Science Societies

Wetlands on the farm: potent, nutrient-capturing tools in (relatively) small packages

By Kristen Coyne

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Half a century ago, in response to burning rivers and other high-profile environmental disasters, the U.S. Congress passed the Clean Water Act (CWA) as a means to protect waterways from sea to shining sea. Commemorating that landmark legislation, the *Journal of Environmental Quality* this year has published a collection of papers celebrating the CWA. *Crops & Soils* magazine will highlight some of that work this month with a look at how one on-farm management practice—constructed wetlands—can significantly reduce water pollution from tile-drained farms. In many states, particularly around the Great Lakes, tile drainage is a common and growing practice that increases yields but also funnels excess nitrogen and phosphorus into waterways, resulting in harmful downstream effects as far away as the Gulf of Mexico. A central Illinois study found that, by setting aside a very small portion of their fields for wetlands, farmers could cut nutrient losses in half.

This fall, as the air begins to cool after a hot, dry summer, ears of field corn will be hanging from brown, brittle stalks ready for harvest on a small central Illinois farm. Landowner John Franklin will owe his yield, in no small part, to his farm's former life as a wetland, which enriched the underlying soils over the many centuries preceding their conversion.

Photo by Tim Lindenbaum.

That occurred back in the 1950s, when Franklin's father readied the land, previously used for grazing, for crops. As had many of his neighbors since the mid-1800s, he dug trenches several feet deep and buried tiles to drain excess subsurface water into nearby tributaries, creating a much more hospitable environment for his crops' roots. In fact, by installing drain tiles below some 12 million acres of crops, the elder Franklin and his Prairie State peers created some of the most productive agricultural land in the country.

"In order to farm that, they had to drain them," explains the younger Franklin, the fifth generation to work his family's land outside Bloomington.

However, drainage tiles (the term harkens back to when the now plastic tubing was made of clay) turned out to have a by now well-documented downside. "The negative effect was that now the water just flushes in much higher volume down to the rivers and streams," Franklin says, "without that ability for the soil to hold on to the water and let it filter."

With that water, of course, flow excess phosphorus and nitrogen from commercial fertilizer and manure. At the Franklin farm, until relatively recently, the water streamed into Turkey Creek, then to a series of ever bigger rivers—the Mackinaw, Illinois, and Mississippi—before gushing into the Gulf of Mexico. There, joining torrents of nutrient-rich water from both tiled and untiled farmland across the vast watershed, it contributed to a **dead zone now the size of Connecticut**.

Over the decades, lawmakers have attempted to protect the nation's waters from such devastation. Around the time Franklin's dad started installing tile drains, Congress passed the Federal Water Pollution Control Act, which sought to stem the flow of municipal and industrial waste into waterways. But the legislation was weak and waste continued to flow, eventually compelling Congress to try again. Fifty years ago this October, they beefed up the 1948 law with a series of amendments that became known as the **Clean Water Act** (CWA).

As did the original act, the CWA focused on major pollution from municipal and industrial waste but added regulatory and budgetary teeth that today are credited with **dramatically improving the nation's waterways**. But while sinking its fangs into those major "point sources," the CWA merely nipped at the boots of farmers. With agriculture and other "nonpoint" sources of pollution, the 1972 legislation opted for carrots over sticks, such as guidance and funds incentivizing producers to adopt practices that help staunch the flow of nutrients.

Over the years, though, the CWA's success with big polluters shifted attention to farm-driven pollution. "It wasn't until the point sources got cleaned up that people began to understand the true contribution of nonpoint sources," says Maria Lemke, director of conservation at The Nature Conservancy's (TNC) Illinois chapter.

Today, most water pollution originates at nonpoint sources, according to the USEPA, which enforces the CWA. Almost half of all impacted rivers suffer only from nonpoint pollution, which also includes urban and construction runoff. For the other half, nonpoint **sources likely account for most of the pollution**.

Conditions are particularly challenging across Illinois and the rest of the Upper Mississippi River Basin. The area features some of the lowest wetland densities, most extensive tile drainage, and highest surplus nitrogen–producing lands in the country as Lemke and her co-authors note in a recent paper (**https://doi.org/10.1002/jeq2.20316**) on constructed wetlands in the *Journal of Environmental Quality* (JEQ). The article, part of a JEQ series marking the CWA's 50th anniversary, examines how adding small wetlands on farms can help.

Water flows out of a tile drain into a nearby ditch. Photo by Jane Frankenberger.

As tile drainage use grows, mitigating its effects becomes increasingly important. Some **56 million acres were reported as being drained by tile in 2017**, a 14% increase over 2012, according to the USDA Census of Agriculture. The highest rates are around the Great Lakes with Illinois reporting a 39% uptick.

"Those tiles are never coming out: That's a given," says Lemke, who has worked with area farmers like John Franklin for more than two decades. "So how do we reach water quality goals and nutrient loss reduction goals in a voluntary environment? What is it going to take, and how do we make that most efficient?"

Underlying Issues

These land management questions intersect in complex ways, says **Deanna Osmond**, a professor and department extension leader in the Crop and Soil Sciences Department at North Carolina State University.

“If you are going to really control nonpoint source pollution, you need to know what practices are going to work on the pollutants of concern,” begins Osmond, who studies agricultural pollutants. “And how do you stack the practices to increase the effectiveness? Then you need to get everybody in the watershed rowing in the same direction relative to those conservation practices.”

“That,” Osmond adds, “rarely happens.”

Lemke wants her part of the watershed to be an exception. She has been passionate about ecology since dreaming of becoming a marine biologist as a University of Oklahoma undergrad. When a professor mentioned that only **about 1% of the planet’s freshwater is available for humans**, she jumped ship (or, jumped *scholar*ship, if you will) from oceans to rivers and lakes.

“I thought, ‘Wow, we really need to conserve that,’” Lemke recalls.

Ashley Maybanks, Maria Lemke, and Adrienne Marino perform cover crop surveys in spring 2019. Photo by Krista Kirkham.

With that mindset, she began partnering with central Illinois farmers in the early 2000s to test ways to reduce runoff, including conservation tillage, grassed waterways, and stream buffers. Their outreach conducted during the seven-year study led some farmers to adopt the practices, a success in and of itself. But in the streams, the impact was disappointing. “We were not seeing any improvements,” Lemke says.

While the surface practices snagged some nitrogen and phosphorus attempting escape by land, most of it snuck out through tunnels, like prisoners outwitting the guards. “That led us to focus more on the tile drainage systems because those are underground,” Lemke says.

That meant upping her game by constructing wetlands, a much bigger ask of farmers. She would need good partners, and she would need time.

Partner Power

Although wetlands once covered **a quarter of the state of Illinois**, most are long gone, largely converted to farms like the Franklins’. Lemke and her team wanted to restore just a fraction of that acreage back to strategically placed wetlands that would filter water from the tile drains before it flowed downstream and then measure the results.

But finding farmers to test conservation practices isn’t easy. Sometimes, it’s not even clear whom you need to convince, explained TNC aquatic ecologist Krista Kirkham, a co-author on the JEQ study.

“You’re often dealing with multiple landowners, possibly a farm manager and then also a tenant,” Kirkham says. “There could be 5 to 10 people making a decision on a single farm.”

That decision can seem even more fraught when you tally up the costs of constructing even a small wetland. You’re easily looking at tens of thousands of dollars, Kirkham says, a tough sell for farmers who will see no financial benefit from the practice.

This is where those carrots come in. Funds are available from a variety of private and government sources, including through the USDA’s **Conservation Reserve Program**, for farmers willing to give conservation practices a try. This helped convince the Franklins to sign on.

“As long as these practices are voluntary—and I don’t see that changing—then we really need to think about what works for the landowners economically,” Lemke says. “They’re making a living out there, so we have to really consider what works for them and understand that better.”

The price tag drops considerably if a farmer can construct wetlands while installing tiles when the heavy machinery is already on site, Lemke notes. And Mother Nature handles most of the maintenance for free. “It’s a set-it-and-forget-it practice, for the most part,” Kirkham says.

Soon after the experimental wetlands were built at the Franklin Research and Demonstration Farm, indigo buntings and other native wildlife began to reappear. Photo by Tim Lindenbaum.

Of course, the longer you can stretch out the benefits of a conservation practice, the more cost-effective it becomes. And thanks to 12 years of measurements, Lemke and her coauthors had the longitudinal data to answer that question, too.

Small Wetland, Big Impact

The study took place at the **Franklin Research and Demonstration Farm**, a 250-ac tract owned by the Franklins and partnered with TNC and the University of Illinois. The researchers built three wetland areas, each made up of three interconnected “cells” from a quarter to three-quarters of an acre in size. This allowed the team to compare nutrient levels after water had drained through one, then two, then all three cells. Each cell represented 3% of the total cropland served by the drain tiles.

After analyzing a dozen years of data, the team found that even a single cell proved a fine filter, reducing nitrates by 15–38% and phosphates by 53–81%. Tacking on the additional cells further boosted results although at a lesser rate; 3–6% of total cropland was the sweet spot.

The important take-home message, according to Kirkham: “These wetlands work at reducing nitrogen and phosphorus levels from tile drainage, and they don’t have to be very big to work.”

In a 2016 study in JEQ (**https://doi.org/10.2134/jeq2015.06.0321**) measuring how well stream buffers mitigated runoff from North Carolina farms, Osmond came to a similar conclusion: Smaller-scale efforts can have an outsized impact.

“Fifty feet was better than 25 ft, but it wasn’t twice as good in reducing nitrogen, so you see this diminishing return as your buffer width increases,” she says. “Really, the maximum buffer width you needed was 50 ft as opposed to 100 ft that many people were recommending.”

But in addition to knowing how well conservation practices work and how much land they require, there’s another big question: How long do they last? In her own 12-study, for example, Osmond learned that stream buffers work slightly better over time, and kick in right away. Lemke’s study also benefited from a long-term look at the issues.

“They have this longitudinal analysis, which I think is really important,” Osmond says. “Because the question is, when these things are constructed, do they work immediately? Or does it take time for them to gear up? Or will they start failing over time?”

That’s a particularly challenging question for phosphorus. Unlike nitrates, which are transformed by bacteria and released into the atmosphere, P remains in the system unchanged. As a result, according to some studies, wetlands can eventually surpass the “full” line and flip from P sink to P source.

But after more than 12 years of data, Lemke has encouraging answers. Because their setup excludes surface runoff, and because the clay soil there contains lots of iron, aluminum, and other elements phosphorus binds to, the Franklin farm wetlands are still welcoming P. “We’re finding that they’re still doing a great job,” Lemke says.

There was one outcome of their experiments that Lemke’s team did not measure. Yet to conservationists Lemke and Kirkham, it was the most rewarding. It was also the most visible—and audible—study result as cattails and rushes begin popping up; as red-winged blackbirds and pollinators start flitting among them; as chorus frogs begin serenading and turkeys began gobbling. Out of a monoculture grew a diverse oasis.

“You’d be amazed how fast creatures find these little wetlands in the middle of a cornfield,” Lemke says. “Overnight almost. It’s incredible.” Productive farmland *and* wildlife habitat? “You can have both,” she says.

Incentives, Intangibles, and the Path Ahead

That metamorphosis makes for a powerful image. But many questions and challenges remain before a peaceful and profitable juxtaposition of maize and muskrats, soybeans and sedges can be realized on a watershed-saving scale. How much will the heavier, more frequent rains of climate change exacerbate conditions? Can smaller studies translate to larger scales? What are the best combinations of conservation practices? And will carrots be enough to get farmers to adopt them?

Three constructed wetlands, each made up of three interconnected “cells,” at the Franklin Research and Demonstration Farm. Even one cell filtered significant amounts of nutrients from water coming from adjacent tile-drained farmland. Photo by Tim Lindenbaum.

“The timing of application, moving from fall to spring, could have a big impact … on what’s running off through the tiles, and when,” says Maria Lemke. Photo courtesy of Adobe Stock/chas53.

Mike Wallace (left) of the University of Illinois Urbana-Champaign and Krista Kirkham of The Nature Conservancy collect water samples at the Franklin Research and Demonstration Farm in January 2015. Photo by Tim Lindenbaum.

Soon after the experimental wetlands were built at the Franklin Research and Demonstration Farm in central Illinois, muskrats and other native wildlife began to reappear. About 40% of the state's threatened and endangered species need wetlands for part of their life cycle. Photo by Tim Lindenbaum.

Lemke and others are trying to answer many of these questions in their ongoing research.

No single conservation practice can fix agricultural pollution, and Lemke and others are studying how to stack practices to improve impacts. Farmers should couple wetlands, stream buffers, or other edge-of-field practices, she explains, with in-field practices such as cover crops and later fertilizer applications.

"The timing of application, moving from fall to spring, could have a big impact, we think, on what's running off through the tiles, and when," Lemke says.

A constructed wetland at the Franklin Research and Demonstration Farm, June 2019. Photo by Krista Kirkham.

There were advantages to limiting experiments to a small farm. For example, the researchers discovered that, during corn years (which alternate with soybean), 80% of nitrate losses occurred between March and June, a finding they could tease out only from farm-scale data and that could empower the producer to develop solutions specific to that problem and that timeframe.

Still, expanding this research to the entire 744,000-ac Mackinaw watershed is the logical next step, Lemke says, which raises the challenge of finding farmers to help.

“It’s very heartening to see that you can get good results from these small wetlands,” Osmond notes. “But in order to get an overall benefit of water quality, they’ve got to go in many, many different places.”

Inspired by the miniature oases on the Franklin farm, Lemke hopes others will see the benefits.

“That could be the case on so many farmlands,” Lemke says. “There can be habitat and farmland that work together, and it’s just amazing to walk out there on the farm and see a bunch of turkey run across the field or pheasant flying up, or you can hear all the frogs calling in a pond right next to a cornfield.”

“You wouldn’t get that in most cornfields,” Lemke adds.

Franklin knows farmers need to maximize efficiency and might see even a small wetland as “just something to farm around.” But he appreciates the “intangible” value of the wetlands.

“I think that probably comes also from having the ground in the family for a long time, and with the idea that it could be there for another 100 years or more,” says Franklin, both a father and grandfather five times over. “And so, take care of what you’ve got.”

Dig deeper

Read the original *Journal of Environmental Quality* research mentioned in this article:

- “Nitrogen and Phosphorus Removal Using Tile-Treatment Wetlands: A 12-Year Study from the Midwestern United States”: **https://doi.org/10.1002/jeq2.20316**

- "Effects of Riparian Buffer Vegetation and Width: A 12-Year Longitudinal Study": **https://doi.org/10.2134/jeq2015.06.0321**

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