In Maryland Survey, Stream Dwellers Decide What's Healthy

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Carrying electrofishing gear on their backs and wearing rubber waders on their feet, Scott Stranko and Tony Prochaska waded into Parkers Creek. Their aim was to stun and identify every fish, frog and stream dweller in a 75-meter stretch of the stream on Maryland's Western Shore. Quickly, the two Department of Natural Resources biologists had their first unique find: Prochaska pulled a 4-inch fish from the stream.

"That's pretty much a record-size eastern mudminnow [*Umbra pygmaea*]," he declared. "They don't get very big. That's a wall-hanger for a mudminnow."

After years of wading into hundreds of Maryland streams, Stranko, Prochaska and other biologists have gotten to know their fish—and streams—well. They are part of the DNR's Maryland Biological Stream Survey, which for the past few years has examined nearly 1,000 stretches of state waterways to determine the "state of the streams."

Unlike traditional water monitoring programs, which focus mainly on chemical pollution, the survey rates waterways based on what their inhabitants have to say. It has produced stacks of scientific reports about the state's 17 major drainage basins, and has just released a reader-friendly summary, *From the Mountains to the Sea: The State of Maryland's Freshwater Streams*, detailing their findings.

The fish and other stream dwellers have a lot to complain about: More than half of Maryland's 9,000 miles of nontidal streams are in bad shape. According to the survey:

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- Survey crews judged habitat in 51 percent of the state's stream miles as being either poor or very poor.
- Populations of insects, clams and other bottom-dwellers—good indicators of a stream's health—were also in poor or very poor condition in 51 percent of stream miles.
- Fish populations were considered to be good or fair—the top ratings—in just 45 percent of stream miles.

Not all the news was bad: Survey teams found one fish thought to have vanished from the state, the stripeback darter (*Percina notogramma*).

But the finding that so many streams are in poor health has surprised many. "A lot of people thought our streams were in better shape than they are," said Ray Morgan, a professor at the Appalachian Laboratory of the University of Maryland's Center for Environmental Science, who helped to design the survey.

The conclusions should not be surprising, he and others say. Three centuries of changing land uses have dramatically altered the state's landscape: Once 95 percent forested, only 80 acres of virgin forest remains.

The remainder of the land has been farmed, logged, paved and bombarded by acid rain. Streams still show the scars. Most have unnaturally high nutrient levels. In fact, the survey concluded that there are no "pristine" streams in the state, although a few dozen high quality waterways are still around.

"We certainly don't think the health of our streams today is anything like it was before European settlement," said Ron Klauda, the DNR scientist who oversees the survey. "It almost scares you a little bit to report some of these results."

Survey results also show development is particularly harmful to streams. No watershed with more than 15 percent "impervious cover"—such as roofs, roads and parking lots—was rated in "good" biological condition. Some creatures are far more sensitive: No brook trout (*Salvelinus fontinalis*) were found in a stream watershed with more than 2 percent imperviousness.

Maryland's situation is not unique. In the United States, almost all streams could use some rehabilitation. Nearly 20 years ago, the EPA and the U.S. Fish and Wildlife Service concluded that 81 percent of the nation's fish communities were negatively impacted in some way. Half of the nation's streams, they said, suffered from habitat degradation.

But Maryland's survey provides one of the most thorough examinations of stream condition available. James Karr, director of the University of Washington's Institute for Environmental Studies, a leading national advocate of using biological indicators to measure stream health, called it "one of the best, probably even the best, state level analysis that I have seen."

The survey's findings are a sobering preview of what's ahead for the Bay Program as it "moves upstream." Its draft Chesapeake 2000 Bay Agreement, expected to be signed this summer, has several commitments aimed at protecting and restoring stream corridors.

The agreement envisions restoring not only the Bay, but pledges to help migratory fish by ensuring that "suitable water quality conditions exist in the upstream spawning habitats upon which they depend." The Maryland survey suggests that job will be enormous.

Traditional water quality monitoring programs are based mainly on measuring the amount of chemicals in a stream. But chemical testing alone is only part of the story. Fish and water-dwelling insects may react less to individual chemicals than to the whole range of pollutants and other stresses—such as degradation and loss of physical habitat.

"We often don't see single chemical impacts," Morgan said. "It is a multitude of chemicals in some places. The biotic community is the best thing to look at because that's the integrator of the watershed. It tells you what is going on in the watershed above that sampling point."

To get that picture for streams across the state, a computer randomly selected hundreds of stream sites to be surveyed by Prochaska, Stranko and others.

With lists of stream sites in their pockets, the biologists—electrofishing equipment strapped on their backs and global positioning systems in their hands—tracked down owners for each site, secured permission to examine the stream (88 percent said yes) and proceeded to study a 75-meter stretch of water.

On some days, survey teams worked in clear mountain streams. Other days, the computer sent them wading through overgrown Coastal Plain streams, where they sometimes hacked their way through overhanging briars with machetes in 95 degree heat and 100 percent humidity.

On still other days, they would stand in the midst of an urban stream with broken sewer lines discharging straight into the water, or—perhaps even worse—pipes spewing unidentifiable orange goo. One fenced-in stream outside Washington was particularly disgusting: "Homeless people were going to the bathroom in bags and throwing it over the fence," Stranko said.

On those days, crews added rubber gloves to their gear.

Once in the water, their electrofishing equipment allowed them to stun, identify and examine every fish, amphibian or reptile in the stream.

Standing in Parkers Creek, Stranko and Prochaska not only found the record-size eastern mudminnow—the most common fish in Coastal Plain creeks—but also American eel (*Anguilla rostrata*), a brown bullhead catfish (*Ameiurus nebulosus*), golden shiner (*Notemigonus crysoleucas*), redfin pickerel (*Esox americanus*), pumpkinseed (*Lepomis gibbosus*), least brook lamprey (*Lampetra aepyptera*), and creek chubsucker (*Erimyzon oblongus*). "Not bad at all," Stranko declared of the eight-species catch. In addition, they netted a bullfrog and pickerel frog.

Then, donning sunglasses to mute the glare, they turned their eyes to the benthic macroinvertebrates—insects, clams and other stream-bottom dwellers (often called "benthos"). They skimmed the water and sediment with a net, then pored through the catch like kids examining a trick-or-treat bag.

They found nothing remarkable, although the contents included some hellgrammite larvae, an immature dobsonfly which can indicate a relatively healthy stream. Most of the benthos were packed off to a lab for further identification.

They surveyed the ground for five meters on either side of the stream for reptiles and amphibians and found none.

Then they turned their eyes to the stream itself: Its banks showed some signs of erosion, though not too serious. The bottom of the stream still had a good amount of exposed rocks and other solid surfaces, which are important habitat features. The streamflow was slow—in part because conditions had been dry, and in part because Parkers Creek is on the relatively flat Coastal Plain.

"Coastal Plain streams get a bad rap because they're turbid and stagnant looking," Stranko said. "They're not as impressive as a fast-flowing mountain stream." **cont. on p. 13**

Healthy Streams/Healthy Inhabitants

Findings of the Maryland Biological Stream Survey

Capt. John Smith described the Chesapeake watershed as a "*delightsome land with clear rivers and brookes running to a faire Bay.*"

He didn't do any scientific monitoring of those streams. But it's a safe bet that today's waterways have been dramatically altered from what the Bay's first explorer saw.

In fact, the Maryland Department of Natural Resources' Maryland Biological Stream Survey concluded in a report summarizing its comprehensive, three-year, stream review that "no truly pristine streams exist in Maryland today."

Except for about 80 acres, Maryland's entire landscape has been changed since Smith's observation: The land has been logged, farmed and built upon; its rivers and streams dammed, straightened—even buried. Acid rain and other pollutants strike even the most remote areas from the air.

The survey grew out of the Department of Natural Resource's acid rain monitoring program, which is funded by a surcharge on utility bills to assess environmental impacts of power generation. Under that program, scientists were able to document that streams in parts of the state were becoming more acidic because of air pollution.

But while they could observe changing stream chemistry, scientists had difficulty saying how acid rain was affecting stream biology: When they saw problems, they often couldn't tell whether they stemmed from acid rain or something else.

That gave birth to the statewide stream survey. It gives scientists and officials a comprehensive baseline of what streams looked like in the mid-1990s. They can characterize what constitutes healthy—and degraded—streams for each region. Using that as a yardstick, future surveys can show whether streams are getting better or worse.

"We don't have a lot of good historical data about where we've been. It's a shame," said Ray Morgan, professor at the Appalachian Laboratory of the University of Maryland's Center for Environmental Science, who helped design the survey.

The sampling techniques used were field tested before the survey began, and peer reviewed by other scientists. So were the criteria used for development of the IBIs—Index of Biological Integrity—which measures the ability of a stream to support and maintain a balanced, integrated adaptive community of organisms which have a species composition, diversity and functional organization comparable to that of the natural habitat of the region.

To develop IBIs, the survey selected reference sites at minimally impacted sites in each geological region of the state to represent natural habitats. During the survey, sites were evaluated based on how they compared to the reference conditions.

Rigorous sampling techniques led to scientifically defensible conclusions that can be used by decision makers. "It's very, very defensible in court," Morgan said.

Also, the random sampling technique allows scientists to extrapolate results to streams over the entire state, similar, in a sense, to the way a poll samples public opinion. For example, based on survey results, scientists could estimate the populations for each of the 83 fish species found in nontidal streams. Combining all species, the survey estimated there was an average of 10,325 fish per mile in wadeable Maryland streams.

"There are a lot of states looking at us, and they're very envious," Morgan said. But, he added, such a detailed survey was possible in Maryland because of its small size: It has only about 9,000 miles of freshwater nontidal streams. Pennsylvania, by contrast, has more than 80,000 miles, making such a program "a logistical nightmare," he said.

Selected Survey Results

❒ **Combined IBIs** A scale was established that rated all sites as good, fair, poor or very poor. Only 12 percent of all stream miles in the state are in good condition based on both the fish and benthic macroinvertebrate IBI. Another 42 percent were fair, and the rest were poor.

❒ **For Benthos** 49 percent of stream miles fell into the range of good to fair, while 51 percent showed signs of degradation. The West Chesapeake had 70 percent of its stream miles rated very poor, while the Susquehanna had no sites rated very poor.

❒ **For Fish** 45 percent of stream miles were considered good to fair, while 29 percent were poor or very poor. Another 26 percent of stream miles were too small to contain fish, and were not rated. Of the 17 basins, the Elk was the best, with 38 percent of stream miles rated as good.

Land Use Relationships

For all of the basins combined, fish and benthic IBI scores decreased with increasing urban land use. No stream with more than 15 percent impervious cover (low density development) was ever rated as good. All sites with more than 50 percent of the watershed in urban land use (high density development) had IBIs that were either poor or very poor. Sites with a good IBI score had an average of 4 percent urban land use, compared with a statewide average of 9 percent urban land use.

Fish IBI scores tended to increase in agricultural areas. No one is certain why. It could be that nutrients in the freshwater systems are increasing the food supply for fish. Or, it could reflect that many fish populations, unable to survive in nearby developed areas, are being displaced into agricultural areas. Benthos fared well in forested streams that were not impacted by acidity.

Acidity

About 18 percent of Maryland's stream miles are sensitive to acid rain. Natural acidification, mainly in blackwater streams on the Eastern Shore, affect about 3 percent of the state's stream miles, while acid mine drainage affects another 3 percent. Fertilizer runoff acidifies another 4 percent of stream miles.

Acidity is measured on a pH scale of 1-14, with 1 being strongly acid, 14 being strongly alkaline and 7 neutral. Because pH is measured on a logarithmic scale, pH 5 is 10 times more acidic than pH 6, and 100 times more acidic than pH 7.

Except for those with natural acidity, streams with a pH below 5 had no fish, while streams with a pH higher than 6 averaged more than 9,000 fish per mile. Streams with a pH between 5 and 6 averaged 500 fish per mile.

Seventeen fish species were absent in acid-sensitive streams—those with low amounts of limestone and other natural buffers to acidity—and 44 other species were less abundant. On the average, acid-sensitive streams had 135 fewer fish per mile than well-buffered streams.

The blacknose dace (*Rhinichthys atratulus*), the most common species in Maryland streams, was among the most sensitive to acidity. Other species that are very sensitive to acidity are the mottled sculpin (*Cottus bairdi*), rosyside dace (*Clinostomus funduloides*), bluntnose minnow (*Pimephales notatus)*, and creek chub (*Semotilus atromaculatus*).

Physical Habitat

The condition of biological communities is directly related to physical habitat quality. Sedimentation, stream channelization, impoundments, urban development, timber harvesting, agriculture, livestock grazing and other activities degrade stream habitat. Statewide, a Physical Habitat Index developed for the survey rated conditions in 51 percent of stream miles as poor or very poor, while 49 percent were considered good or fair. Here are some major components of habitat quality:

❒ **Buffers** Statewide, 58 percent of stream miles had forested buffers, while 14 percent had other kinds of vegetated buffers, such as wetlands, old fields, tall grass, or lawns. Another 28 percent had either no buffer, or had discharge pipes directed into the stream, effectively bypassing streamside vegetation.

❒ **Channelization** The survey estimated that about 17 percent of Maryland's stream miles have been channelized —or straightened—mainly for agriculture but also for storm water drainage. The most channelization was in the Pocomoke with 81 percent of stream miles being channelized.

❒ **Erosion** Based on criteria such as the height of the stream bank, the bank angle, the amount of bank protected by root cover, and other factors, the survey ranked erosion potential. Statewide, 35 percent of stream miles had a high potential for erosion, and 7 percent had a very high potential. Another 35 percent had low, and 22 percent very low, erosion potential. More than three-quarters of stream miles in the Patuxent and Gunpowder had poor bank stability. But two-thirds of streambanks in the Youghiogheny and the North Branch Potomac were considered good.

❒ **Instream Conditions** Instream condition was assessed based on the substrate, quality of pools and eddies, quality of riffles and runs, and other features needed to support health communities. Statewide, 12 percent of stream miles were very poor, 38 percent poor, 28 percent fair and 22 percent good.

Highlights

❒ Maryland has about 9,000 miles of nontidal streams, divided among 17 drainage basins.

❒ Statewide, there are more than 60 million fish in those streams of which about 1 million are game species.

❒ The blacknose dace is the most common fish in Maryland, with an average of 1,970 individuals per stream mile, and nearly 11.6 million individuals statewide.

❒ Statewide, 4 percent of stream miles had no fish, excluding watersheds which drain less than 300 acres and are considered too small for fish.

❒ All fish were examined for external anomalies. The occurrence of anomalies was lower among game fish (2 percent) than nongame fish (5 percent). Anomalies tended to increase with stream size. Most anomalies were related to parasites.

❒ Pathological anomalies were found in a fewer portion of fish, 0.8 percent of game fish and 0.5 percent of nongame fish. Numbers were highest in larger streams, perhaps indicating the cumulative impact of upstream pollution.

❒ The biggest stream stressor in the state was physical habitat degradation, which affected an estimated 52 percent of streams.

❒ About 4 percent of stream miles had beaver ponds, with the highest occurrence in the lower Potomac basin.

❒ Only three fish species, largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), and pumpkinseed (*L. gibbosus*), were present in all 17 river basins.

❒ Only two amphibians (green frog and bullfrog) and one reptile (northern water snake) were present in all 17 basins.

Finally, their work done, they packed their equipment and their samples of benthos and stream water for later analysis. Then it was off to the next site.

That process was repeated nearly 1,000 times from 1995-97. The large number of randomly selected sites allows scientists to estimate with confidence the condition of the state's roughly 9,000 miles of nontidal streams.

In fact, they can even estimate the numbers of fish in those streams. By the survey's estimates, the state has more than 60 million fish in its wadeable nontidal streams, of which about 1 million are game fish (but only about 119,000 are of catchable size).

What is more important than their numbers, though, is what those fish are saying. The survey largely determines the state of a stream by the state of its residents—fish and benthos. To determine that, scientists use an "index of biological integrity"—or IBI. An IBI weighs numerous factors, such as the number of species in a stream, and the abundance of each species, to help gauge the stream's condition.

For instance, a stream with a high IBI score would not only have a lot of fish, but many different species as well. A stream with a low IBI may still have lots of fish, but they might all be from a couple of pollution-tolerant species. Similarly, IBIs were developed to measure the health of benthic communities.

With the IBI, Klauda said, "the biotic community tells us how they feel. But they don't always tell us why they don't feel well." That still requires some detective work.

Playing detective means drawing on information about physical habitat and water quality information collected at the streams. In addition, scientists compare results with land use information upstream from each survey site.

Putting it all together, the scientists found nutrient levels several times higher than the statewide average in streams where farmland accounted for more than half the watershed. They found that habitat quality improved as forest buffers got wider. And they found a stark decline in species, and habitat quality, associated with development—the biological health of streams with more than 50 percent urban development in the watershed was always poor.

But not all of the answers are in. Some IBIs need refinement. No IBI was developed for naturally acidic "blackwater" streams on the Eastern Shore. Also, high-quality coldwater trout streams are naturally less productive than warmwater streams and may need a separate IBI.

Nor has all the information been reaped from the mountains of data generated by the survey. While several scientific papers have already been published, more are planned as scientists work their way through the information.

Morgan, for instance, is analyzing survey results about fish anomalies—such as parasitic infections, lesions or tumors. Normally, information about anomalies is collected only near discharge points, not statewide. The survey data will help him learn what other factors may contribute to such problems. "We found anomalies in some watersheds—low numbers—but it is important as a baseline for future work," he said.

Features of Good Streams

A Mix of Pools, Riffles & Runs

To provide good habitat, rivers and streams need a mix of deep and shallow areas, known as pools and riffles. These provide different habitats for insects and fish. Many insects live their entire lives in a specific site, such as a riffle. Fish may use different habitats during different life stages, and depend on different types of insects during various life stages.

Good Substrate

All streams need some solid material such as cobble, submerged logs or snags to provide habitat for certain insects, as well as a spawning area for some fish species. Generally, small streams need more substrate as a percentage of stream bottom than larger waterways.

Stable Stream Banks

Usually anchored by tree roots, stable banks are important because they keep dirt from eroding into the stream where it can smother bottom-dwelling insects or silt over cobble bottoms. Also, grains of sediment increase the natural erosion power of moving water. A ton of sediment added to water can cause several tons of erosion in the stream channel.

Forested Buffers

Forests were the natural environment for most Mid-Atlantic streams, and they provide a host of stream benefits. Their leaves form the base of the food chain in small streams, their roots stabilize streambanks, their shade moderates stream temperature, and they contribute large woody debris. In addition, they filter pollutants from both runoff and shallow groundwater before it can reach the stream.

Lots of large, Woody Debris

Fallen logs and limbs create channel diversity, forming pools and riffles. As they rot, they add nutrients to the water which, like leaves, fuel stream productivity.

Development Heating Up Brook Trout's Battle to Survive

The brook trout is the most abundant sport fish found in Maryland's freshwater streams. But it might not have much of a future in many parts of the state.

The Maryland Biological Stream Survey estimated that 318,000 brook trout live in state streams today. But that may be only about a tenth of the number found a few centuries ago.

Trout require cold, clean, undisturbed streams. Much of their habitat has been lost since Colonial days.

Today, according to the survey, streams with good habitat conditions average 599 brook trout per mile. If that number were multiplied by the nearly 5,000 miles of streams in the Piedmont and mountain portions of the state—which historically would have been suitable for brook trout—Maryland streams would have once contained nearly 3 million brook trout, according to an estimate by Paul Kazyak, a Department of Natural Resources biologist.

Instead, brook trout are only found in portions of seven of 17 river basins in the state.

What's happened to brook trout habitat?

In a word, development.

The survey never found brook trout in watersheds having more than 2 percent impervious surfaces—things like roads, parking lots and roof tops.

In fact, brook trout were only rarely seen in watersheds with more than 0.5 percent impervious surfaces. For reference, a two-lane road running through a square mile is equivalent to 0.5 percent impervious surface.

The bottom line: Only a little development can make a watershed out-of-bounds as far as brook trout are concerned.

It's unclear exactly what factors cause the brook trout to be lost, said Scott Stranko, a DNR biologist working on the survey. But, he said, two likely suspects are temperature and sediment.

Because impervious surfaces collect heat on hot summer days, the rain hitting them is raised to warmer than normal temperatures. When it runs off roads and parking lots, it can raise the temperature of small streams many degrees.

Brook trout require cold streams. In Maryland, the survey never found one in a stream warmer than 23°C (73°F).

Also, rapid runoff from pavement tends to increase stream erosion, increasing sediment buildup in the spaces between rocks—areas important for brook trout spawning.

As streams degrade, it gives a slight competitive advantage to the larger brown trout (*Salmo trutta*), a nonnative species that has been stocked in the streams.

Brown trout can tolerate warmer streams—up to 26°C (79°F)—and more development. Brown trout were found in watersheds with up to 5 percent impervious surfaces.

As development takes place and imperious surfaces expand, brown trout will continue to gain a competitive advantage over the native brook trout.

Brook trout are not the only fish species to disappear with low levels of development, Stranko said. "There are some others we haven't found at about that same threshold," he said. "But brook trout are a good example because most people like them."

Several species of amphibians have also disappeared with low amounts of development. Several are never found in watersheds with more than 3 percent imperviousness. They include the mountain dusky salamander, seal salamander, Jefferson salamander and the northern slimy salamander.

Even as scientists continue sorting through information from the first statewide survey, a second round is set to begin this year. Through 2004, crews will examine more than 1,500 sites—some revisited from the first round, but mostly new ones. The survey will also add tidal streams to its sampling.

The new round of sampling will help scientists begin answering the key question of whether waterways are getting better or worse.

Beyond that, the survey is expanding to include volunteer monitors. Teams of three to five people will take benthos samples at about 20 sites. Asking each team to do so many sites is "pretty ambitious," acknowledges Dan Boward, a DNR biologist coordinating the effort, but it will cover an additional 1,000 sites per year in smaller watersheds. The response has been enthusiastic: Nearly 200 people were trained at monitoring workshops.

To build more public interest, the DNR plans to widely distribute a first-of-its-kind "State of Maryland Streams" report. It also plans to make watershed-specific information from the survey available on the Internet, so people can easily find out about their local watershed.

Public outreach is important, survey scientists say, because of the tough decisions about Maryland streams that lay ahead. While information from the survey will help to identify where restoration efforts should be focused—for example, where forest buffer restoration could link areas of good habitat—it also raises difficult questions.

With more than half of the streams in bad shape, the survey reveals a daunting task ahead when it comes to stream restoration. It's a potentially costly task—restoration of urban streams can easily cost $1 million a mile.

That raises serious questions, scientists acknowledge: Is limited restoration money best spent on costly efforts to restore highly degraded urban waterways, or is there more "bang for the buck" in restoring a greater amount of less-degraded habitat elsewhere?

The River Continuum Concept

Streams are organic machines that use raw energy and turn it into different products—or organisms—as it flows downstream. Streams begin in the hills or mountains as rainfall seeks low areas and groundwater seeps to the surface. Headwater streams are often too small to have fish—the Maryland Biological Stream Survey rarely finds fish in drainage basins of less than 300 acres.

Frequently, these streams are totally shaded by the riparian forest canopy, which limits the growth of algae. Groundwater often keeps temperatures stable. Inhabitants —mainly insects—rely on twigs, leaves and other organic matter for fuel, which they break down into finer particles.

As a stream widens, more sunlight hits the water, increasing the production of algae and stream plants. These, combined with fine particles from upstream, fuel a more diverse community of insects and fish. Warmer temperatures also create thermal niches along the stream that increase species diversity.

As streams widen into rivers, sunlight increases algae production even more, making it the dominant food source. But fine particulates are important, especially in rivers with a lot of sediment, which blocks light and limits algae production.

Under this scenario, known as the River Continuum Concept, the links between the land and the aquatic biological community are strongest in the headwaters and diminish as the stream becomes larger. Land-based activities that affect the headwaters not only alter the stream locally, but can have ripple affects downstream as well.

Nonnative Species & Biodiversity Loss

Of the 83 fish species found by the survey in freshwater streams, 19 were not native to Maryland. While they did not account for a large percentage of the total fish population, they were found in 46 percent of stream miles. Seven nonnative species are game fish, and some—largemouth bass, bluegill and pumpkinseed—are the most widespread, living in all 17 drainage basins. The presence of nonnative species is a concern because they can alter stream ecology and replace native fish.

The survey found that several fish species were very rare. Ten species were found in less than 0.5 percent of the state's streams. The survey estimated that there were fewer than 600 individuals each of three species: rainbow darter (*Etheostoma caeruleum*), banded darter (*E. zonatum*) and stripeback darter (*Percina notogramma*).

The survey found that five species were more rare than previously thought, and are now being considered for listing under the state's Heritage Program, which would offer them further protection.

Reptiles & Amphibians

The survey collected 45 species of reptiles and amphibians in and near streams. In many cases, especially for salamanders, results show that their populations are closely related to land use within a watershed.

Statewide, the number of aquatic salamander species decreased with increasing urban land use, indicating a loss of biodiversity. A similar negative relationship was observed between aquatic salamanders and increasing agricultural land use statewide.

But aquatic salamander species diversity increased with forest land use statewide. In fact, four species were never found in watersheds with more than 3 percent impervious surface.

Aquatic salamanders appear to be an especially useful indicator for stream quality, especially for streams too small to contain fish populations.

The survey is considering the possibility of developing an IBI for reptiles and amphibians in the future.

And, despite the emphasis on "smart growth," the survey results raise questions of whether any growth is smart in some areas if sensitive species such as brook trout are to be maintained at viable levels. "What I'm afraid of is that development is going to overwhelm some systems so much that we'll not be able to restore them properly," Morgan said.

Ultimately, those decisions will affect more than just local waterways; they will trickle down to the Chesapeake as well. The Bay and the rivers and streams that feed it are shared by many of the same inhabitants. Decisions made about those waterways, not just in Maryland, but throughout the Bay's 64,000-square-mile watershed, will ultimately affect the fate of the Chesapeake.

"I don't see," said Klauda, "how the Bay can be any healthier than the streams that are feeding into it."

Maryland Stream Video

The DNR has produced a 30-minute video that overviews the types of streams found in Maryland and major issues facing its waterways. *Maryland Streams: An Undiscovered Realm,* offers a close-up look at many dynamic and bizarre stream dwellers. Copies of the video are available for $10, (including shipping and handling) from the MD DNR Monitoring and Non-Tidal Assessment Division, Tawes State Office Building, C-2, Annapolis, MD 21401.

The complete report, From the Mountains to the Sea: The State of Maryland's Freshwater Streams, *is available on-line at http://www.epa.gov/maia/html/reports.html. Or call Ann Smith toll-free at 1-877-620-8DNR, ext. 8611.*