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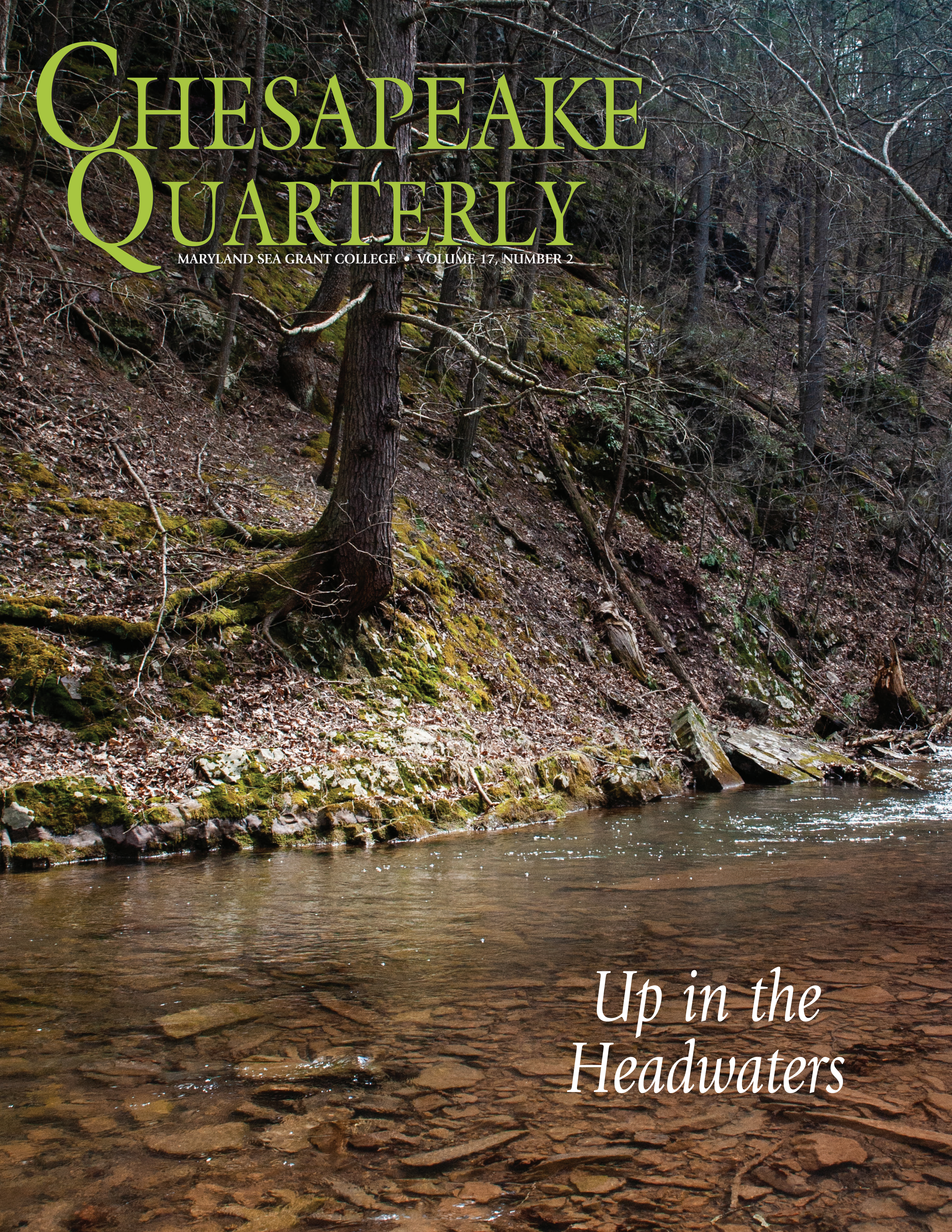

Up in the Headwaters

contents

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Chesapeake Quarterly explores scientific, environmental, and cultural issues relevant to the Chesapeake Bay and its watershed. The magazine is produced and funded by the Maryland Sea Grant College. The college receives support from the National Oceanic and Atmospheric Administration and the state of Maryland.

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Cover photo: *A stream flows through Green Ridge State Forest on its way to the Chesapeake 200 miles downstream.* PHOTOGRAPH, NICOLE LEHMING

Seeing the Chesapeake through the Forest

"I'm going to Western Maryland. I'm doing a Chesapeake Bay story." As soon as I said it, I realized my 13-year-old was flummoxed. Did I need a map? Didn't I know that was the wrong direction?

The fact is, in 14 years of writing about the Chesapeake Bay — for *The Baltimore Sun,* then the *Bay Journal,* and now this magazine — I only went to Western Maryland twice. And once was for a story relating to a military unit in the Iraq war.

***Editor Rona Kobell** posts on our social media accounts from a Western Maryland forest.* PHOTOGRAPH, NICOLE LEHMING

But the forests, streams, and air west of Hagerstown have important stories to tell about the Bay — stories that will help us restore the health of the estuary, and help us better connect to the people who live 200 miles from it. This issue of *Chesapeake Quarterly* looks at some of those stories, many of which come from work done at the University of Maryland Center for Environmental Science's Appalachian Laboratory next to Frostburg University. There, ecologist Andrew Elmore is examining how a decrease in nitrogen oxide pollution in the air — unquestionably a good development — is allowing forests to grow leaves earlier, and what that means for species that depend on forest habitat. Elmore is also looking at buried streams, mapping all of these now-hidden waterways in the Potomac River basin and encouraging federal officials to do the same nationwide to prevent flooding.

The lab is reaching out to residents around Frostburg for citizen-science projects and public education. One effort, Watershed Moments, brought dozens of residents to the lab one evening to learn about the macro-invertebrates that live in streams.

The lab is involved in other fascinating research under the leadership of director Eric Davidson, current president of the American Geophysical Union. Katia Engelhardt, a wetland ecologist, is working with a University of Maryland, College Park plant geneticist, Maile Neel, to determine the genetic biodiversity of a Chesapeake Bay grass species and how it responds to varying water clarity. And ecologist Robert Hilderbrand dives into the mysterious world of Didymo, a world-traveling algae that has appeared in Maryland streams.

Also upstream from the Bay, but not quite as far: our newest extension agent, Kelsey Brooks, is focused on engaging residents in Harford, Baltimore, and Carroll Counties on matters of clean water. She just started the newest Watershed Stewards Academy in Bel Air, Maryland. So while Western Maryland might not be near the Chesapeake, it is definitely of it. After all, everyone lives upstream from somewhere.

— *Rona Kobell*

A Forest's Story

Climate change is bringing earlier springs to the forests. Can they still trap carbon and nitrogen?

By Rona Kobell

On a frigid April day, Andrew Elmore has come to a high ridge at the edge of the Appalachian Mountains to see the trees through the forest.

Green Ridge State Forest boasts nearly 50,000 acres of majestic white and red oaks as well as towering poplars. Looking at them collectively, Elmore and his colleagues noticed they seemed to be leafing out earlier. Because of warmer temperatures, spring appeared to be coming early in many parts of the country. It wasn't just anecdotal. Four decades of observations of these forests from space, through satellites, suggested earlier springs and later autumns.

If the science showed that the earlier springs were occurring, and likely to come even earlier, what would that mean for the forests and the Chesapeake Bay watershed? Forests are important sinks for carbon and nitrogen. In longer growing seasons, would trees absorb more nitrogen and carbon, which they use for growth, and produce more wood? And if they could do that, would they then be able to help keep pollutants out of the Chesapeake and help reduce the rate at which atmospheric carbon dioxide increased?

***Scientists noticed** that forests were leafing out earlier. Their studies showed that this was true — by at least five days, a number likely to increase with rising temperatures in the future.* PHOTOGRAPH, NICOLE LEHMING

To answer these questions, Elmore brought his increment borer — a T-shaped device designed to extract a core of wood from the tree and determine how fast it is growing each year — to the forest to take samples. One tree ring at a time, the trees tell the forest's story. In addition to ring width, which is related to how fast the tree is growing, Elmore and his colleagues measure nitrogen isotopes in tree rings to understand how available nitrogen is to the tree, and provide clues as to how much is then left behind for streams and rivers to carry to the Chesapeake. This technique is a novel addition to the tools available to scientists interested in understanding the impacts of climate change on forests.

What Elmore and his colleagues found confirmed that forests were leafing out sooner, giving Western Maryland trees an earlier start to the growing season. But from the tree cores they discovered that an earlier spring and a longer growing season did not lead to more tree growth. That's because, in years of an earlier spring, nitrogen was less available at the time and under the conditions they needed it to grow. Why? Elmore hypothesizes that in years of an earlier spring, soil microbes release less nitrogen to trees than the trees need, resulting in a shortage. This effect might be amplified by rising atmospheric carbon dioxide, which causes the trees (and soil microbes) to demand more nitrogen each year.

"The simplest way to say it is that demand exceeds supply for nitrogen with an earlier spring," Elmore said. "The faster growth you'd expect to see associated with longer growing seasons and elevated atmospheric carbon dioxide is slowed down in an earlier spring, and that is because nitrogen is less available. Demand exceeds supply. So if we were hoping that a longer growing season would lead to more wood production, that appears to not be happening because the effect was countered by reduced nitrogen availability."

This story has become good news, bad news. The good news? With climate change and longer growing seasons, trees are demanding nitrogen faster than it can be provided by the environment, therefore absorbing nitrogen that would otherwise enter the Bay. Flows of nitrogen from large forested river basins such as the Potomac are on the decline. The bad news? Low nitrogen availability appears to be slowing tree growth. Scientists hope industries do not interpret that observation as a call for more nitrogen pollution. In Rhode Island, for example, upgrades to sewage-treatment plants — paid for with close to $1 billion in public money — mean less nitrogen enters the waterways there to feed clams and other fisheries. But the answer is not more sewage so clams can get fatter, Elmore said.

His initial forest discovery led to a paper published two years ago (in a sub-journal of *Nature*) and has major implications for the Chesapeake nearly 200 miles east of Elmore's home institution at the University of Maryland Center for Environmental Science's Appalachian Laboratory in Frostburg. In that study, Elmore and his colleagues ran the annual wood samples of more than 200 trees through an isotope ratio mass spectrometer. The resulting data reflect the composition of the nitrogen available to trees in any given year. When nitrogen is highly available, soil microbes can use it as an energy source, resulting in processes like denitrification, which preferentially transfers the lighter isotopes of nitrogen from the soil to the atmosphere. The remaining pool of soil nitrogen is isotopically heavy, and once incorporated into tree ring wood, this isotopic signal represents higher nitrogen availability. On the other hand, when nitrogen is less available, microbes perform less denitrification, hold onto both isotopes of nitrogen, resulting in lighter nitrogen isotopes showing up in tree-ring wood.

Ecologist Andrew Elmore *(above, top) extracts a core sample from a tree in Green Ridge State Forest. An example of a dried core sample (above, bottom) before it is prepared for the spectrometer.* PHOTOGRAPHS, NICOLE LEHMING

Working with ecologists Dave Nelson and Joseph Craine, Elmore continues to visit Green Ridge's mountains, sampling trees to evaluate evidence that earlier springs and rising atmospheric carbon dioxide lead to less nitrogen for trees and the broader ecosystem. That forests have less nitrogen available shouldn't be an excuse to burn more fossil fuels or use nitrogen fertilizers wastefully, Elmore said. Rather, the finding is yet another call to plant more forests and save the ones Maryland has. The trees, and the forests, provide a more valuable service today than ever before.

— *kobell@mdsg.umd.edu*

THE AIR FIX

Legislation in 1990 to protect humans from deadly respiratory diseases helps to clean the Bay

By Rona Kobell

Every so often, a scientist discovers something that changes how we see everything. Such was the case for Keith Eshleman in 2013. He and two colleagues from University of Maryland Center for Environmental Science's Appalachian Laboratory in Frostburg, Robert Sabo and Kathleen M. Kline, wrote a paper in the *Journal of Environmental Science and Technology* titled: "Surface Water Quality Is Improving due to Declining N Deposition."

They found that nitrogen in forested streams declined by nearly half (from 1986 to 2009) in nine predominantly forested Appalachian watersheds around the Potomac basin. A sewage treatment upgrade or an agriculture best-management practice will improve nutrient concentrations in the small waterway where the discharge occurs. But this change was much broader — across three states and different topographies. It had come from the sky.

Eshleman credited the improvement to Congress and President George H.W. Bush for the 1990 Clean Air Act amendments, which closed some loopholes that had allowed power plants and other industrial facilities to emit nitrogen oxide and sulfur dioxide that produce smog and soot that pose serious health hazards. At least one third of the Chesapeake's pollution comes from atmospheric deposition: gases and fine particles deposited in the water by rain, snow, winds, and settling.

A pollution reduction was good news for a struggling estuary. But much of the federal-state Chesapeake Bay Program's resources were being spent on reducing pollution from agriculture. Then, as now, the federal government paid for farmers to plant cover crops, install manure pads, erect riparian buffers and grass waterways, and build stream-bank fences — all in hopes of keeping nitrogen and phosphorus out of streams. Now, it seemed that legislative action two decades before, largely to protect human health, had also improved stream health.

Keith Eshleman, *forefront, made a surprising discovery several years ago: nitrogen concentrations in forested streams were dropping by large amounts, and that power plant standards Congress passed in 1990 were the main reason why.* PHOTOGRAPH, CHERYL NEMAZIE, UMCES

Eshleman and Sabo followed up with a 2016 paper that said that Chesapeake Bay regulators had no direct evidence that the money farmers spent on pollution-reduction practices was improving water quality — not yet, anyway. This study examined 18 sites in forested and agricultural watersheds and found that less atmospheric deposition led to less nitrogen in all of their waterways. Eshleman didn't say the practices that farmers were putting in place had failed to work; he simply said that research had yet to prove they were the main driver of the improvements to date.

"I'm providing an alternative explanation for the improvements," Eshleman said. "We're asking, which one is the big driver for recent improvements in the Bay, atmospheric deposition or agriculture? If you had one knob that has been turned, which one was it? I'm arguing atmospheric deposition is the big knob that has been turned effectively so far. The [Bay Program] thinks it's agriculture."

Appalachian Lab director Eric Davidson said the main take-away is that curbs on emissions from power plants, factories, and vehicles are helping humans, streams, and the animals that depend on them. Any rollback of the Clean Air Act Amendments of 1990 would bring harm.

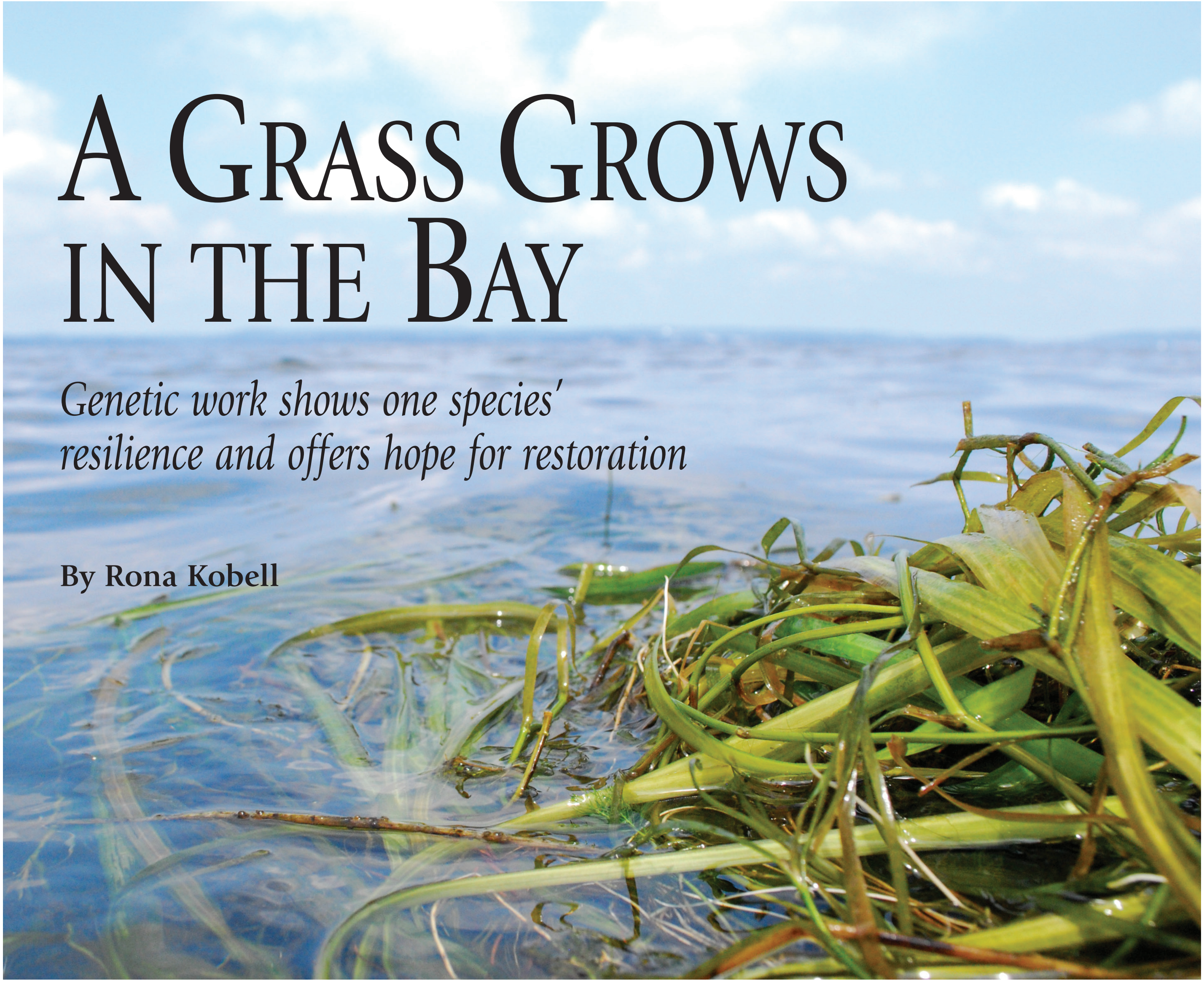
"No one's saying we should let up and stop trying to improve agricultural practices that reduce nitrogen and phosphorus runoff to the Bay. Those are still wise things to do, and some of them can actually save farmers money too," Davidson said. "But let's give credit where credit is due, which, for the moment, is that the scientific evidence says that air pollution controls are reaping huge benefits."

— *kobell@mdsg.umd.edu*

A Grass Grows in the Bay

Genetic work shows one species' resilience and offers hope for restoration

By Rona Kobell



Chesapeake Bay underwater grasses are celebrating an amazing recovery. For the fifth year in a row, these sentinels of clear water — several species in all, most native but some not — have increased in abundance. In 2017, grasses throughout the Chesapeake broke the 100,000-acre mark, the highest seen in several decades of monitoring.

It's a happy twist in what has been at times an ecologically sad story. Bay grasses were once so plentiful in Maryland that marina owners would ask state officials to poison the plants so they would not foul boat propellers. But the growing population in the watershed and the resulting increases in nutrients and sediment entering the Bay, combined with these ill-informed herbicide campaigns and natural diseases, sent grasses into decline by the early 1970s.

Plants need nitrogen and phosphorus for growth, but too much fuels algae blooms that block the light they require. Sediment leads to turbidity in the water, which also blocks light and stops or slows growth. Stressors associated with human population growth — more impervious surfaces, more sewage, development of once open land — began the grass decline, but Tropical Storm Agnes accelerated the job in the spring of 1972. The storm, hitting at the most vulnerable juncture as plants were starting their new growth, wiped out the beds in the Susquehanna Flats and other regions of the Chesapeake. Declines persisted through the 1970s and '80s and recovery was slow through the '90s, making the recent recovery that much more remarkable.

Now, the question becomes: How do scientists and restoration managers sustain the recovery, which bodes well for the crabs and fish that call these areas home, and push for further restoration efforts to help nature along? Two scientists are working on an answer.

Vallisneria americana, also known as wild celery, has become a power house among the species of grasses that grow in the Chesapeake. A Frostburg ecologist and a College

Park plant geneticist are looking at the genetic diversity of the plant, and hoping what they have learned will help fuel the continuing recovery of these essential plants in the estuary. The takeaway is that water-quality improvements need to continue for grasses to keep on rebounding.

"The big message, and we need to hit it hard, is that it's mostly about water quality," said Maile Neel, the plant geneticist at the University of Maryland, College Park who is working on the project with the Appalachian Laboratory's Katia Engelhardt. Given the levels of genetic diversity that have been found, if water quality continues to improve, then the species should thrive, Neel said.

In 2017, the Chesapeake Bay contained almost 105,000 acres of underwater grasses total, more than halfway to its ultimate restoration goal of 185,000 acres. The highest percentage of increases in grass levels occurred in the tidal fresh parts of the Chesapeake, where wild celery thrives. The grass helped the region reach 96 percent of its acreage goal.

Its resilience led to questions that Neel and Engelhardt hoped to be able to answer. Given the decades-long declines in the species, scientists had concerns that genetic diversity could be too low to promote resilience. Many assumed that this species rarely reproduced by seed. Without sexual reproduction, many shoots that look like separate plants when viewed from above would actually be the same individual.

Along with their students, Neel and Engelhardt collected plants from a variety of areas in the Bay and its watershed including the Susquehanna Flats, the mainstem of the Potomac, the Baltimore tributaries, and the non-tidal Potomac north of Great Falls. Neel's team extracted the DNA from approximately two-centimeter pieces of leaf from each sample and ran genetic tests to determine how many varieties of the plant existed. To date, they have analyzed 3,771 samples of wild celery from locations that represent different growing conditions.

They have determined that most populations of wild celery in the Chesapeake are made up of many genetically different individuals, which bodes well for the long-term survival of the species as well as for restoration efforts. The only exception to this pattern is in the Potomac River upstream of Great Falls where two types of plants dominate over hundreds of kilometers of the river. They found genetic differences among populations in the Bay that indicate three different regions in which populations share genetic information. The scientists regularly discuss their findings with Brooke Landry, a biologist with the Maryland Department of Natural Resources, who also heads the Chesapeake Bay Program's SAV (submerged aquatic vegetation) Workgroup, and others who work on SAV restoration efforts.

Simultaneously, Engelhardt has grown selected individuals, identified genetically by Neel, in a greenhouse. She is conducting experiments to

***In a greenhouse** at the Appalachian Laboratory, ecologist Katia Engelhardt (above, top) propagates different species of wild celery to see how they respond to varying light conditions. Meanwhile, at the University of Maryland, College Park, geneticist Maile Neel (above, bottom) tests their genetic makeup. Wild celery and water stargrass (opposite page) are thriving in the Susquehanna Flats.*
PHOTOGRAPH ABOVE TOP, NICOLE LEHMING; ABOVE BOTTOM, RONA KOBELL; OPPOSITE PAGE, CHESAPEAKE BAY PROGRAM

Katia Engelhardt uses shade cloth *(above) to mimic changes in light levels in the Bay due to different levels of water clarity. The lighter shade cloth on the left allows some light through to the plants below, while the right blocks most of the light. She is finding that some individuals can persist with most of the light blocked, whereas others do not. DNR biologist Brooke Landry (right), who chairs the Chesapeake Bay Program's SAV Workgroup, stands with colleague Becky Golden.* PHOTOGRAPH ABOVE, NICOLE LEHMING; RIGHT, COURTESY OF BROOKE LANDRY

determine how the genetic diversity at the individual, local, and regional scales affect the species' ecology. These experiments have revealed that productivity increases when plants with similar genetics, or "genotypes," are planted together, and that different genotypes have different growth patterns.

Algae that thrive on nitrogen and phosphorus, along with floating sediment particles, can block light and prevent plant growth. In experiments using shade cloth to mimic changes in light levels in the Bay due to different levels of water clarity, Engelhardt has determined that conditions in which plants could grow in the wild vary across genotypes. She is finding that some individuals can persist with most of the light blocked, whereas others do not.

Discovering the genetic diversity and range of wild celery has led to changes in how the Chesapeake Bay community restores grasses. In addition to state-sponsored restoration efforts, the Chesapeake Bay Foundation and some watershed organizations run re-seeding programs across the watershed. Now, restoration managers are calling Neel and Engelhardt for advice, and the scientists are telling them to group genetically similar grasses in places where they're known to grow well instead of assuming all the seeds are alike and dispersing randomly.

"She (Neel) has convinced us that we need to keep our seeds in the same region that they were harvested from," Landry said. "Her argument is that it's best to keep the plants local. It might be a waste of seeds and time if we move them too far — they might not be genetically suitable for the conditions in that spot. Plus, since they've found so much genetic diversity in the wild celery populations in the Bay, there's no need to move the plants outside their region to increase diversity."

Maryland and Virginia have made some efforts to restore the beds by planting mostly eelgrass in the southern portion of the estuary, but many of those efforts were not successful long-term. Wild celery restoration efforts are relatively recent. Neel, Engelhardt, and Landry are hopeful they will be more resilient.

"Restoration managers paid a lot of attention to habitat requirements for the different species of grasses," Neel said. "But they were not paying attention to genetic diversity within species because they didn't know anything about it."

Engelhardt agreed. "Prior to Maile's and my work," she said, "there really was no thought to where people were putting things."

Bay grass recovery is the result of decades of dedication. Neel and Engelhardt's work indicates excellent prospects for continued recovery and resilience.

— *kobell@mdsg.umd.edu*

Meet the Extension Agent KELSEY BROOKS

By Rona Kobell

Kelsey Brooks spent the early part of her career writing stormwater permits for the Virginia Department of Environmental Quality's largest jurisdictions. All that time inside convinced her she'd rather be on the other side: out in the field, helping nonprofits, county governments, and cities implement their own practices to reduce pollution. So last year, she joined Maryland Sea Grant as a watershed specialist. Brooks works with a team across Maryland, though she is based in northern Baltimore County and responsible for projects there as well as in Baltimore City, Baltimore County, and Carroll County.

"I prefer the carrots to the sticks, and this position is pretty much all carrots," Brooks said.

In order to receive their stormwater permits, the largest jurisdictions (major metropolitan counties and Baltimore City) must show they are reducing pollution. Their permits have specific limits as to how much jurisdictions must reduce, but they don't dictate the means by which they go about it. That's where Brooks comes in. Working with a team of specialists, she can recommend a rain garden, rain barrel project, tree planting effort, stream restoration, or other green infrastructure features that will filter the water when it runs off streets and slow it down, reducing the amount that enters streams or the Chesapeake Bay.

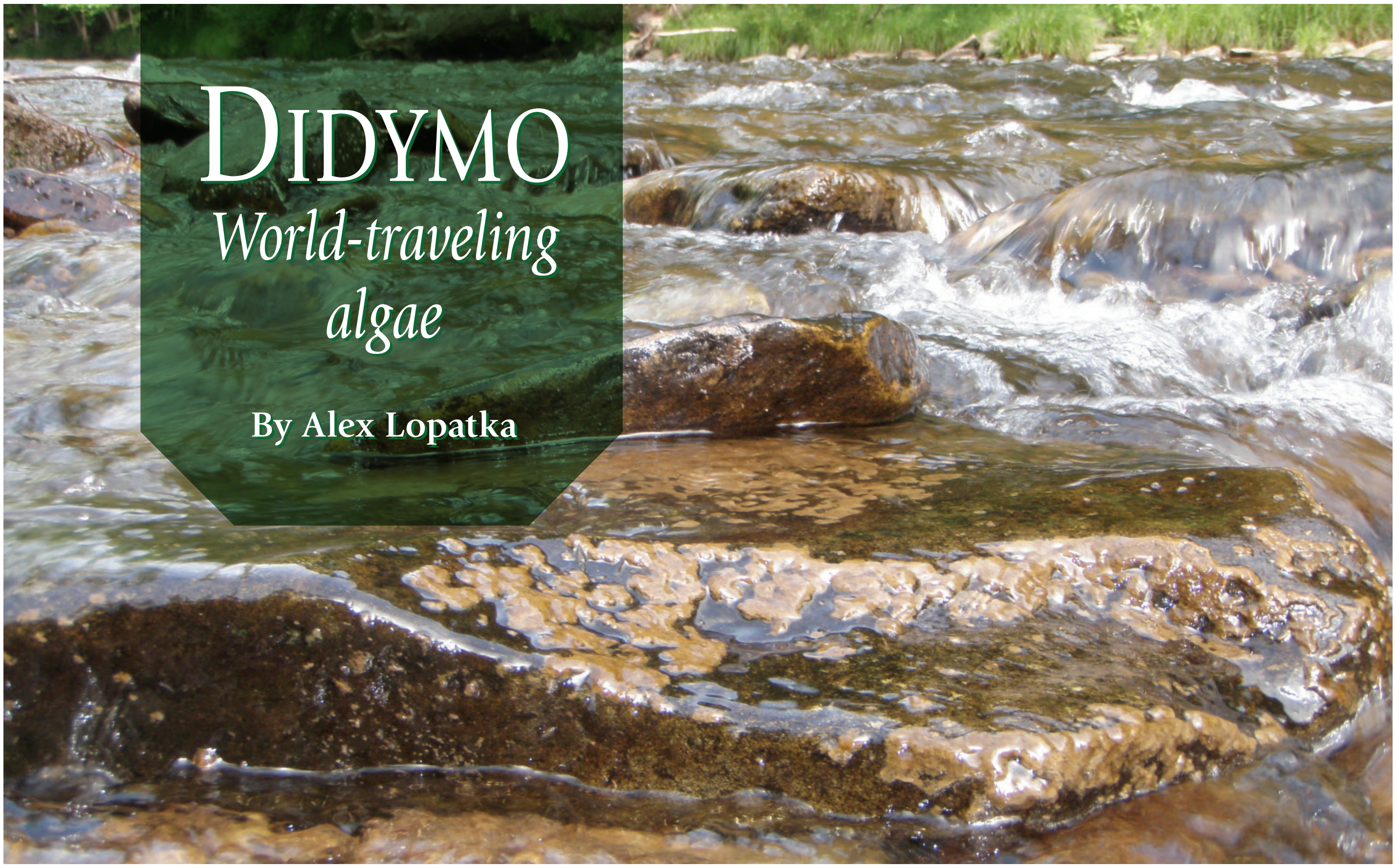
In short order, Brooks helped develop the Harford Watershed Stewards Academy, which trains volunteers to be leaders in reducing pollution in their watersheds, and led master gardener training sessions. These watershed stewards are working on a floating wetlands project at Ladew Topiary Gardens in Baltimore County, which brings in thousands of visitors a year. The academy's projects are visible, and its graduates become leaders for more green infrastructure projects in the community. It is an outgrowth of the successful program in Anne Arundel County, and Brooks is hoping to keep the program growing.

Brooks graduated from Princeton University in 2011 with a degree in ecology and evolutionary biology. She earned her master's in city and regional planning, with an environmental focus, from Rutgers University and intended to work on making brownfield sites suitable for reuse. But then, she said, "Hurricanes Irene and Sandy hit New Jersey, and pretty much everyone became interested in water issues." That brought her to stormwater management just at the time that many public entities were beginning to understand its importance, and as residents were beginning to resist having to pay for yet another thing.

With the four other watershed specialists at Maryland Sea Grant, Brooks is working to break down that resistance. The more communities can see the benefits of rain gardens, rain barrels, disconnecting downspouts to reduce the flow of runoff into sewers, and building pervious parking lots that absorb water, the more they will want to do. The more carrots Brooks and her colleagues can offer, the better the environment and the Chesapeake Bay can be.

Editor's note: *This article is the first in a series about Maryland Sea Grant's Extension agents in the field.*

Kelsey Brooks *in her element — the outdoors.* PHOTOGRAPH, NICOLE LEHMING



Didymo

World-traveling algae

By Alex Lopatka

In early spring 2008, fishermen in the Gunpowder River found something they had not seen before in the stream.

A fibrous mat of grey-green algae was covering the rocks and boulders. Nicknamed "rock snot" for the way it stuck to rock boulders along the bottom of the stream channel, the algae blanketed the stream's rocks. Fisheries managers worried it would spread quickly throughout one of the area's remaining pristine fishing areas. By April, the Maryland Department of Natural Resources (DNR) had identified it: rock snot's scientific name was *Didymosphenia geminata,* or Didymo for short.

Unlike many other algae that have invaded the Chesapeake Bay and its tributaries, Didymo thrives in cold, clear waters with especially low phosphorus concentrations. Given these preferences, the prevailing hypothesis has been that Didymo originated in Scotland and other areas in the far northern latitudes of Europe and Asia. Until 2008, scientists had not observed Didymo on the East Coast of the United States. So, how did it get into the Gunpowder?

In 2014, scientists at Dartmouth College compiled fossil evidence from the Delaware River suggesting Didymo had been in Pennsylvania for hundreds of years and was native to Maryland too. The researchers used time-series data from the EPA's Environmental Monitoring and Assessment Program to show that when there was a lot of phosphorus in the water, there wasn't much Didymo, but with only a little bit of phosphorus, there could be a lot of Didymo. However, new work published in late 2017 led by the University of Maryland Center for Environmental Science's Appalachian Laboratory in Frostburg, and the University of Vermont uncovered some surprising new results: Didymo is most likely an invasive species, sharing genetic material with other Didymo algae found in such far-flung places as Italy and New Zealand.

Before Bob Hilderbrand, an aquatic ecologist at the Appalachian Laboratory, began his research, there was some evidence Didymo might be invasive to Maryland. The Didymo found in the Gunpowder River watershed in spring 2008 was the first sighting in the state. If it were truly native to the Mid-Atlantic region, Hilderbrand argued, there should have been reports of it before — whether among fishermen, or in newspapers, or other historical documents. No such evidence has been found.

As quickly as Didymo appeared in Gunpowder Falls in 2008, it disappeared after a few months. According to the DNR, the second and last confirmed Didymo sighting happened in spring 2009 in the Savage River, in Western Maryland.

Is Didymo truly gone? To determine that, Hilderbrand and colleagues went to 76 different sites in Maryland along with dozens more in Pennsylvania. They were looking for DNA in the water, known as eDNA or environmental DNA as a chemical tool to search for Didymo's genetic material in the streams. This technique allows even trace amounts of Didymo to be detected. To collect samples, they used a specially designed net with very fine mesh to filter 10,000 liters of water at each site.

Once they had their sample of eDNA from each stream site, they used a technique common in many biology labs called polymerase chain reaction (PCR) to identify the Didymo DNA in the sample and produce many copies of it rapidly. With an abundance of DNA, Hilderbrand and his colleagues then used a "probe" to identify their unknown samples. Hilderbrand described the probe as a kind of lock made from known Didymo DNA. This particular lock would only open with a Didymo DNA key. So each sample was paired with the probe to try and unlock it. The only two keys that unlocked the probe were from DNA samples from the Gunpowder and the Savage Rivers — the two locations where Didymo was found in 2008 and 2009, respectively.

By comparing their DNA results to what was already catalogued in GenBank — the National Center for Biotechnology Information's collection of publicly accessible genetic data — Hilderbrand and colleagues constructed a family tree for Didymo. They determined that the Didymo found in Maryland's Gunpowder and Savage Rivers had also been found before in other places around the world.

"Didymo is a world traveler," says Hilderbrand.

The surprising result is that the Didymo DNA found at the two rivers consists of multiple different strains. Some samples from Gunpowder Falls are more like the Didymo found in Colorado, Italy, and New Zealand. "There is some Didymo diversity," says Hilderbrand. The Didymo found in Maryland is "not just one weird mutant."

The timing for the discoveries of Didymo across these different places would not be possible from evolution — it's just too fast, Hilderbrand said. Rather, Didymo may have made a new home in these different places after people unwittingly introduced it into the ecosystem. In other words, fishermen who love the Gunpowder also tend to love the Savage, and maybe on their trips to Western Maryland, they brought along an unwelcome guest.

After the 2008 outbreak, anglers worked with government and businesses to restrict Didymo's spread. Theaux Le Gardeur, Gunpowder Riverkeeper and the owner of a local fishing shop, helped lead that effort. They convinced many anglers to carry another pair of shoes, switch to rubber-soled waders, and clean their gear. Felt-soled waders were acting like sponges and absorbing and spreading Didymo. In 2011, with fishermen's support, the DNR instituted a state-wide felt-soled wader ban.

"In Maryland's case, we had folks who were biologists who said let's try to stop the spread of this. It was very progressive," said Le Gardeur.

Maryland has not experienced a nuisance bloom like Gunpowder River's in 2008 or Savage River's in 2009. In 2012, there were unconfirmed sightings of Didymo at Big Hunting Creek and the North Branch of the Potomac River in Garrett County.

The last field season for Hilderbrand and his colleagues was in 2014. Out of the 76 Maryland research sites, only two, Gunpowder and Savage, had Didymo present. Even nearby water body sites — streams with cold, clear, low-phosphorus water, the kind of environment Didymo should thrive in — had none of it. But, Hilderbrand also noted that some Maryland streams, like the Gunpowder, are seeing increases in phosphorus from fertilizers and other sources, suggesting low phosphorus levels may not tell the full story. Scientists do not yet know how changing phosphorus concentrations affects Didymo.

Didymo could restrict food sources for fish, and also slow spawning for different fish species. Many "need clean substrate" — rocks without

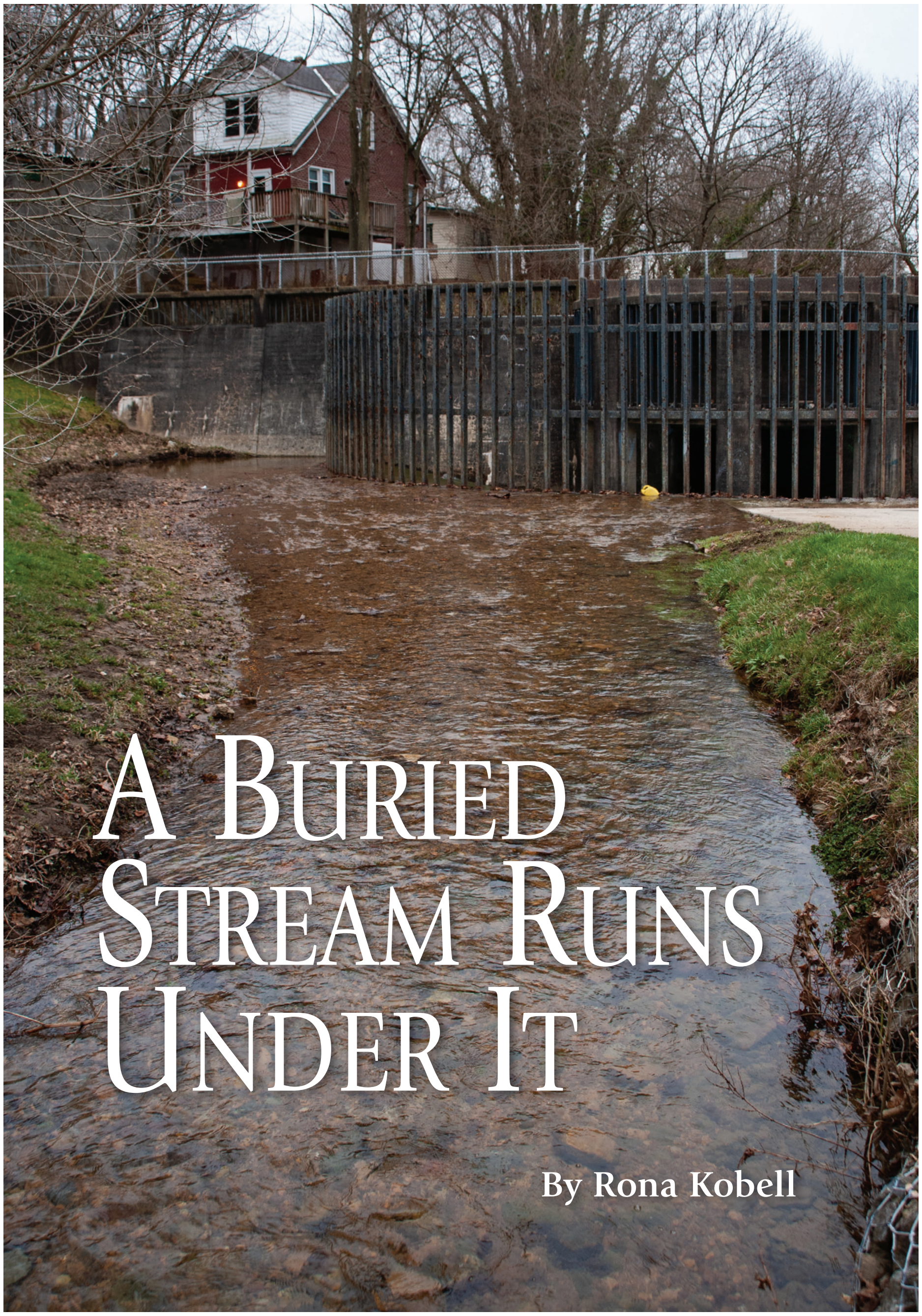
The early stages *of a Didymo bloom (opposite page). Also known as "rock snot," Didymo disappeared as quickly as it had appeared in Maryland. Ecologist Robert Hilderbrand (above) is trying to figure out why it came, where it went, and if changing phosphorus conditions might allow for its return.* PHOTOGRAPH OPPOSITE PAGE, MATTHEW SHANK, SUSQUEHANNA RIVER BASIN COMMISSION; ABOVE, RONA KOBELL

Didymo on them — to lay their eggs, said Hilderbrand. Initial research by Maryland DNR shows that the trout populations seem unaffected by the Didymo outbreak at the Gunpowder River. But Hilderbrand cautioned that a multi-year event could have much more negative consequences by causing sustained changes to light levels and food availability for these fish populations.

Removing Didymo would be difficult and costly. Strands can grow up to two feet long, which then become entangled. This gritty mat of algal material has proven difficult to remove from the rocks it clings to in streams. State biologists could find no successful eradication effort.

Scientists do not know why the bloom hasn't returned to the Gunpowder. But now that they have linked Didymo genetically with other sightings of this species across the globe, new work may uncover more about its life cycle and possible harm to fish populations.

Alex Lopatka, a former Maryland Sea Grant intern, is an associate editor at Physics Today. *He earned his Ph.D. in geology at the University of Maryland, College Park.*



A Buried Stream Runs Under It

By Rona Kobell

Wills Creek runs through Cumberland on its way into the Potomac River's North Branch. Outside of town, it's indistinguishable from the river it eventually reaches: wide and murky, with ample room for kayaks. Within town, though, Wills Creek is not a creek at all but a flood control structure. Its concrete bottom and steep, sidewalk-like banks channel water downstream. That water can rise quickly and run fast in heavy rains. There are signs not to enter it, not that anyone would find it inviting.

"Wills Creek is an example of a stream that was too big to bury, but they did their best," said Andrew Elmore, an ecologist with the University of Maryland Center for Environmental Science's Appalachian Laboratory who maps and studies buried streams to gauge their effect on flooding and water quality.

A buried stream is a waterway that planning officials have decided should not be a stream anymore. Engineers route the flow through culverts and pipes. Then they simply pave over the engineered channel, building a road or highway. What was once an open stream becomes hidden. In Baltimore, the Jones Falls, a Patapsco River tributary, is one of the largest buried streams in Maryland; much of it sits under Interstate 83, also known as the Jones Falls Expressway.

Burying a stream causes problems for a waterway because it changes biological, physical, and chemical processes. Plants can no longer grow there, so they cannot absorb nitrogen and phosphorus from upstream sources or from air pollution dissolved in rainwater. Insects no longer hatch their eggs in the stream, decreasing their populations and depriving some fish of an important food source. A natural, meandering stream with vegetation and natural banks can remove nutrients and sediment from runoff on its way to larger rivers and the Chesapeake Bay. But in a buried stream, the concrete acts like a chute; rushing water from runoff, often filled with fertilizer, enters the waterways at a rapid rate. With no plants to take it up and no natural banks to slow the flow down, it carries these pollutants straight to the Bay.

Streams also exacerbate flooding. Even a buried waterway does not forget it was a stream. In a heavy rain, water fills up these channels; the water wants to go where it flowed in the past, even if that place is now covered in concrete and is near homes. That's what happens on Valley Road, which runs parallel with Wills Creek in Cumberland, Md. and is next to a stream called Dry Run that's often anything but. Valley Road and Wills Creek together dive under the city, part road and part stream, not successfully performing either function well on rainy days. Metal fences and rock dams attempt to control the flow, but often fail to do so. Valley Road wants to be a stream, ecologically, even if it looks like a street, aesthetically.

A decade ago, Elmore and his colleague, University of Maryland, College

Park geologist Sujay Kaushal, began mapping the buried streams around Baltimore, focusing on the Gunpowder and Patapsco Rivers. They found that streams, in particular those in the headwaters, where they form, were being buried at a rapid rate. Planners and public officials often didn't know where the streams were, or that they even had once been streams.

Having mapped the Baltimore area, Elmore and his colleagues turned to a much larger challenge: the Potomac River basin. The area they studied crossed West Virginia, Virginia, the District of Columbia, and Maryland. They found that patterns of stream burial are remarkably consistent: upstream, smaller streams are buried first, with a preference for low-gradient streams flowing through the best development sites.

It's best, Elmore said, not to bury any more streams, and especially not to bury them when other streams in that area are already buried. The more managers can keep networks of streams together, the more connected the waterways will be, and the more useful habitat the plants and animals who depend on them will have. Managers need to know where the streams are, in order to protect them.

With climate change producing heavy rains and more flooding, Elmore said the country could use a detailed buried streams map sooner rather than later. He and his colleagues have been working with national policymakers to push for a map of both what has been buried and what is in danger of being buried in the future. They are hoping that agencies such as the U.S. Army Corps of Engineers, the Environmental Protection Agency and the U.S. Geological Survey will be interested in creating buried stream maps for the whole country — to understand flooding in the buried areas and to perhaps compensate for habitat loss with restoration efforts.

Wills Creek *starts out as a full-fledged stream of the Potomac, but is contained in a concrete flood control structure as it passes through Cumberland, MD. Here it's a river surrounded by concrete; buried tributaries to Wills Creek enter it through tunnels passing under the city. For example, a couple miles upstream (opposite page), Dry Run enters the tunnel seen here to empty into Wills Creek.* PHOTOGRAPHS, NICOLE LEHMING

"You have to have that tool, that map, if you are going to approach the problem," Elmore said. "For any resource you want to conserve, you need to know where it is."

— *kobell@mdsg.umd.edu*

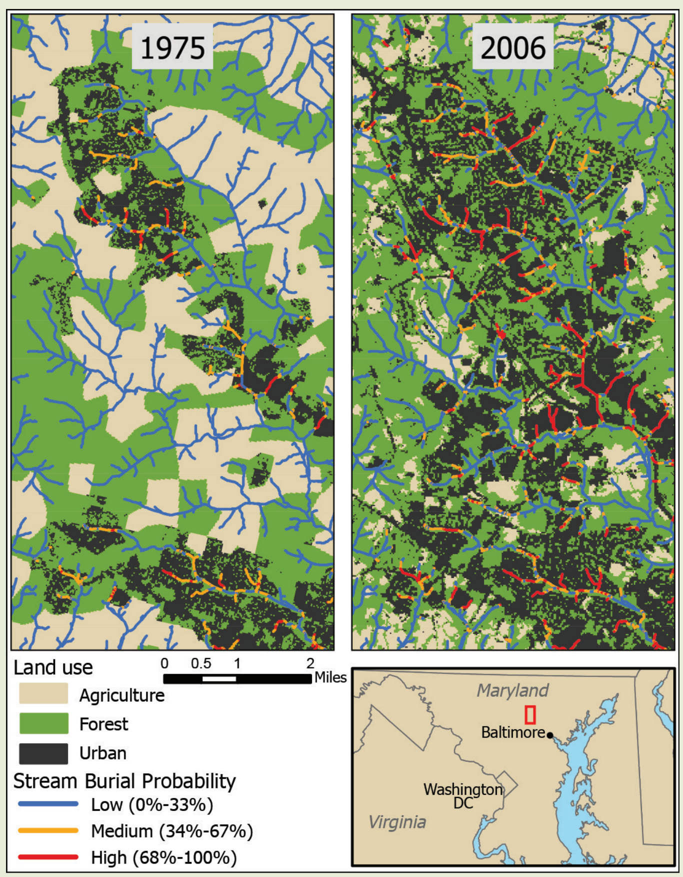
Topography Under Cover

Developing rural areas often results in streams being buried. They are directed into culverts, pipes, concrete-lined ditches, or simply paved over. Researchers at the Appalachian Laboratory wanted to find a way to better predict which streams would become buried as a result of urbanization. Using a new stream-mapping model[a] that they developed, they incorporated field and remotely sensed observations with maps of impervious cover such as pavement. The researchers found that stream burial rates go up with increased urbanization intensity. Small headwater streams are among those most affected by urbanization because they are the most physically and economically feasible to bury.

This historical time series shows how the probability that a stream will be buried increased as urban intensity increased in the Washington, D.C. region between 1975 and 2006. The shading represents land use with the colored lines representing tiers of probability that a stream will be buried (blue 0–33%, orange 34–67%, and red 68–100%).

[a] For more information, see our article "To Map Streams for Restoration, First Go to the Source" in the April 2015 issue of *Chesapeake Quarterly*.

GRAPHIC COURTESY OF DR. ROY WEITZELL, CHATHAM UNIVERSITY



Bugs and the Bay

Insect populations offer valuable clues to the quality of water entering the Chesapeake

By Rona Kobell

If girls aren't supposed to play in the mud with bugs, no one told Zora Edmondson.

On a cold spring evening, the Grantsville, Md., fifth-grader was hunched over a metal tray filled with water, dirt, and a collection of tiny stream invertebrates — mayflies, caddisflies, and water pennies. (Known as aquatic macro-invertebrates, they are organisms with no backbone that are large enough to see without a microscope, though using one helps.) Her mission was scientific yet simple: Determine how clean the water was by the sorts of backbone-less bugs that lived in it.

"I thought it would be fun," Zora said when asked why she and her parents drove 30 minutes to the University of Maryland's Center for Environmental Science's Appalachian Laboratory in Frostburg. "Actually, it was my mom's idea, but when I got to thinking about it, I started liking it."

Zora joined about 50 curious participants at the lab's spring Watershed Moments program called "Lab After Hours: What's in Your Water?" It's part of a quarterly series hosted by the Frostburg laboratory. Other UMCES facilities, including the Horn Point Laboratory on the Eastern Shore, the Chesapeake Biological Laboratory in Solomons, and the Institute for Marine and Environmental Technology in Baltimore, also host community events throughout the year. They include lectures, open houses, and hands-on science programs.

The difference in Western Maryland, though, is the distance from the Chesapeake — Frostburg is a good 200 miles from the estuary's shoreline in Annapolis or Baltimore. But the program is really about the watershed — the creeks, gulleys, and streams that flow into the Chesapeake Bay. And it is about the land — 64,000 square miles of it — that affects the water. It is about farms, forests, housing developments, and urbanized, concrete culverts in places like Cumberland and Frostburg. And it is also about local industries, where many Western Maryland residents historically made their living, and some still do.

Longtime residents often viewed the natural surroundings as key to their livelihoods in paper mills and coal mines and rubber tire factories, industries known to have a history of environmental violations.

Regardless of those infractions, residents often see efforts to preserve their surroundings as something that could take away jobs and income. Scientists say that relations between the lab and nearby towns weren't always the warmest because of that conflict.

"Until recently, here, the industry was mostly extraction. People often think that anything environmental takes away from the economy and they don't want anything to do with it," said Robert Hilderbrand, a stream ecologist at the lab who led the workshop. "People here are just beginning to see how valuable the environment can be. People take clean air and clean water for granted, until it's gone."

Hilderbrand believes two factors are bringing about a different attitude toward the natural environment here. First, Western Maryland is embracing its forests, streams, and relatively inexpensive housing to market itself as a vacation destination and second-home community. Deep Creek Lake has long been a popular vacation site, but now communities such as Friendsville and Frostburg are also becoming popular second-home destinations and vacation stops. Wineries, creameries, brew pubs, and bookstores are popping up in the shadow of ski resorts, trout streams, and outdoor-adventure emporiums. Those industries, Hilderbrand notes, were among the lead voices opposing fracking for natural gas, a practice Maryland's governor decided to ban after six years of study. At the same time, new year-round housing is being built in areas within commuting distance of Washington, D.C.

The second factor is a realization that upstream waters are not just a means to the end goal of a clean Bay, but can be environmental draws or drawbacks in their own right. Clean water and clean air are important, whether one lives next to the Chesapeake or hundreds of miles from it. Talk about the Chesapeake may resonate in Annapolis, but talk about the Potomac or the Casselman is more likely to be meaningful in Frostburg. And if those rivers aren't clean, the Bay won't be, either. Visitors won't come to appreciate the beauty of Western Maryland if the rivers don't have healthy fish and clean water.

"As long as these rivers and streams are considered a point source rather than a part of the system, they're historically an afterthought. They don't produce oysters. They don't produce crabs. But that water is critical for the health of the Bay," Hilderbrand said. "The Bay really wouldn't exist in its form without the freshwater sources."

In a spacious room with lab tables and a few sinks working overtime, Hilderbrand explained Stream Health 101 to the group. A water sample can test for pollutants and acidity levels. But to determine whether a stream can support life, you just need your eyes and a decent macro-invertebrates chart.

The healthiest streams are the ones with the clearest water, the most abundant plant life, the most oxygen-rich environments to support the most sensitive organisms: Tiny mayflies (order: Ephemeroptera) and hook-legged stoneflies (order: Plecoptera). If any of these bugs are in your stream, Hilderbrand told the group, the water is of excellent quality and can support plant and animal life. Other animals that indicate good stream health include the water penny (order: Coleoptera), flat with legs on the bottom, and the spiky hellgrammite (order: Megaloptera), a rare, dark creature with pinching jaws and feathery gills.

"The Bay really wouldn't exist in its form without the freshwater sources."

— Robert Hilderbrand

Some caddisflies (order: Trichoptera) will only live in the most pristine streams; see one, and you know the habitat is good. But the net-spinning caddisfly is part of the Diptera order, a slightly different one, and it can survive with what one might call the lesser bugs in moderately healthy streams. The net-spinning caddisfly is one of the 20 or so organisms in that family that can withstand more stress. It is more worm than fly with a long, pliant body. Common bugs in the moderate stream-health category also include damselflies and dragonflies, in addition to crayfish and clams.

The pollution-tolerant organisms may be the least loved: the leech, the black fly, and the midge. One reason they're so common is because they can withstand large amounts of nitrogen, phosphorus, and sediment in the water, even if those of us who enjoy wading in the streams would rather not withstand them.

Local students *Gabrielle Rinard, Zora Edmondson, and Kevin Rinard (left) look for bugs in the Appalachian Laboratory. Brent Chippendale (above) drove 40 minutes to learn about bugs in streams in hopes of restoring the ones on his own land.*
PHOTOGRAPHS, RONA KOBELL

Brent Chippendale came to the workshop from his home about 40 minutes away in Centreville, Pa., hoping to learn the state of a stream that runs through his 52-acre property. Retired after a long career with social services, Chippendale said he's looking at property improvements to enhance stream health. First, he said, he began removing invasive species on the banks. The next step, he said, is determining what he might be able to do on land — planting trees, increasing buffers — to enhance aquatic life. His visit to the lab was a step in that direction.

"I'm 67, and I've been interested in biology my whole life," he said.

Zora and her friend, third-grader Gabrielle Rinard, and Gabrielle's brother Kevin looked at different critters under a microscope while her parents looked on. Her mother is a nurse. Her father is a dentist. Zora is leaning toward the scientific fields as well. "I'm planning to be a zoologist, and an ob-gyn, and some other stuff on the side," the fifth-grader said.

Her mother, Ginelle, homeschools Zora, so she doesn't have access to

continued on page 16

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Bugs and the Bay, from p.15

a facility like the one in Frostburg, or to the insects. But a neighborhood stream is home to crayfish. Zora took one home and put it in her fish tank; it didn't work out so well, she said. "That's when I learned I shouldn't pick up wild animals."

After the stream lecture and the closer look at the insects, the crowd lingered, asking Hilderbrand about the bugs they were seeing in their own streams. Many said they planned to return for the next event. That excited Hilderbrand because the lab, set back in the woods a couple miles from Frostburg's Main Street, isn't widely known in the community, despite the important work done there. For example, lab director Eric Davidson is nationally known in part because he is president of the American Geophysical Union, which has more than 60,000 members worldwide. Some other researchers at the lab have become famous in their fields, among them John Hoogland, one of the nation's foremost experts on prairie dogs.

"We're still not that well-known, after we have been here 30 years, as an institution," Hilderbrand said. "So, anything we can do to raise environmental awareness is important."

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Scott Budden Joins Board

Maryland Sea Grant is pleased to welcome Scott Budden to our External Advisory Board. The board advises Sea Grant on our efforts to connect with Maryland stakeholders through our strategic plan and outreach activities. Current members represent key government agencies at the state and federal level, nonprofits focused on environmental conservation and restoration, marine-related industries, and educational and service organizations.

Budden, 32, is an Eastern Shore native with a longtime love of the Chesapeake Bay and its rivers who now has an oyster aquaculture business. He is the founding partner of the Orchard Point Oyster Co., which operates water-column oyster aquaculture leases in Kent, Queen Anne's, and Talbot Counties. Orchard Point focuses on the half-shell market, selling its product at high-end restaurants in Baltimore, Washington, D.C., and Annapolis. The oysters are marketed as Orchard Point Oysters. Budden graduated from Bucknell University in 2007, and was recently featured on its alumni magazine cover for his entrepreneurship. A former media analyst in Washington, D.C., Budden

Kent County Oyster Farmer *Scott Budden brings knowledge, enthusiasm, and maybe oysters to our board.* PHOTOGRAPH, JAY FLEMING

has become active in environmental restoration since returning to the Shore. In addition to his Sea Grant appointment, he serves on the boards of ShoreRivers, a clean water advocacy group on the Eastern Shore, and the Chesapeake Oyster Alliance. When he's not working, he enjoys hunting for waterfowl, oyster shucking, boating, and cooking.

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