If we treat agricultural pollution with a scalpel instead of a hatchet, we might have a fighting chance of cutting the flow of fertilizers into rivers, lakes, and coastal waters.

Precision Conservation

by John Carey

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When Katie Songer started cold-calling farmers

in Wisconsin's Pleasant Valley in 2008, she was the messenger for an uncomfortable truth. It wasn't just that nutrient pollution from agriculture was choking rivers and lakes, causing harmful algal blooms and creating oxygen-free "dead" zones the size of small states along the nation's coastline. The starker fact was that the more than $4 billion Congress had been typically spending each year on conservation in a series of Farm Bills was barely making a dent in the problem. In those federal programs, farmers receive payments for taking steps such as voluntarily restoring wetlands, setting aside land from cultivation, or adding buffer zones along streams. Since the early 1990s, farmers have restored more than 2 million acres of wetlands, put more than 31 million acres into conservation reserves (though often just temporarily), and built hundreds of thousands of miles of buffer strips. Yet toxic algal blooms have kept getting bigger and more frequent.

One of the main reasons, scientists realized, is that most of the nutrients flowing from fields and pastures come from a small percentage of farms—about 15 percent, some studies showed. And those farms usually are not the ones that implement programs under Farm Bill conservation provisions, which are strictly voluntary. "Sixty percent of landowners could sign up for conservation practices and accomplish exactly nothing," says Rich Bowman, director of government relations for The Nature Conservancy in Michigan.

So researchers have begun to talk about a new approach, dubbed "precision conservation." The basic idea: identify from which farms—and exactly where on each farm—nutrient pollution is coming, and then figure out how to stop the flow. Unlike Farm Bill programs, which are evaluated in terms of miles of buffer installed or acres enrolled in reserves, precision conservation's effectiveness is measured in terms of the amount of nutrient pollution that actually enters waterways. "The culture of these federal programs is that they are seen as more of a benefit to farmers than to the environment," says Craig Cox, former executive director of the Soil and Water Conservation Society, who was among the first to use the term "precision conservation." So there's an urgent need to target the money on actual problems, he says.

Sounds great in theory. But making it work in the field requires a wholesale shift in farm policy. Instead of waiting for farmers to walk into the feds' conservation offices, precision conservation requires experts to go out into the field to identify and fix spot problem areas—some as small as a few hundred square feet—where nutrient pollution pours into creeks and streams. Yet it's not as impractical as it may seem. The idea has been getting a boost both from early trials and from new technologies that can help spot and eliminate pollution hotspots with surgical accuracy.

Katie Songer was part of a team conducting one of the first big tests of precision conservation on the ground. It was a project born in a tense clash between Wisconsin's natural resource agency and the state's farmers in the early 2000s.

Like most states, Wisconsin had a growing water pollution problem. Phosphorus and other nutrients pouring into creeks and streams were causing harmful algal blooms in rivers and lakes. The mounds of rotting *Cladophora* algae on the Lake Michigan beaches of Cleveland, Wisconsin, were so thick, for instance, that the town had to dig paths though the sludge with backhoes before boats could be launched for a fishing derby. Trying to tackle the worsening water quality in the state, the natural resource agency had asked the legislature to require all farmers to put 30-foot-wide buffer strips along streams to reduce nutrient runoff. No way, the farmers retorted.

Into the fray stepped Pete Nowak, professor of environmental studies at the University of Wisconsin, Madison, and a self-described "subversive conservationist." Taking on sacred cows on both sides of the conflict, Nowak brought the warring farmers and government conservationists together—along with environmental groups and scientists—in a project called the Wisconsin Buffer Initiative (WBI). He snared a $629,000 three-year federal grant for the project. His team ranked the state's 1,598 watersheds for pollution problems and quickly zeroed in on phosphorus runoff as a major problem. More important, the team suspected that most of the pollution from agricultural runoff was coming from as few as

10 to 15 percent of the farms. So Nowak recommended targeting just those farms with outreach, funding, and conservation measures.

Meanwhile, The Nature Conservancy had been looking to start a precision conservation project in southwest Wisconsin, in a departure from its normal focus on just buying, preserving, and restoring land. The group worked with Nowak and the WBI to pick two similar watersheds feeding into the Pecatonica River. Each had farm fields and pastures with the potential to dump high levels of phosphorus into its creeks and streams. Using leftover WBI money, Nowak brought in the U.S. Geological Survey to install nutrient pollution monitoring instruments in each watershed. Then The Nature Conservancy was able to raise more than $800,000 from the McKnight Foundation and the Monsanto Company for the effort; it also contributed countless hours of staff time.

The plan was to leave one watershed alone as a control. In the other, researchers would go from farm to farm to find the biggest sources of pollution, then figure out how to stop the flow. Contacting the 62 farmers in the Pleasant Valley watershed and convincing them to participate was the job handed to Katie Songer, then a graduate student at the University of Wisconsin.

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The area, a pretty landscape of rolling hills and valleys, burbling creeks, well-manicured farms with red barns, and picturesque towns such as New Glarus, which bills itself as America's Little Switzerland. Generations of farmers have raised dairy cattle and grown crops there. It's not an easy living: many of today's farmers work several jobs. Gary Baumgartner, 67, grows corn, soybeans, wheat, and alfalfa on 1,000 acres and also works full-time for a seed supplier. Scott Jelle, 45, raises beef on a farm that's been in the family for 120 years—while also running a landscaping business and directing public works for New Glarus. These men, and their families and neighbors, say that they care deeply about the land and the environment. "It's beautiful country and we want to try to keep it beautiful," says Baumgartner.

But Songer was bringing them a disturbing message: some of the 62 farmers in Pleasant Valley were inadvertently polluting the creeks and streams with significant amounts of phosphorus and sediment. Not surprisingly, she recalls, she found the farmers "guarded" at first. "Us old farmers, we kind of got a mind of our own," says Baumgartner. "When she called, we wondered, what are we getting into?" She had a few doors slammed in her face, says Nowak.

Once Songer got through the door, though, she earned their trust. "Katie was able to get into kitchen tables that some of the older fellows couldn't," says Dane County conservationist Pat Sutter. When the team got to work taking soil samples and observing the operations, the results confirmed the underlying premise of precision conservation. Ten of the 62 farms were the source of most of the phosphorus flowing into the creeks and streams. The team then approached those farmers carefully. "We wanted to avoid the typical agency approach that we're from the government, you have a problem, and we're here to help," says Nowak. "One of the things that we have traditionally failed to do is capture the problem-solving capacity of farmers."

Nine of the ten farmers eventually agreed to make changes—spurred by federal, state, and nonprofit dollars and by the chance to make their operations both more efficient and more environmentally sound. Some, like Jelle, became downright enthusiastic. On his farm, cattle tromping through Lee Valley Creek had been creating a muddy, manure-laden mess. Plus, rainwater flowing over the cattle's feeding area had been carrying manure down into the creek. So Jelle and the conservation team fenced off the creek, except for two reinforced cattle crossings. They constructed a building up on a hill and surrounded it with concrete and gravel to create a place to feed the cattle. That kept manure away from the waterway.

The day after the fences went up, "the creek was so much clearer," Jelle says. "It was an immediate good feeling." The fencing also solved the problem of cattle getting stuck in the mud when calving, and it enabled him to rotate the animals among different pastures.

On Gary Baumgartner's farm, the solution was to switch from traditional plowing to "no-till" agriculture (where the ground is left intact with the stalks of the previous crop) and to apply just the amount of fertilizer indicated by soil-sampling data. The new practices were an adjustment for Baumgartner and his son, Kevin. But the changes are paying off in less tractor fuel needed, lower costs for nutriments, and "a lot less runoff," Baumgartner says. "It makes a tremendous difference."

Not everyone was as responsive as Jelle and Baumgartner. When the project started, Paul Kittleson was totally opposed. He even tossed the government soil conservationist off his dairy farm. But then he saw how two of his upstream neighbors—and the stream that flowed from their farms–were benefiting from improvements on their land. And he knew that when the rains came, water flowed through his barnyard, washing manure through a culvert and into Kittleson Valley Creek. He agreed to put in a catch basin, a grass waterway, and a buffer strip, creating two collection points to trap the manure.

All told—and with the help of additional funding and staff time from USDA's Natural Resources Conservation Service—the project converted 2,100 acres of cropland to no-till, installed eight barnyard-runoff systems, fenced off livestock from more than four miles of streams, and added 14 cattle crossings to the streams between 2010 and the end of 2012.

In the nearby Ridgeway Branch "control" watershed, in contrast, it was business as usual. A few farmers continued to participate in voluntary federal conservation programs, but there was no effort to pinpoint problem areas and concentrate resources on them.

Now the researchers will monitor whether the stream gauge at the exit to the Pleasant Valley watershed shows a significant drop in phosphorus and other pollutants, compared to the gauge at the "control" watershed. Given that the pollution readings vary tremendously depending on the weather (big storms bring spikes in runoff and pollution) and also reflect years of previous pollution, determining the ultimate successes of the precision conservation experiment will require several years of measurements.

Modeling by The Nature Conservancy, the USGS, and the University of Wisconsin suggests that the eventual effect should be dramatic—phosphorus levels should drop by 25 percent or more. "We've done a great job of targeting fields and pastures, so there's a lot less runoff," explains Steve Richter, The Nature Conservancy's director of conservation for southwest Wisconsin. And the anecdotal evidence is striking. Already "there's a big difference," says Dane County's Pat Sutter. Kittleson Valley Creek used to be murky where it merges with Pleasant Valley Creek. Now, the water runs clear. "We've taken some before-and-after photos that are staggering," Sutter says.

If the project does succeed, it will be one of the first real victories in the fight to slow the nutrient-driven decline in the nation's water quality. The hope is that the idea will spread, spurred by both new technology and the urgent need to do more with less money. "The whole world of conservation is changing as funding is drying up," says Jeff Allenby, conservation planner at the Chesapeake Conservancy.

And that's where precision conservation is intriguing, especially because it also dovetails with another trend sweeping across the farming community for economic reasons—precision agriculture. Using yield sensors, GPS- and autopilot-guided tractors, variable computer-controlled sprayers, and other technologies, farmers can apply just the needed amount of fertilizer and water to each small patch of field. "Precision agriculture is just taking off," says Colorado State University soil scientist and founder of the International Society of Precision Agriculture, Rajiv Khosla. "It's making our agriculture more productive, more efficient, more profitable, and more sustainable." Surveys show that up to three-quarters of American farmers are now using at least some precision technologies, with gains in both productivity and environmental benefits.

Farmers used to think, for instance, that low yields on parts of their fields meant they should dump more nitrogen on those areas, says Ohio crop consultant Joe Nester. Dead wrong, the data have revealed. The low productivity is due to poor soils or other problems, not to lack of nitrogen. So the right tack is to use less nitrogen on those spots, leaving less to flow into streams. Similarly, consultants and farmers learned that applying phosphorus on frozen ground is an invitation to increased runoff—and a waste of valuable fertilizer. Nester has been working with farmers to change their practices, saving them up to $25 per acre in fertilizer costs. "The economically right thing to do is also the environmentally sound thing to do," he says.

New technologies are also increasing farmers' abilities to sense how plants are faring—and then to deliver the precise doses of water and nutrients that the crops require, says Khosla. Obviously, plants can't tell you what they need. But illuminating plants with specific wavelengths of light, and then measuring the absorbance of the light and fluorescence that is induced, provides crucial clues about the crops' health. The first such sensors worked well only in the dark. But one of Khosla's experiments recently showed that sensors (made by the French company FORCE-A) using multiple wavelengths of light can provide a detailed assessment of plants' health and needs—even in broad daylight. The results were so "unbelievable that I had my post-doc repeat the study," Khosla says. Feed the information from such sensors, mounted on the front of a tractor, to the fertilizer sprayers on the back, and "farming by the foot becomes a reality," he says.

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Reducing fertilizer use is only part of the solution to the pollution problem, though. A lot of nutrient runoff occurs during heavy rains and other extreme weather events, which are becoming more frequent with climate change. So traditional, tried-and-true approaches—such as no-till farming; planting cover crops; and installing buffers, catch basins, and other structures or devices to slow the flow—are still vital. The trick is to put them precisely where needed.

That's where high-resolution imagery from satellites and light detection and ranging (LIDAR) systems comes into play. The conventional wisdom used to be that steep hillsides were the source of most of the runoff into waterways. Wrong again. "It's the flat areas where water builds up, where we get runoff," explains Cornell University biological and environmental engineer Todd Walter. Map the topography and soil type of an area, and it's possible to precisely chart the slight dips in those flat landscapes where most of the runoff occurs. That information may prove especially useful in the Chesapeake Bay area, where up to 60 percent of the bay's nutrient pollution comes from headwater areas. Many of those headwaters are still unmapped for runoff flow, says the Chesapeake Conservancy's Allenby, who coauthored a recent report on the role of technology in precision conservation.

The Chesapeake Conservancy is now using these technologies to map water flows and target pollution hotspots in the Nanticoke River watershed in Delaware and Maryland. Out in the field—using iPads to overlay contour lines, aerial photos, and exact GPS locations—the researchers identify low spots that may otherwise be hard to see. After taking pictures and uploading them to the master map, they can suggest remedial action—such as adding buffers or cover crops—to slow runoff across those low spots.

More tools are coming. Researchers at Intel, one of the high-tech companies that have been working with the Chesapeake Conservancy, are now developing sensors to measure nitrogen, phosphorus, and turbidity and then wirelessly transmit the data to researchers. The immediate challenge is to bring down the cost, now about $500 per device.

Of course, the best technology and intentions are of no help unless the underlying policies are supportive. The grand vision of the precision conservationists is to flip usual government practice on its head. Instead of paying for programs in general, pay only for results or for conservation approaches proven to work. It's basically a government version of "Moneyball," the baseball notion of fielding a team based on hard data, not hunches. And this reset is needed not just for farming, but also for everything from medical treatments to social programs. "Less than $1 out of every $100 of government spending is backed by even the most basic evidence that the money is being spent wisely," argue the Obama administration's former Office of Management and Budget director Peter Orszag and the George W. Bush administration's former Domestic Policy Council director John Bridgeland in a recent *Atlantic* story. Improving on that ratio doesn't seem like such a difficult target for precision conservation to hit. ❧

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