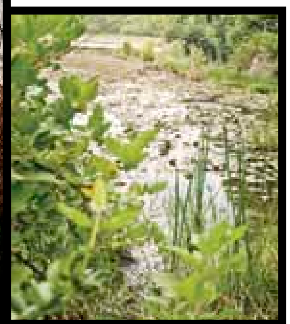

Increasing interest in the issue of acid mine drainage and new funding from the federal government are driving a wave of scientific research that seeks better methods to revive runoff-damaged streams and assess their health.

In the mid-1990s, a small group of practical visionaries set out to do what many said couldn't be done: save a southeastern Ohio creek considered beyond repair after decades of poisonous coal-mine runoff. ¶ That quixotic effort, though remarkably successful thus far, still has a long way to go. As years have passed, however, the work has been supported by an expansion of scientific know-how, much of it the work of Ohio University researchers. ¶ "They're always on the cutting edge of what's happening out there in the reclamation world," says Constance White, Ohio River watershed specialist with the Ohio Department of Natural Resources' Division of Soil and Water Resources. ¶

SCIENTISTS, ENGINEERS, AND POLICY EXPERTS WRITE THE PRESCRIPTION FOR WATERSHEDS POLLUTED BY YEARS OF COAL MINING

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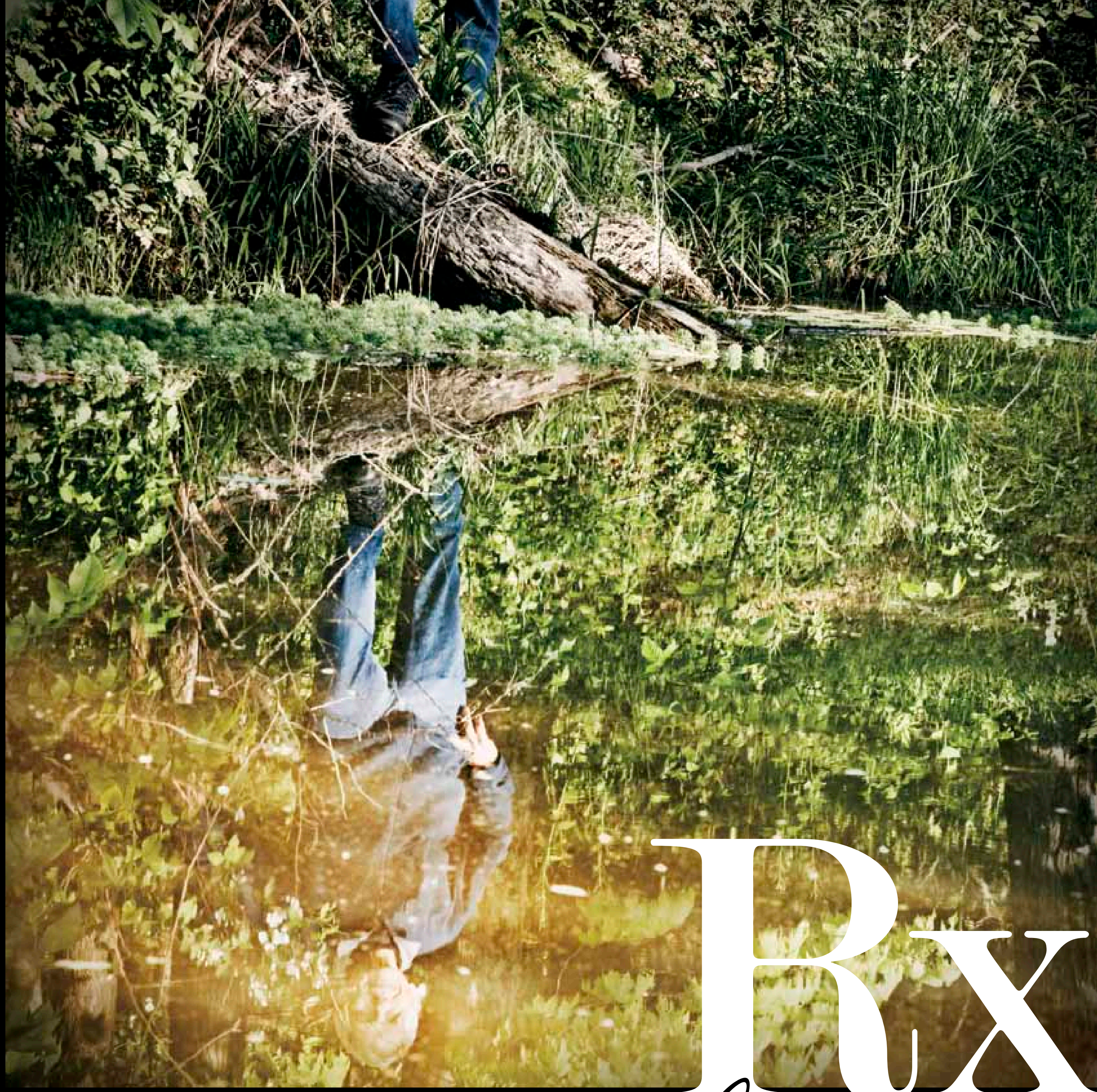

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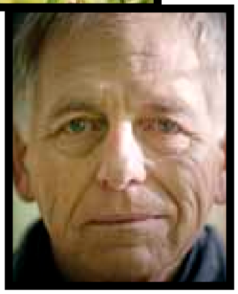
by JIM PHILLIPS

photography by KEVIN RIDDELL



TED BERNARD

Mitch Farley of the Ohio Department of Natural Resources and Ohio University biologist Kelly Johnson sample streams in southeastern Ohio for insects, fish, and other signs of life.

Some 15 years ago an informal coalition of scientists, activists, and state environmental officials, led by now-deceased Ohio University geology professor Mary Stoertz and Mary Ann Borch of Rural Action, ignored conventional wisdom, cobbled together the Monday Creek Restoration Project, and rolled up their sleeves. As recounted by Ohio University environmental studies professor Ted Bernard, they faced a gargantuan challenge. But they turned skeptics into believers by showing that with the right technology and a strong community effort, a stream killed by acid mine drainage *could* be brought back from the dead.

In the process, the Monday Creek Restoration Project—still a going concern, like projects in other area watersheds—has become an inspiration and model for communities that want to clean up their own mine-ravaged backyards.

"By 2008, the Monday Creek Restoration Project had become one of the premier watershed projects in the Eastern Coal Lands," writes Bernard in his newly published book, *Hope and Hard Times*. Tons of dissolved metals and acid have been removed from the creek and its tributaries, the pH has been raised over most of the main stem, and life—fish, bugs, and microorganisms—is coming back.

This is important not only for the environment, Bernard stresses in his book, but

also because a successful effort by a financially impoverished community to bring its streams back to life can help instill pride, and counter the sense of helplessness that sometimes accompanies entrenched poverty.

In the early days, participants in a watershed campaign could do little more than lay the groundwork for a reclamation effort. They inventoried the watershed, wrote a management plan, cleared logjams, set up monitoring sites, reclaimed a "gob pile" of mine waste, and gave presentations in local schools.

In recent years, however, greater interest in acid mine drainage, and increased willingness by the federal government to put money into fixing the problem, are driving a wave of scientific research to find new and better methods to revive runoff-damaged streams and assess their health.

Some methods developed or improved in Ohio University labs are being put to use in the field, while others are still in the exploratory stages. Areas where Ohio University faculty researchers are making contributions include working the glitches out of a method that uses waste slag from the steel industry to lower acid levels; finding better ways to diagnose and monitor the health of a waterway; and even turning stream pollutants into commercial products that can be sold to help finance cleanup programs.

The problem of acid mine drainage (AMD) is complex, but basically stems from millions of gallons of water that have filled up the underground mines found all through the Hocking Valley, a legacy of the coal boom of about 1870-1970. Exposed to oxygen and bacteria, the water reacts with iron sulfides to create sulfuric acid. This acid solution, which dissolves various metals such as iron, manganese, cadmium, zinc, copper, arsenic, and aluminum, creates a lethal soup that can seep into a stream, turn it orange, and render it unlivable for fish, bugs, and other organisms.

The task of AMD reclamation, put in simplest form, is to raise a stream's pH (make it less acidic), clean out the metals, then keep track of whether, and how quickly, living things take up residence again. Raising pH used to be done mostly with limestone beds, limestone being a good source of alkalinity (which neutralizes acids).

Newer methods that have largely supplanted limestone, however, include "active" treatments such as calcium oxide "dosers" to regularly put alkali materials into a stream, and "passive" treatments such as the increasingly popular steel-slag approach. Natalie Kruse and Guy Riefler are two Ohio University researchers who've taken on the challenge of trying to figure out why steel-slag beds work quite well, and sometimes fail quite badly.

Tons of dissolved metals and acid **have been removed** from the creek and its tributaries, **the pH has been raised** over most of the main stem, **and life** —fish, bugs, and microorganisms—**is coming back.**

"Some of them are clogging, but some of them aren't," explains Jen Bowman, environmental projects manager for Ohio University's Voinovich School of Leadership and Public Affairs, who serves, in her own words, as a "resource person" for the handful of watershed groups in the counties around Ohio University. "Some of them are hardening but still working; some of them are clogging and not working."

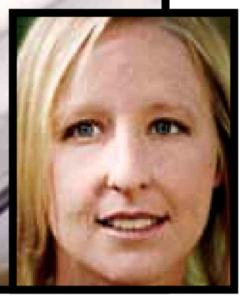
Steel slag, a crust that forms on steel as it's being processed, looks like a waste product to the steel industry—but to someone wanting to reduce acidity in streams, it's a godsend.

Compared to limestone, says Mitch Farley, manager of ODNR's acid mine drainage program, steel slag provides "an order of magnitude more alkalinity—10 times at least. If we could perfect the use of steel slag effectively, we would get 10 times the bang for the buck, so to speak."

To make it even more attractive, steel mills practically give the stuff away—the major cost in using it is trucking it to your site. Typically a pit is excavated, lined, and filled with slag, and clean water, from a side stream or other source, is run through it to pick up alkalinity. That alkaline water then flows into a stream with acidity problems, to neutralize it and precipitate out any dissolved metals for removal.

Unfortunately, when water runs through steel slag, the slag has an unpleasant habit of gluing itself into a mass, which means that a bed full of it will often harden. Riefler, an associate professor of civil engineering, and Kruse, an assistant professor of environmental studies at the Voinovich School, are taking different but parallel approaches to solving the problem—Riefler trying different mixtures of particle sizes, and Kruse trying combinations of steel slag with other materials.

Of the various steel-slag beds in use in creeks around the region, Riefler notes, "some of them are working great, but some are



NATALIE KRUSE

By using engineering strategies to clean heavy metals out of streams and raise the pH of the water, researchers hope to make watersheds habitable for fish and other wildlife.

performing poorly for a variety of reasons. It's very strange; it's not at all clear what the cause is."

Riefler faces very practical problems in his research; while steel mills are happy to get rid of slag, he notes, they're not willing to sort it by chunk size. "We're a small market for them," he says. "And you know, they're giving it away to begin with. It's one of the limitations of working with a free product."

Kruse—who at age 25 has been working on acid mine drainage since Stoertz took her and her brother to a mine site when she was 10—notes that there are other questions to be answered about steel-slag beds, such as their probable longevity. "We're not 100 percent sure of things like their lifetime," she admits. "How long will they last? How long will they be producing alkalinity?"

As important as treating the AMD problem is keeping track of the treatment's effectiveness. Contributing to that effort is Kelly Johnson, American Electric Power Watershed Research and Reclamation Professor at the Voinovich School. She has written a manual to help nonscientists properly use a sampling method called the Macroinvertebrate Aggregated Index for Streams (MAIS), which measures the health of a stream by looking at its macroinvertebrates—basically insects and other nonmicroscopic creatures without bones, such as crayfish.

A decade ago, state agencies relied more on chemical testing to assess stream health. In recent years, however, biological sampling has come to be considered more reliable. The Ohio EPA's "gold standard" of testing uses fish, but Johnson is convinced that bug sampling with the MAIS is very nearly as accurate, as well as cheaper, easier, and quicker.

"It's the easiest," she says. "The fish are really good indicators too, but it's not so easy to collect fish data ... We filled a niche with good data that can be collected more frequently."

While the MAIS "has a strong scientific background; it was developed using some fairly complex statistical methods," Johnson says, "it is something that moderately trained people can use." She helps train samplers from organizations such as the nonprofit Rural Action and local watershed groups. To collect samples that meet state standards for credible data, she says, is "as easy as cooking if you are careful and follow the protocol."

"You walk people through it," she explains. "You have to show someone how to use the net and recognize habitats, and how to pick animals from the net carefully, but you can do that in a day."

After volunteers are trained, they usually work their first season on a crew with more experienced leaders before sampling on their own.

Johnson notes that the next step will be to try to pry more information out of the macroinvertebrate data collected over the years, to see if a model can be developed to help predict the path of a stream's recovery.

"The cool thing is, we couldn't have done this 10 years ago, because we didn't have the data," she enthuses.

Nate Schlater, water quality specialist for Monday Creek Restoration Project, is one of the nonbiologists who gets to collect macroinvertebrates. He says bug-based monitoring seems to be a more sensitive indicator than chemical testing, and is showing improvements in many stream areas.

"We're absolutely getting better results during the last four, five, six years," Schlater says. "This is a big identifier of a good stream."

Though it may be a while before it's used in the field, an approach being studied by Morgan Vis, a professor of environmental and plant biology, and graduate student Nathan Smucker could one day provide additional information that could improve the assessment of stream recovery.

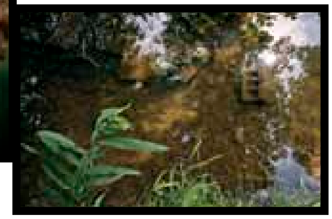
Vis and Smucker look at diatoms—ubiquitous, microscopic, single-celled organisms. Their plan of attack is to profile the diatom populations in streams largely unimpacted by mining or agricultural runoff, then compare how diatoms in a polluted stream deviate from this unimpacted condition.

"Basically we looked at the best streams in the region, and what the diatom communities in those streams were like," Smucker says, adding that "we really do see dramatic changes in the diatom community" between clean and polluted streams.

Vis notes that diatoms have some definite attractions as a biological indicator—including the fact that they're present virtually everywhere on Earth. "The good thing with diatoms versus other types of algae is, if you go to a stream, you're going to find diatoms," she says. "With some other groups of algae, you don't see them in every stream."

Smucker points out that with around 20,000 different species of fresh-water diatoms known, there's a large range of environmental conditions for diatom populations to fluctuate in terms of the presence, absence,

GUY RIEFLER



Through such collaboration, **Ohio has become a model** for other states of how to do watershed reclamation right.

and abundance of different species. A highly acidic stream, for example, might favor the ascendency of six or seven abundant species known to thrive on low pH.

While Vis and Smucker count populations of creatures so tiny they can be seen only with a microscope, another Ohio University project works on a much larger scale—dealing with the giant mounds of waste that's hauled out of AMD-polluted streams. With help from Matthew Friday, an assistant professor of art, Riefler aims to turn lemons into lemonade—or more precisely, iron-based sludge into marketable art supplies.

When iron precipitates out of an AMD-impacted stream, it's good for the stream's health—but you're left with a lot of iron oxides to dispose of. The treatment also costs money. So why not solve both problems by selling the sludge?

Friday recalls Riefler bringing him a jar of the reddish powder and telling him, "I think we might be able to use this for something." Friday's response was that "it looked very much like something I'm used to using," which makes sense, given that iron oxide is one of the oldest pigments known to humans.

By mixing it with either linseed oil or acrylic binders, he got a usable paint, though "the particle size was a little big." But that was enough to inspire Riefler and Friday to apply for grants to establish a pilot plant at the Truetown mine site outside Chauncey to develop pigment for commercial marketing.

"We've got to find a way to dispose of this sludge," Riefler observes. "And running a treatment plant is very expensive, so we've got to find a way to pay for that."

One project helpful to anyone working on the AMD issue is a website managed by the Voinovich School—watersheddata.com—into which different researchers can enter data on streams. Bowman says the site covers Monday, Sunday, Raccoon, Huff Run, Rush, and Yellow creeks, and soon will include Moxahala and Leading creeks. Vis notes that even data on diatoms, which aren't yet extensively used as a monitoring tool, can be accessed.

"All of the researchers can put their data into this," Vis says. "You can see all of the data on fish, macroinvertebrates, and chemical water quality, and it's kind of at the push of a button."

One reason these creative research projects can happen is that the funding environment has improved in recent years, due to the federal government's decision to re-authorize a severance tax on the mining industry. Revenue from the tax goes to fund reclamation of abandoned coal mines, and the government also is disbursing moneys from the tax that had been withheld in previous years. This has meant a major influx of federal funds into states such as Ohio that have suffered serious mining impacts.

Farley of ODNR says based on current projections, the federal grant to Ohio for abandoned mine land projects should increase every year until 2013, when it will peak at around $18.6 million.

With their experience in this area, Ohio University researchers are well-placed to take advantage of the situation with further research into watershed reclamation. Kruse, for example, has just begun to look at how aluminum in streams may adversely affect fish, and how it might best be removed. "That's like another 10 years of research," she predicts.

The collaborative effort among university faculty, state officials, and citizens groups already has shown remarkable results and promises more in the future. Among Ohio University researchers, cooperation takes place through an informal network called the Appalachian Watershed Research Group. It includes Vis, Smucker, Johnson, Bowman, Kruse, geologist Dina Lopez, geographer James Dyer, and Ed Rankin, a senior scientist at the Voinovich School. Rankin not only created a qualitative habitat analysis and was instrumental in developing the database, but also has a deep understanding of state water quality regulations after spending more than a decade researching and analyzing Ohio's water quality laws during his time as a senior scientist at the Ohio Environmental Protection Agency.

Through such collaboration, Ohio has become a model for other states of how to do watershed reclamation right, says David Hanselman, chief of the ODNR's Division of Soil and Water Resources. "I think we're quite proud of the structure we've created to support the development of local watershed action plans," he says.

White of Soil and Water Resources adds that Ohio University researchers have played, and will continue to play, a major role in keeping Ohio at the forefront of this important effort.

"I can honestly say it puts us ahead of the game having that research," she says, "and having the university there."