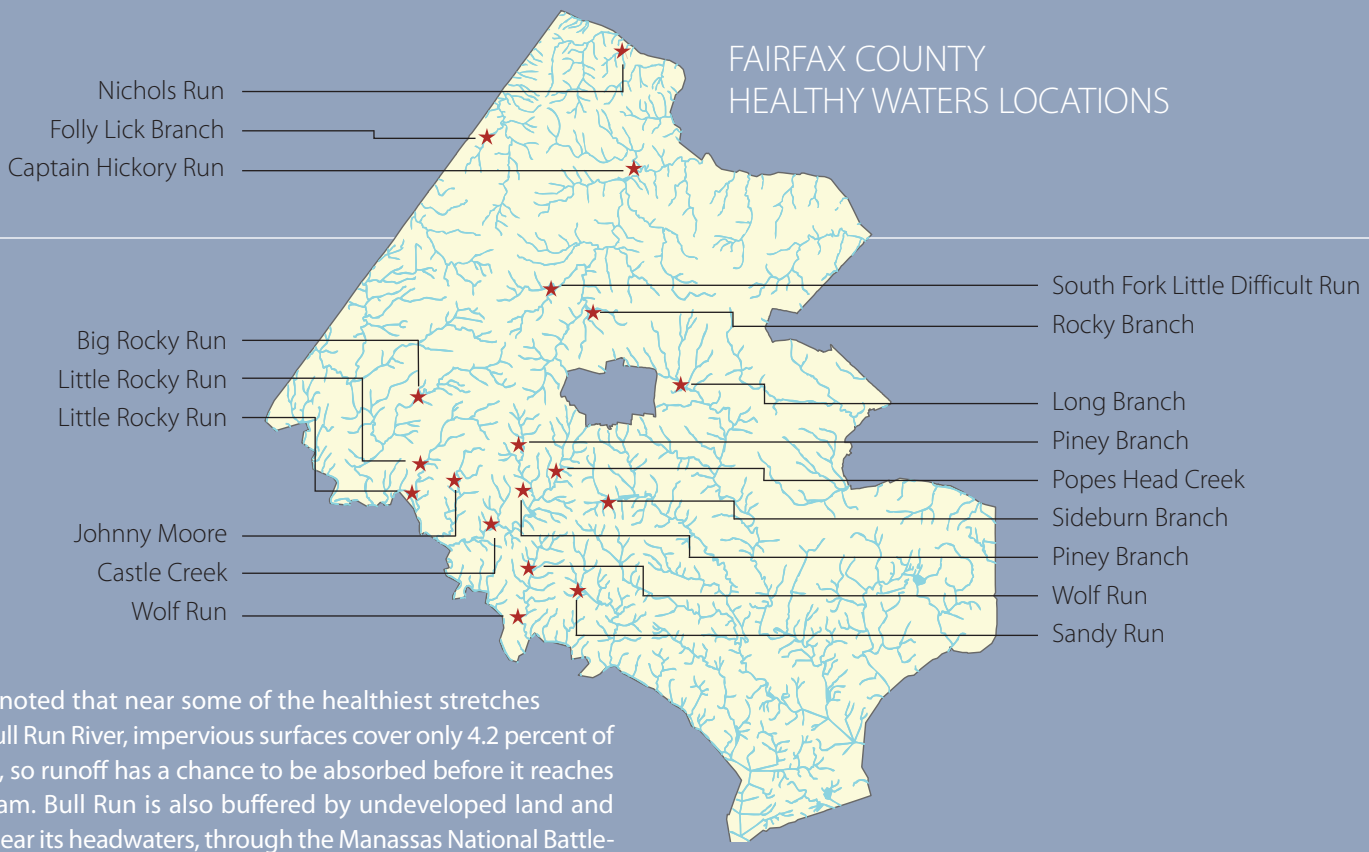
But in 1982, excess nutrient pollution from urbanization had reached an alarming level in the Occoquan Reservoir, which supplied drinking water for half the county. "It was a matter of public health, and the county had to control it," Rose said.

To combat the problem, Fairfax developed a Watershed Supply Protection Overlay District that restricted new development to one dwelling per five acres in portions of the watersheds that flow into the reservoir. Rose said the requirement protected two-thirds of the area south of Route 29, west of Route 23 and north of the Bull Run River that had not yet been developed. A majority of the county's healthy streams identified by INSTAR are in this area.

"It was very controversial….We were taken to court by developers," he said. The county won in a landmark decision.

Fairfax was also one of the first counties to develop best management practices for controlling nonpoint source pollution from storm runoff. As a result the county succeeded in reducing phosphorus levels from new development in the Occoquan watershed by 50 percent and elsewhere in the county by 40 percent. Phosphorus primarily comes from excess fertilizer that washes off yards and fields during storms.

Rose explained that the county requires developers to demonstrate how runoff will be treated or controlled before projects are approved. Developers can choose from a variety of options that include creating wetland marsh ponds where vegetation can stop contaminants and take up excess nutrients before they reach streams, or best management practices, including limiting use of impervious areas, such as paved roads and parking lots, or by a variety of other techniques.



He also noted that near some of the healthiest stretches of the Bull Run River, impervious surfaces cover only 4.2 percent of the area, so runoff has a chance to be absorbed before it reaches the stream. Bull Run is also buffered by undeveloped land and forests near its headwaters, through the Manassas National Battlefield Park and along an 18-mile hiking trail that winds along the river from Bull Run Regional Park to Fountain Head Regional Park.

"Hiking along the trail, you'll forget you're in Northern Virginia," Thomas said.

Like other jurisdictions in the Chesapeake Bay watershed, Fairfax must also comply with the Chesapeake Bay Preservation Act, enacted in 1993, which requires 100-foot buffers around perennial streams in designated Resource Protection Areas to stop runoff from entering the water before new construction can be authorized. Perennial streams flow year-round and are indicated with blue lines on U.S. Geological Survey (USGS) quadrangle maps.

The regulations are very strict, Rose said. "Even at an existing residence, you can't cut trees or build decks or additions near a perennial stream without submitting a formal request for approval or going through a hearing process."

In 2003, to further protect its water, Rose said Fairfax County voluntarily increased the number of perennial streams that fell under the Resource Protection Area requirements by a third. Instead of using USGS maps, the county began identifying perennial streams with a more scientific protocol through stream assessments based on biological indicators and habitat, similar to INSTAR assessments. Fairfax County's protocol has since been adopted as a recommended state standard by DCR's Chesapeake Bay Local Assistance Program.

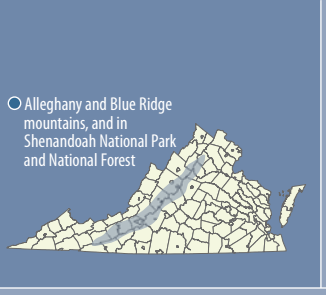
Fairfax also conducted a comprehensive physical assessment of each stream that looked at habitat in detail, including dump sites, erosion, substrate alterations, etc. The county is currently developing watershed management plans to help rehabilitate degraded streams. Depending on each stream's situation, Rose said measures may include additional stormwater controls, buffer restoration projects, dump site removal and Low Impact Development (LID) techniques, such as installing rain gardens, green roofs, rain barrels, etc.

Garman said counties that do not have the resources to conduct their own stream studies may use stream assessment information available through INSTAR to help evaluate streams and prioritize their local planning efforts.

Rose said Fairfax County also "deliberately educates the public" about how to protect streams. This helps gain public support and develops advocates for the county programs. Each watershed planning project also has an advisory group comprised of homeowners and representatives from environmental groups, schools, highway officials, parks, businesses, and other stakeholders who provide input on plans for their areas.

The county also organizes neighborhood stream cleanups and provides seasonal information through radio advertisements about using fertilizer, cleaning up after pets, dumping motor oil and other tips.

Since 2005, increased funding for its efforts is provided from county real estate taxes based on one penny for every dollar of assessed property value. That generates an average of about $20 million a year.



PROTECTING THE BROOKIES

The idea of healthy waters almost always conjures up the image of fast-flowing cold mountain streams and the beautiful, wild and elusive brook trout, *Salvelinus fontinalis*, Virginia's state fish and the passionate pursuit of dedicated anglers.

Larry Mohn, fisheries manager for the Virginia Department of Game and Inland Fisheries, said the brook trout is a well-known indicator of healthy waters: "Streams have to be relatively pristine, or they wouldn't have the 'brookie.'"

In Virginia, trout streams are found at high elevations in the Alleghany and Blue Ridge mountains and in Shenandoah National Park and National Forest. They're also in the Blue Ridge plateau, mostly on private land in Floyd, Carroll, Patrick and Grayson counties.

Although the brook trout is not a rare, threatened or endangered species, it is a species of concern. "We've lost about 90 percent of the historic trout population to sedimentation and temperature changes," Mohn said. Acid rain is also a threat.

Sedimentation resulting from poor logging techniques, removal of streamside vegetation, and agriculture in riparian areas was a bigger problem in the past than it is today since better land management practices have been adopted, he said.

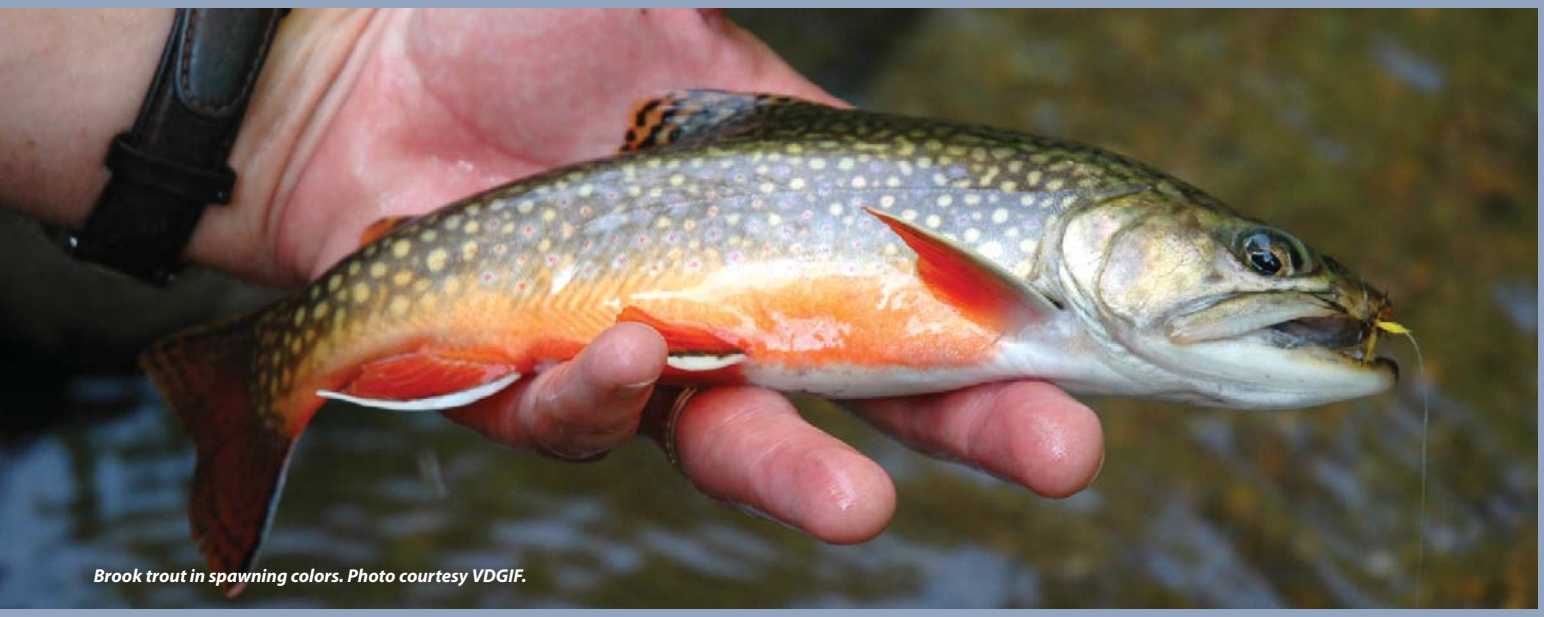
When silt covers stream bottoms, it destroys habitat for insects that live in the crevices of rocks and pebbles. That means less food is available for trout. Sediment also affects trout reproduction. Trout lay their eggs in shallow gravel nests on stream bottoms where highly oxygenated water can constantly move over the eggs. If they're covered with as little as one-quarter inch of silt, the eggs will die. Global warming and rising water temperature pose a potentially greater threat – trout streams must remain below 70 degrees Fahrenheit. With Virginia's warm weather, Mohn said most trout streams are already borderline, ranging from 68 to 70 F in summer months.

Alteration of stream channels may also raise water temperatures and eliminate fish cover. "Trout need undercut banks, large rocks or submerged logs for cover, and if that's removed, the trout will leave. The amount of suitable cover in a stream also affects the number of large trout a stream can support," he said.

Streams are also affected by acid rain formed when sulfur and nitrous oxides – windborne pollutants that originate mostly from coal-fired power plants in the Ohio Valley – mix with precipitation that falls in Virginia.

In the late 1990s, the St. Mary's River around Lexington and Staunton had become so acidic, "it was down to the last few trout," Mohn said. Liming improved the water quality, and native brook trout, other fish and invertebrates have begun repopulating the river. An additional liming was necessary six years after the first application and will need to be repeated periodically.

Since trout fishing is one of Virginia's most popular outdoor sports, creel and size limits help protect brook trout from fishing pressure. According to Mohn, 99 percent of the fishermen who catch native brook trout want to help protect them and voluntarily release any they catch.
Around the 1930s, when trout populations began to decline, DGIF and the U.S. Fish and Wildlife Service started stocking streams with non-native rainbow trout and Euro-



Brook trout in spawning colors. Photo courtesy VDGIF.

pean brown trout to enhance sport fishing. Now, Mohn said, rainbow and brown trout are stocked only in waters that are not suitable for native trout.

"Ten years after rainbows are introduced, there's usually nothing left but rainbows," he said, explaining that in the Mount Rogers area, rainbow trout have completely taken over the streams. "They out compete brookies for food and space, and they're better at reproduction," he said.

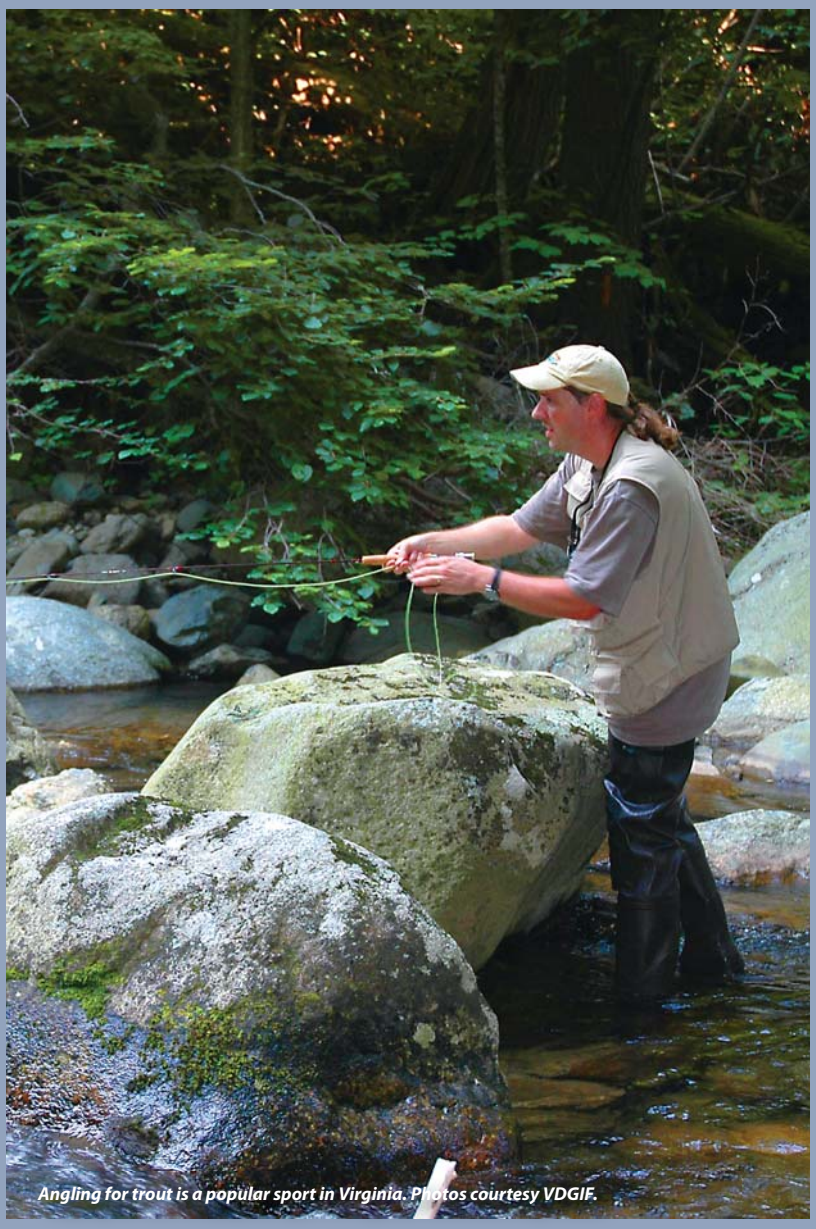
"European brown trout prey on the brook trout, but overall the native population where they've been introduced has not been too badly impacted. It remains about the same," he said.

According to DGIF, Virginia has more native brook trout streams than all southeastern states combined. About 1,800 miles, or 80 percent, of Virginia's trout streams are still populated exclusively with the native brook trout.

To help boost native trout populations, DGIF recently started stocking native trout streams with wild brook trout taken from existing populations instead of using hatchery fish. "Wild characteristics are bred out of hatchery fish so they don't fare as well," Mohn explained.

In addition to restocking efforts, DGIF is attempting to restore native trout populations in spring fed creeks in the Great Valley from Winchester to Bristol along the I-81 corridor, where the last 'brookie' was seen in 1965.

ⓘ For more information, visit *www.dgif.virginia.gov.*



Angling for trout is a popular sport in Virginia. Photos courtesy VDGIF.

RESOURCES
FOR INDIVIDUAL STEWARDSHIP EFFORTS

HOME AND YARD TIPS:

VIRGINIA DEPARTMENT OF CONSERVATION AND RECREATION has two publications available online:
A Virginian's Year-Round Guide to Yard Care: Tips and Techniques for Healthy Lawns and Gardens
www.dcr.virginia.gov/soil_and_water/documents/yardcare.pdf
Tips on Keeping Your Lawn Green and Virginia's Waters Clean:
www.dcr.virginia.gov/soil_and_water/documents/tipsstate.pdf

THE CHESAPEAKE BAY FOUNDATION offers suggestions for home and yard landscaping and maintenance efforts at:
www.cbf.org/Document.Doc?id=59

ALLIANCE FOR THE CHESAPEAKE BAY provides toolkits, advice and instructions for installing and using rain barrels to minimize stormwater runoff, minimizing pollution from household cleaners, reducing air pollution and other homeowner efforts at: *www.acb-online.org/toolkits.cfm*, and *www.acb-online.org/pubs/projects/deliverables-146-3-2003.pdf*

THE EPA CHESAPEAKE BAY PROGRAM suggests how individuals can help at home, on the water, on the road, at work, at school and in their backyards at: *www.chesapeakebay.net/helpthebay.aspx?menuitem=14796*

HOW TO INFLUENCE DEVELOPMENT IN YOUR COMMUNITY:

THE CHESAPEAKE BAY FOUNDATION offers a comprehensive citizen guide for effective advocacy efforts at:
http://www.cbf.org/Page.aspx?pid=537

OTHER RESOURCES:

For additional information and links to more resources and advocacy groups,
visit the Healthy Waters website at *www.dcr.virginia.gov/healthywaters.*

HEALTHY WATERS

HEALTHY WATERS IS A MULTI-AGENCY INITIATIVE ADMINISTERED BY:

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HEALTHY WATERS

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