Soil & Water
Conservation Club

Getting Into Soil & Water 2022

A publication of the Iowa State University
Soil & Water Conservation Club

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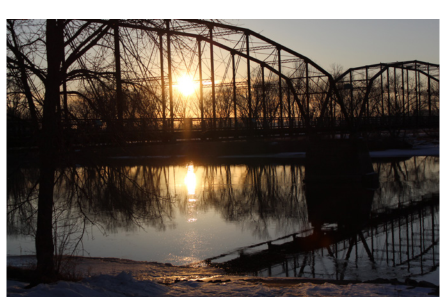

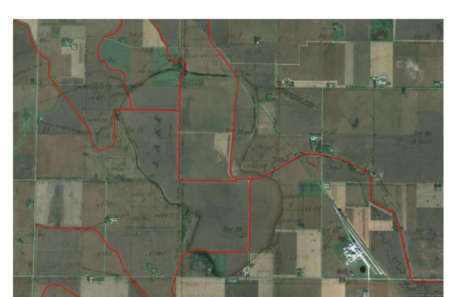

Cover Art: Photos from the Iowa Water Conference 2021 Photography Contest winners.

The suggested format for citing an article from this publication is: Author. 2021. Title of Article. Page(s) of Article. In Blauwet, M., Luke, C., Muench, R., Platner, E., Strauser, C (eds.) Getting Into Soil and Water 2021. Iowa Water Center. Ames, IA.

Meet our Editors

WE REMAIN DEDICATED TO SOIL AND WATER CONSERVATION EDUCATION

Rebekah Muench

Rebekah Muench

I am a Senior in Agronomy, a member of the Soil and Water Conservation Club since 2019, and now serving as Lead Editor. Growing up on a small farm in West Central Minnesota, I was unaware of the many environmental impacts, both good and bad, that agriculture creates. Being involved in this publication's creation has taught me valuable lessons related to soil and water and professional development. I hope that through this publication, you all can take home some important messages about conservation and share them with others. Together we all can make a difference in creating a sustainable future.

Megan Blauwet

Megan Blauwet

I am a junior in Agronomy, and I joined the Soil and Water Conservation club in the Fall of 2019. I grew up in the northwest corner of Iowa and always had an interest in agriculture. I enjoyed being involved in this publication because I was able to read through articles and learn new information about recent issues and research in soil and water conservation. This publication provides new insights and great pieces about relevant topics that concern us all.

Casey Luke

Casey Luke

As an Army Veteran I spent 3 years overseas before coming home; then I went back to school with the intention of pursuing a farming career. I learned about so many more opportunities along the way, and now my goal is to focus on a career in Soil Science, specifically in GIS applications and conservation. My hope is to be able to build a career that lets me travel and work all over the world as one of my passions is to travel to and experience new places and cultures. I am currently a Senior in Agronomy and Secretary of the Soil and Water Conservation Club and am looking forward to Graduate School next year.

Evy Platner

Evy Platner

I am a senior studying agronomy and I joined Iowa State's Soil and Water Conservation Club in the Fall of 2019. I grew up in Norwalk, Iowa, and have always had a passion for conservation and the preservation of Iowa's natural resources. Upon arriving at Iowa State, I decided I wanted to invest more time in learning conservation practices that I could then transpose to my future job. Having the position of co-editor of this publication has allowed me to make connections with professionals and groundbreaking scientists in conservation. It is inspiring to work with scientists firsthand to create articles that reflect the success of Iowa conservation. I hope you are as inspired by these stories as I am.

Carly Strauser

Carly Strauser

I am a senior in agronomy with a soil science certificate and a minor in horticulture. I am from Waverly, Iowa, and have always been passionate about conservation and preserving natural resources. This made joining the Soil and Water Conservation Club in the spring of 2020 a no-brainer. The club has allowed me to share my interest in conservation with other like-minded individuals who care about protecting the environment for the future. It was great to work as co-editor for this issue of Getting into Soil and Water as I got to connect and learn from those making new and exciting strides in the world of soil and water conservation.

Investigating the Prevalence of 'Forever' Contaminants (Per- and polyfluoroalkyl substances [PFAS]) in Iowa

By Dana Ward Kolpin, Research Hydrologist

Per- and polyfluoroalkyl substances (PFAS) are a class of more than 4,700 synthetic compounds. Due to their unique properties (e.g., oil and water repellency, temperature and acid resistance, friction reduction), they have been frequently used in many household and industrial products globally for decades. The same properties that made them attractive for use also make them persistent and mobile, causing environmental exposures even in regions far removed from their initial use or manufacturing. It is this persistence that has caused PFAS to be called "forever" contaminants. Furthermore, their affinity for bioaccumulation has led to PFAS detections in a wide variety of aquatic and terrestrial organisms (including humans). Thus, once input into aquatic ecosystems, PFAS can easily bioaccumulate in organisms and propagate through the food web. PFAS exposure is associated with a variety of potential effects to humans, including cancer and immune dysfunction.

While research has documented multiple potential agriculture-related pathways for PFAS (e.g., land application of municipal biosolids), most environmental research to date has been conducted proximal to potential urban PFAS sources such as wastewater treatment plants (WWTPs), airports, and military bases. To fill this research gap, a statewide spatiotemporal stream sampling across Iowa was conducted to provide the most comprehensive assessment of PFAS concentrations in Iowa streams to date (Kolpin et al., 2021; Meppelink et al., 2021). As a vast majority of Iowa's landscape is devoted to agriculture (leading the Nation in corn, swine, and egg production), Iowa is an ideal area for determining the prevalence of PFAS in rural, agricultural streams (Figure 1). In this study, 119 water samples from 60 streams were collected from June 2019 to January 2020 for the analysis of 34 PFAS using direct aqueous injection-liquid chromatography/tandem mass spectrometry. The sampling network contained a range of basin sizes, urban and agricultural land use, and human and livestock densities covering 88% of the basin area within Iowa.

Dana Ward Kolpin

PFAS were detected in 19 of the 60 sampling sites (Figure 2), with 10 different PFAS detected. The most frequently detected PFAS in streams were: PFBS (11 detections), PFOA (11), and PFNA (10). The highest individual PFAS stream concentration measured was 134 ng/L (PFBA) in an agricultural stream, and the largest cumulative PFAS concentration measured in an individual stream sample was 197 ng/L in a municipal WWTP effluent-affected stream. Sites with the greatest number of PFAS detected were small, municipal WWTP effluent-affected streams. And, while PFAS exposures were more sporadic in basins dominated by agriculture, such exposures were observed, indicating that either agricultural activities may be contributing to stream PFAS concentrations or there were other unidentified PFAS sources in these basins. The longitudinal sampling along a 5.1-km reach of Muddy Creek clearly documented the effect of WWTP effluent to stream PFAS concentrations. An abrupt increase in both the number of PFAS detections and concentration was observed between the sampling site just above the WWTP outfall compared to the site just below due to the input of WWTP effluent. Limited PFAS attenuation was observed through the 5-km travel distance along Muddy Creek following the input of WWTP effluent.

While many of the measured PFAS detections were low (below 10 ng/L), their affinity for bioaccumulation renders the documentation of even such low concentrations an important endeavor. In addition, a better understanding of the contributions of nonpoint, agricultural PFAS sources could be accomplished by stream sampling specifically targeted toward periods of use (i.e., land application of municipal biosolids) and corresponding precipitation events that are known to drive chemical transport to streams. Furthermore, water concentrations likely underestimate stream PFAS exposures as bed sediment can also be an important exposure pathway to aquatic and terrestrial organisms. Future PFAS research of agricultural streams could include: (1) simultaneous multi-matrix sampling of water, bed sediment, and biota to better understand exposure and the corresponding propagation and effects of PFAS on aquatic and riparian food webs and (2) an analysis of both PFAS and total fluorine to capture unidentified organic fluorine and to better evaluate the extent of potential organic fluorine contamination.

Figure 1. Typical agricultural setting (U.S. Geological Survey station 06600030; Little Floyd River near Sanborn, Iowa) that was sampled as part of the spatiotemporal study of PFAS in Iowa streams (Kolpin et al., 2021). Photo taken by David Warweg (U.S. Geological Survey, Central Midwest Water Science Center).

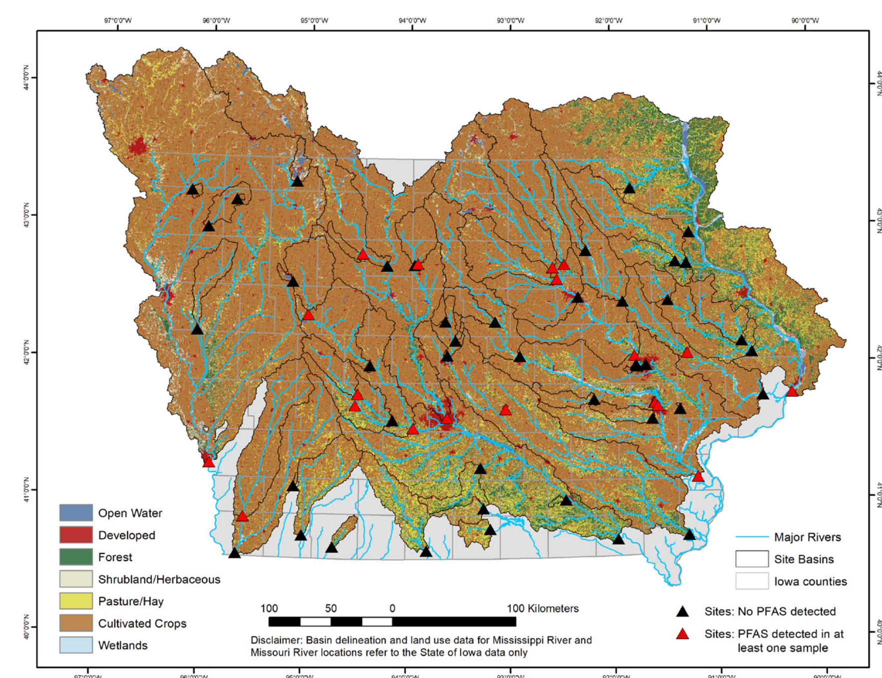

Figure 2. PFAS water results from the spatiotemporal sampling of 60 Iowa streams (June 2019 to January 2020; Kolpin et al., 2021). Land cover data from Homer et al., 2016.

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Dana W. Kolpin1, Laura E. Hubbard2, David M. Cwiertny3, Shannon M. Meppelink1, Darrin A. Thompson3, and James L. Gray4

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4U.S. Geological Survey, Strategic Laboratory Science Branch, Denver, CO 80225, United States

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The reason health is emphasized in soil science today is because it is a surrogate for soil function as assessed by ecosystems services provided. The more ecosystem services that a soil performs, the better it is functioning and the healthier it is.

Prairie Strips Have Disproportionate Benefits for Agriculture and Ecosystems

By Cole Dutter, Graduate Student in Soil Science and Sustainable Agriculture, Iowa State University

The environmental consequences of converting prairie to cropland in the US Midwest is well studied and documented. An abbreviated list of these consequences includes increased erosion rates, lower organic matter, increased nutrient loss from soils that end up in waterways, nutrient-laden waterways that often result in areas of hypoxia, and reduced floral and faunal diversity. While this list may seem overwhelming, all is not lost. Farmers, policymakers, scientists, and community members have taken notice and have taken action. For decades, the Conservation Reserve Program (CRP) has paid farmers to take land out of production and place it into prairie. Historically this meant that an entire field was taken out of production. This created a tradeoff between crop production and environmental protection. Then, recently, CRP added a new practice, prairie strips.

Prairie strips are a rapidly growing agricultural conservation practice (Figure 1), made part of the CRP (CP43), and recently NRCS has published a technical note (CP43, Technical Note 41). Farmer's take only 10-25% of his/her field out of production but receive in return disproportional benefits. These benefits include 37% reduce total runoff, 95% reduce sediment loss, 77% reduce phosphorus loss, 38% reduce nitrogen runoff, and 72% reduce nitrate in the groundwater1. However, less is known about the effect of prairie strips on the soil health of the surrounding cropland.

Cole Dutter

As a quick definition, soil health is the capacity of a soil to function as a vital living system, to sustain plant and animal productivity, maintain or enhance water and air quality, and promote plant and animal health. What this means in the field is that we analyze the soil's chemical, biological, and physical components. A soil that has greater nutrient availability or increased microbial activity (community size, composition, or enzyme activity) or better physical attributes (aggregate stability, lower bulk density) could be considered healthier. Ultimately, we look for a response from all three of these categories as an indicator of health. The reason health is emphasized in soil science today is because it is a surrogate for soil function as assessed by ecosystems services provided. The more ecosystem services that a soil performs, the better it is functioning and the healthier it is.

Prairie improves soil health in a myriad of ways. Three related ways that prairie improves soil health: water stable aggregates, soil organic matter, and microbial biomass. After 12 years of having a prairie strip planted over it, the soil improved the water stable aggregation by 49%, the soil organic matter improved by 12%, and the microbial biomass increased by 56% (figure 2). These three metrics may not seem related initially but they are indeed. Water stable aggregation is the soil's ability to withstand weather, the higher the stability percentage the stronger the soil aggregates. This could be compared to the story of the three little pigs and their houses. No-till agriculture may be a house

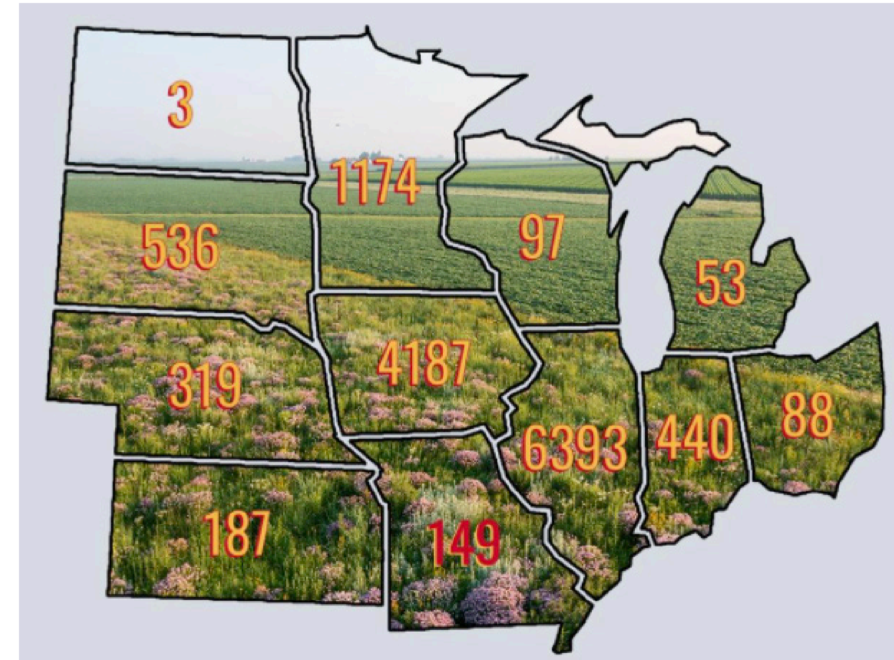

Figure1. The latest Conservation Reserve Program (CRP) numbers from the Farm Service Agency October CRP enrollment report. Not shown here are acres in Colorado, Tennessee, and Maryland. Missouri has no Prairie Strips CP43, but some will be installed in 2022, Missouri acres (in red) on this map are private acres we've helped establish. There are currently over 14,000 acres of Prairie Strips CP43 in 14 states, and adoption is continuing to grow! We've lost track of how many private acres there are. A good problem to have! Figure courtesy of Omar de Kok-Mercado and the prairie strips Instagram page. #prairiestrips #iowastate #iowaag

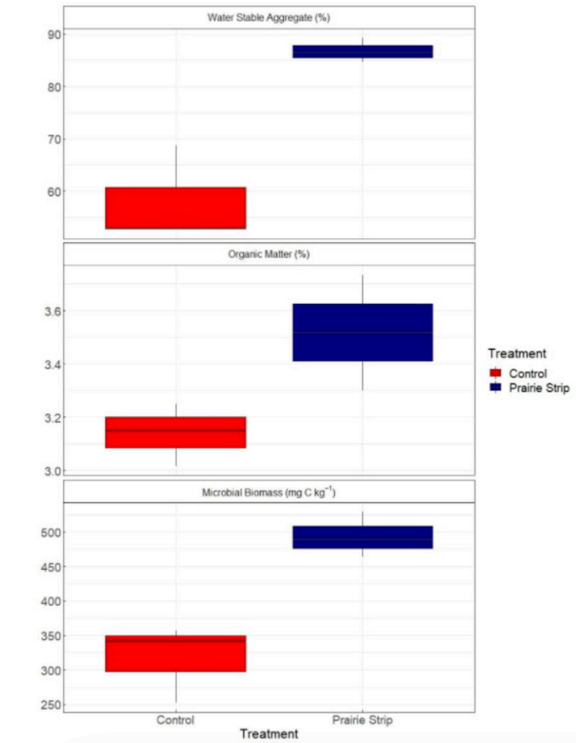

Figure 2. Soil health increased under the prairie portion of the prairie strip as compared to cropland controls. Samples were analyzed from six different watersheds, three with prairie strips and three with no-till cropland.

of sticks, but prairie soil is the house of bricks. This impacts many factors, not only things such as carbon storage and erosion, but it also influences microbial habitat. Organic matter, quite simply, is the amount of plant and animal tissue in the soil in various stages of decomposition. Organic matter influences all categories of soil health, chemical, physical and biological. As a rule of thumb in the Midwest, the soil with more organic matter tends to be more productive. With this in mind, in the soil, one of the major roles for soil organic matter is a food source for microorganisms. Finally, microbial communities are the engine behind the soil's productivity. Microbes cycle nutrients that are then plant available and help crops thrive. So, by increasing the house strength and size (water aggregate stability), increasing food supplies (organic matter), and increasing the nutrient cycling ability of a soil (microbial population), prairies are increasing the soil's health for us and future generations. With all this, it may be possible for the benefits of prairie strips to also improve the cropland that is adjacent to them as well. This is currently being studied. There is also research occurring that is examining how long after the prairie strip is re-cropped that these benefits last. We hope to bring you those results soon.

Photo by Omar de Kok-Mercado

Overall, prairie strips have a large impact on environmental health, a large impact on soil health where they are grown. With more results coming soon. Prairie strips are proving themselves to be an effective conservation practice that minimizes the tradeoff between production and environmental health!

Quality Relationships and Conservation Partnerships: Comparing Landowners and Farmers

By Derek Franklin, Graduate Research Assistant

Derek Franklin

Photo courtesy of Soil and Water Conservation Society.

The American Midwest is famous across the globe for its fertile soils and high levels of commodity production. But the agricultural system that dominates much of the Midwest (and increasingly the world) relies heavily on inputs to produce a few commodities. This agricultural system has also led to some environmental problems such as soil erosion, nutrient loss, and impaired waterways affecting farms and communities in Iowa and around the world.

Many researchers want to see more conservation practices on farms. These practices would protect against soil and nutrient loss and improve water quality in response to agriculture-related environmental degradations. These researchers include biologists, chemists, engineers, and social scientists like myself (along with many more!). As a social scientist, I conduct research using surveys and interviews to study people's values, beliefs, and behaviors. Ultimately, I hope my research will help to inform the development and increase the effectiveness of conservation policies and programs.

Some of my research has focused on non-operator landowners (NOLs), who own farmland but do not farm it themselves and instead rent it out to a farmer. Rented farmland is more common than many people realize—for example, in Iowa, 51% of the farmland is rented, and up to 68% of the land is rented in some Iowa counties (NASS 2017 Census of Agriculture). Thus, over 15 million acres in Iowa alone are rented, but many conservation programs are designed for land that is not rented but owned by farmers. We need to understand the people behind rented farmland better to make sure that these acres can readily receive conservation practices, too.

Farmers' use of conservation practices has been studied for several decades, but NOLs are increasingly becoming a focus of researchers as NOLs care deeply about their land and can influence agricultural decisions. We, as researchers, would like to know more about how farmers and NOLs compare to one another: in what ways are these two groups similar to or different from one another? Most studies focus on only farmers or NOLs, but we surveyed both NOLs and farmers in four counties—two in Iowa and two in Ohio—to compare their responses.

Research in sociology (the study of human societies and interactions) tells us that the alignment of the values and expectations in a relationship influences the quality of the relationship, such as a relationship between a farmer and an NOL. For example, aligned expectations and values can make relationships more resilient to strain and help determine how much effort a person puts into a relationship. With this in mind, we asked these groups questions about values related to agriculture and the environment. We also asked questions about expectations and beliefs regarding NOL-farmer relationships. Upon comparing the responses, we found areas in which these groups seem to see things differently and some areas of alignment.

Farmers and NOLs, on average, seemed to be misaligned regarding some of their key values and the sense of who was ultimately responsible for environmental outcomes on the land. Non-operating

Photo courtesy of Soil and Water Conservation Society.

Farmers' use of conservation practices has been studied for several decades, but NOLs are increasingly becoming a focus of researchers as NOLs care deeply about their land and can influence agricultural decisions.

landowners seemed to place a high amount of importance that was about equal on both productivist values (highest yield, newest machinery, etc.) and stewardship values (minimizes erosion, considers waterway health, etc.). Whereas farmers rated both of these values as important but on average rated productivist values as more important than stewardship values. We found another misalignment as NOLs seemed to see both groups as being equally responsible for environmental outcomes, but farmers tended to see themselves as solely responsible. These areas of misalignment point to potential points of conflict and tension that policies and programs could address.

But we also found areas of alignment, and these could serve as places of common ground to build on. The most important element in an NOL-farmer relationship for both groups was trust, and both groups also rated soil and nutrient management as important. On average, both farmers and NOLs also seemed to be on the same page about the qualities found in a good renter. These results suggest that NOLs care more about land stewardship than commonly assumed and that NOLs feel responsible for the practices on the farmland they own. Altogether, these findings can help the promotion of NOL-tenant conservation partnerships.

Special thanks to J. Arbuckle at Iowa State University for analytical assistance, along with Eric Toman and Theresa Groth at The Ohio State University for leading survey design and data collection.

Our Community Environment: A Computer Simulation & Storytelling Tool That Fosters Discovery and Connection

By Linda Shenk, Associate Professor; Kristie Franz, Professor; Scott Boylen, K-12 educator; and Liz Siepker former ISU Extension K-12 program coordinator

From K-12 through college, educators are striving to talk less so students can discover more. Students thus become creative thinkers who ask "wide questions". In environmental science courses, such wide questions empower students as future stewards of the land who consider the interconnection of social and environmental systems—how land use affects water quality and biodiversity, how weather associated with climate change requires adaptations, how community collaboration and local knowledge matter.

As two Iowa State University researchers, a 7th-grade environmental science teacher in Winneshiek County, and a former ISU Extension K-12 program coordinator, we are developing a curriculum that joins one of science's most imaginative tools—the computer simulation model—with the power of creativity and personal connections that arise with one of the humanities' most powerful tools—storytelling. Using a simple "Community Environment" computer simulation model (created at Iowa State University), students work together to create digital narratives that explore the way environmental and social systems affect each other. And they do this by integrating their own personal eco-stories with classroom content.

At the center of the activities is the Community Environment (CE) model, an agent-based model created using the open source software NetLogo that is simple enough to run on lap-tops. Through simple controls on the interface, students create and explore social-environmental scenarios that approximate causations among soil erosion, water quality, various land use practices, biodiversity, periodic wet and dry extreme events, human readiness to take action, and differing types of community collaborative ties (what social scientists call "social capital").

Linda Shenk

Kristie Franz

Scott Boylen

Liz Siepker

These limited interactions do not capture the complexity of coupled human-environmental studies, but that is the point. Unlike traditional models which strive to create mini-worlds with as much "right" as possible, CE's sketch-like format, like a simple cartoon, invites users to insert the details and contexts of their own stories and questions. What geographical area should we consider—a town, a local watershed, a HUC 10 watershed? What type of weather conditions are important to explore? What might support, or hinder, individuals from being ready to take action? What groups in a community could work together to create change?

It is CE's simplicity that makes it a model of discovery. Essentially, it "talks" less, so users can share their stories, ask wide questions, and discover more.

Before beginning work with CE, students do a "blue marble activity" inspired by Wallace J. Nichols's book Blue Mind. They talk about ways the Earth is a "blue marble," reflecting on the centrality of water on our planet as the means for sustaining life. If time allows, they tell a brief narrative about their own connection to water. Then they begin creating and exploring scenarios with CE, filling out the simulation's sketches of stories with their questions, experiences, and growing knowledge.

The sessions with CE occur periodically throughout the course. In between sessions, students explore multi-modal course content that includes: fresh water availability; mycorrhizal networks and soil health; water movement in the various soils and geologies of Northeast Iowa; Robin Wall Kimmerer's Gathering Moss; and the movie Kiss the Ground. Each time the students work with CE, they see more of how the model's stories acknowledge or leave space for their local expertise as well as for what they have been learning in class. Many of the students living in the Driftless Region have substantial experience with fishing and already know why CE would depict mayflies. Students can fill in the story of this unassuming species much like they can, over time, integrate how the model suggests, but does not show outright, the power of the soil's microbial network. Students are also encouraged to add their ideas of what else the model does not show outright—but should. The classes have been particularly interested in equity and environmental justice and have shared ways that CE does not acknowledge poverty or the unequal distribution of environmental and health impacts. Students expand the stories CE tells and make them their own.

This process is mind-stretching. Analytical, non-traditional thinkers come into their own, while students who typically excel in traditional, structured learning environments find themselves in less familiar territory. The mix of critical and creative systems-thinking involves primarily Life Science standards MS-LS2-1, MS-LS2-3, MS-LS2-4 as well as addresses some skills relevant to MS-LS2-5 and Earth and Space Sciences standards MS-ESS3-3 and MS-ESS3-4.

In the spirit of these standards, our goal for the students and for Iowa's community and ecosystem health is to foster imaginative, courageously creative learners empowered to imagine the next chapter of our soil, water, and community stories.

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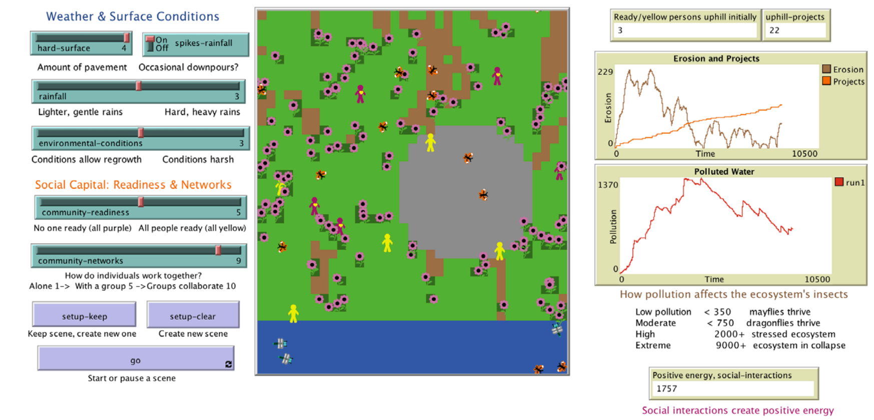
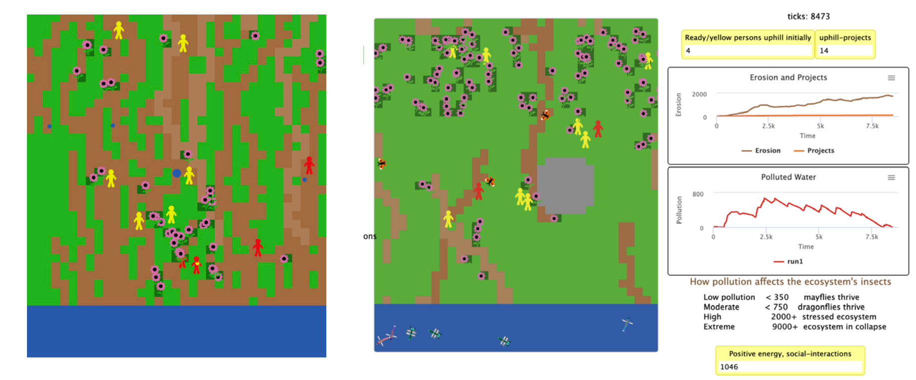
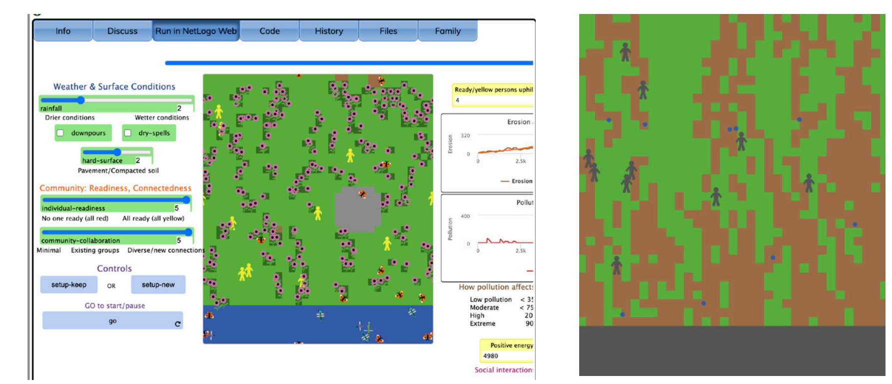
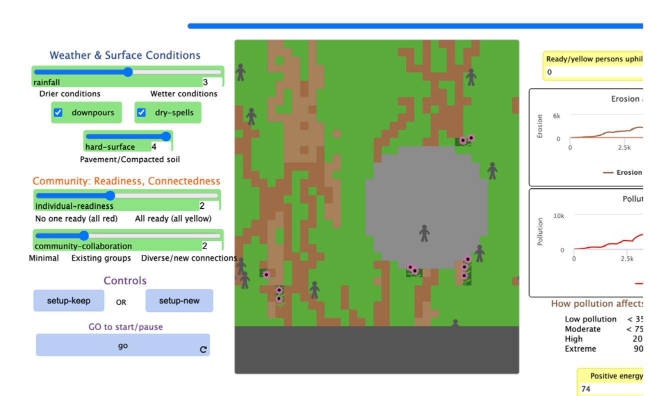








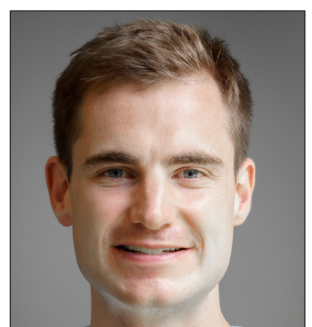
Many Iowan shareholders have worked hard to reduce phosphorus's waterborne presence through agricultural best management practices and improved wastewater treatment.

Monitoring Iowa's Phosphorus Using Turbidity

By Elliot Sobek Anderson, PhD Candidate, Civil & Environmental Engineering, The University of Iowa

When we want to gauge the quality of surface water, one of the first steps is often looking at how clear that water is. Water clarity is a relatively straightforward and intuitive concept, and it has been evaluated for decades. Darker, murkier water often indicates that more sediment is present and can give us clues about potential contaminants that may be lurking. Our research is taking this a step further and using water clarity to inform us about one of the most important chemicals in the state of Iowa: phosphorus. Iowa has a sort of love-hate relationship with phosphorus. It's an essential nutrient needed by all plants and animals to survive. It's naturally present in our soils and is a vital ingredient of the fertilizer used to boost crop yields. However, when phosphorus enters our water bodies, it becomes a pollutant. Phosphorus is responsible for the chronic algal blooms that have harmful consequences for both the environment and human health.

Many Iowan shareholders have worked hard to reduce phosphorus's waterborne presence through agricultural best management practices and improved wastewater treatment. Keeping phosphorus on farm fields and out of Iowa's waters is likely the most vital component of these practices. But it's not easy to evaluate how well these strategies are working. Phosphorus is challenging and expensive to measure directly. Samples must be collected onsite, brought to a lab, and analyzed with several chemical procedures. Phosphorus levels can also change quite quickly over a short period, meaning that we can't adequately perceive what's occurring with phosphorus in between collected samples. Current and historical sampling of Iowa's principal water bodies has only measured phosphorus once a month—not nearly enough to fully evaluate its presence. This concept is similar to measuring flow in a river once a month. If we did this, we wouldn't be able to say much about that river's hydrologic behavior. Therefore, flow is typically measured every 15 minutes. However, directly measuring phosphorus in this manner is entirely impractical, and this is where water clarity comes into play.



Elliot Sobek Anderson

Turbidity is how water clarity is measured quantitatively. A device called a turbidimeter emits a beam of light through water. It then captures how much of this light is scattered by adjacent particles within that water. More light will scatter if the water is cloudy and filled with particles. The cloudier the water, the higher the turbidity. Whereas phosphorus is difficult to measure directly, turbidity is relatively easy. A turbidimeter can comfortably produce turbidity values every 15 minutes. Utilizing Iowa's historical phosphorus data, we've developed statistical models that predict a site's phosphorus level based on its coinciding turbidity—with an example shown in Figure 1. Again, the concept here is similar to flow measurement. It is the river stage that is measured every 15 minutes, not discharge, and this stage information is used to calculate the corresponding flow.

Our turbidity models allow us to quantify phosphorus at a specific site better.

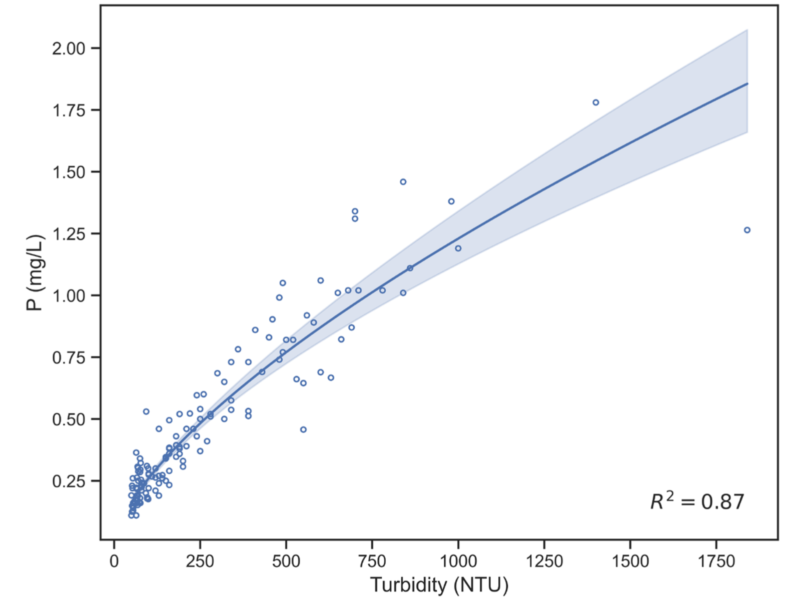


Figure 1. Phosphorus vs. Turbidity model along the Skunk River at Augusta, IA.

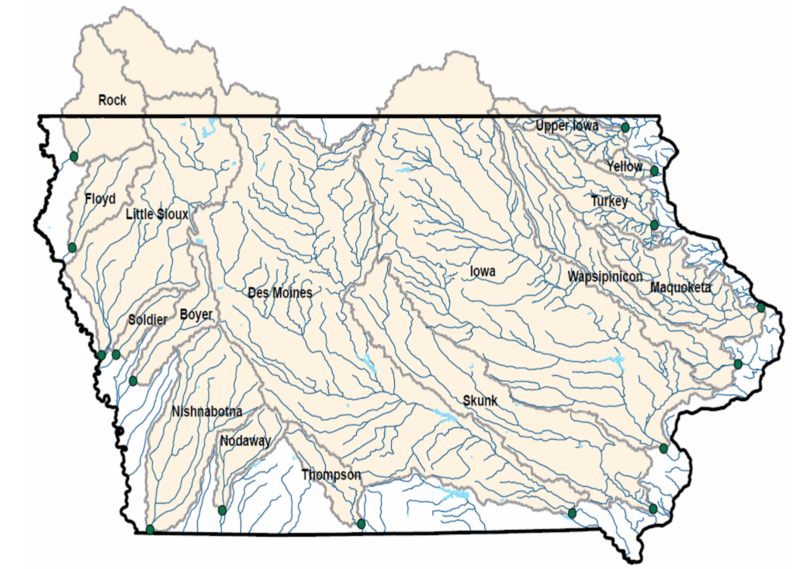


Figure 2. Iowa's 16 major watersheds and their most downstream monitoring locations.

Obtaining phosphorus estimates every 15 minutes significantly reduces the uncertainties associated with solely relying on monthly samples. With these models, we've developed phosphorus records throughout recent years, assessing how its presence has changed over time. These records help us track the progress of phosphorus reduction strategies implemented by so many across Iowa. Our recent efforts have focused on 16 sites along Iowa's major rivers (Figure 2). These sites are critical because they monitor water at the most downstream locations before it leaves the state. Quantifying phosphorus here is especially important, as these sites encompass nearly all of Iowa. These locations help us monitor phosphorus presence statewide, which is the overarching goal of Iowa's nutrient reduction efforts.

We've also deployed numerous turbidimeters within the state to better understand phosphorus patterns and trends in Iowa's various watersheds. In many cases, we can further improve phosphorus models by incorporating seasonal and flow-related factors along with turbidity data. Moving forward, we view these turbidity-based models as a key component in Iowa's strategies to improve its water quality and hope the results ultimately inform policymakers. It seems the simple concept of water clarity has excellent potential to refine Iowa's complex relationship with phosphorus.

We were surprised to learn that, in a dry year, a late-terminated cereal rye cover crop can dramatically reduce soybean yields—in addition to going to seed.

It All Depends on the Soil

By Jon Bakehouse, Owner/Operator, Maple Edge Farm, Inc.

It all depends on the soil.

Those six words are how we try to answer questions on our corn and soybean farm in southwest Iowa. Questions about fieldwork, yield, bottom line, land value, environmental quality—and ultimately farm success—all start with that answer.

Jon Bakehouse

It hasn't always been this way. Our original focus was on water and how to get rid of it.

Decades of repeated tillage on our flat, poorly drained soil had formed nearly impermeable compaction layers. After a rain, large ponds of water sat on our fields for days. The water that didn't hang around ran off, taking soil with it.

We adopted no-till in the late 90s to address our runoff problem and saw immediate improvement. Over the next decade, we also saw a slow improvement in water infiltration. As a bonus, our soil organic matter started to improve from its usual three percent. All of these factors started to plateau, however, before we were 100% satisfied.

By 2010, we were hearing a lot about cover crops and how cereal rye's rapidly growing, extensive fibrous root system promoted better infiltration. We attended a Practical Farmers of Iowa cover crop seminar in our neighbor's shop, bought a well-used Great Plains no-till drill, and shifted our focus to where it belonged: underground.

We drilled our first cereal rye cover crop that fall and looked forward to seeing what an "extensive fibrous root system" looked like. The following spring, we pushed our way into waist-high cereal rye and started digging. We were amazed by what we saw. The root system of the cereal rye was so massive and so thick, we had to twist, pry and pull to break a shovel full of soil free. Soil crumbled between our fingers, and the smell was less like a bog and more like soil.

What we found beyond the root system, however, was what truly amazed us. There were all kinds of soil critters, from slithering earthworms to skittering arthropods, whose daily routine we had interrupted. The ground was literally

crawling with life. We weren't yet familiar with the soil food web, but here it was, unfolding before our eyes despite our inscience. We knew we were on the right track.

We were excited about what was going on underground but started by quantifying what was going on above ground. Through Practical Farmers of Iowa's Cooperator's Program, we started running on-farm field trials to learn what worked—and what didn't—for our farm.

We were surprised to learn that planting an earlier maturing corn (101-104 relative maturity) yielded as well as longer season corn. This allowed us to plant cereal rye as early as September 25th. We also found similar yield results in early maturing soybeans (late group 1 and early group

Photos courtesy of Jon Bakehouse

2), though we were hard-pressed to reliably drill any frost-sensitive species before October 1st.

We weren't surprised to learn that cereal rye planted earlier and at heavier rates increased spring biomass, but we were surprised to learn that cereal rye planted prior to corn can reduce yields on poorer performing soil, but not necessarily on better performing soil.

We were surprised to learn that, in a dry year, a late-terminated cereal rye cover crop can dramatically reduce soybean yields—in addition to going to seed.

While we were busy recording what was going on above ground, our soil resumed its slow improvement below ground. Our fall 2020 soil samples showed us that our soil organic matter had started to improve again, now averaging four percent, with occasional measurements of five and six percent. This told us our water holding capacity was increasing, which supported our observation of less standing water after spring deluges. The water that does stand disappears a day or two faster than it did 20 years ago.

We still aren't 100% satisfied with how our soils are performing, but I'm thankful we started our journey when we did. Soil improvement is a decades-long proposition. Patience and keen observation are key. Visualizing what we want our farm to look like in 20, 30, or 50 years is paramount; not an easy task when farming is about this year's yield, this year's crop prices, and the year's weather.

So what's next on our list of practices to implement? It depends on the soil.

Erosion and Sediment Delivery in Southern Iowa Watersheds: Implications for Conservation Planning

By Matthew T. Streeter, Assistant Research Scientist, University of Iowa

Matthew T. Streeter

Sediment eroded from agricultural croplands is a major contributor to water quality impairment in Midwestern streams and reducing soil export from agricultural watersheds is a key component of the Iowa Nutrient Reduction Strategy. Over the last few decades, improvements in land management and installation of best management practices (BMPs) have reduced field-scale soil erosion, but water quality benefits of BMPs have been poorly quantified. Reducing the amount of soil erosion occurring from field to field is not the same as reducing the amount of sediment exported from a watershed, so sediment delivery ratios (SDRs) are used to estimate the fraction of gross soil erosion that is exported from a watershed for a given time.

In 2020, IGS Soil Scientist, Matthew Streeter and State Geologist, Keith Schilling published new research in the "Journal of Soil and Water Conservation" that studied five eastern Iowa watersheds ranging in size from 8 to 1,487 km2 with the objective to develop a new SDR curve for the southern Iowa drift plain landform region in southeast Iowa that accounts for the effects of currently implemented BMPs as well as current climatic conditions. The watersheds of interest included the HUC 12 Rapid Creek watershed in Johnson County and two of its headwater subbasins, as well as the dominating English River watershed, which stretches from its headwaters near Grinnell in Poweshiek County to where it discharges in the Iowa River in Washington County (Figure 1).

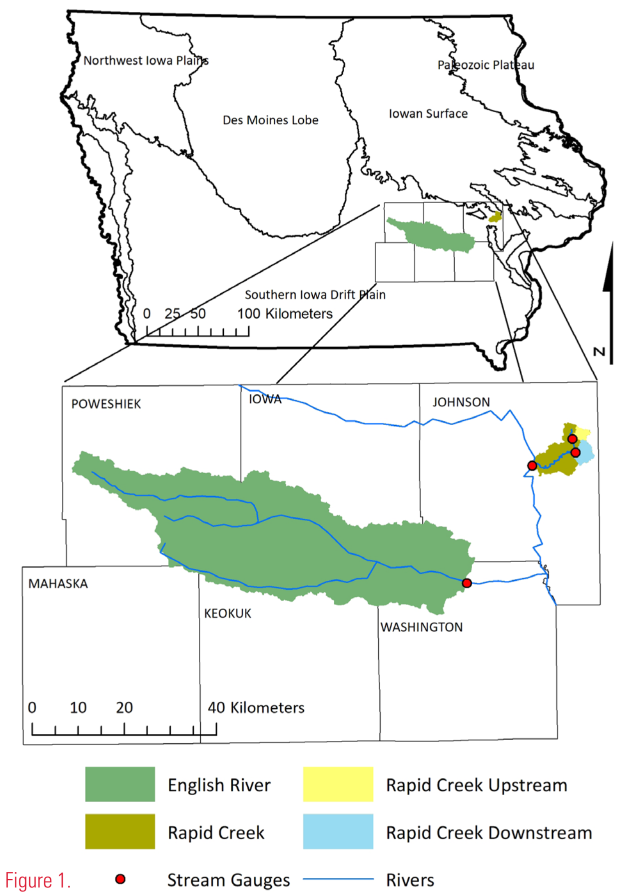


Figure 1.

The study utilized several new technologies to make accurate estimates of in-field soil erosion and total suspended solid (TSS) concentrations in streams. First, watershed-scale sheet and rill soil erosion was modeled using the Revised Universal Soil Loss Equation (RUSLE). RUSLE data is widely available in Iowa. However, typically, RUSLE models utilize 30-year average rainfall data rather than yearly estimates and do not account for agricultural conservation practices like reduced tillage, contour planting, or terrace construction, all of which may have significant impacts on rates of soil erosion. The IGS gathered maps of existing structural BMPs within the watersheds (provided by the Iowa BMP mapping project, Iowa State University (2019)) to estimate all of the land area within the watersheds where soil erosion is reduced and sediment trapping occurs due to BMPs including contour terraces, contour buffer strips, and water and sediment control basins (Figure 2). Further, the IGS acquired current annual estimates of rainfall for the watersheds. RUSLE models were rerun with the new data, and new estimates of soil erosion were made. Furthermore, the IGS used the Agricultural Conservation Planning Framework (ACPF) toolbox to locate the best locations for new conservation practices within each watershed (Figure 2) (US Department of Agriculture 2019). Again, the RUSLE model

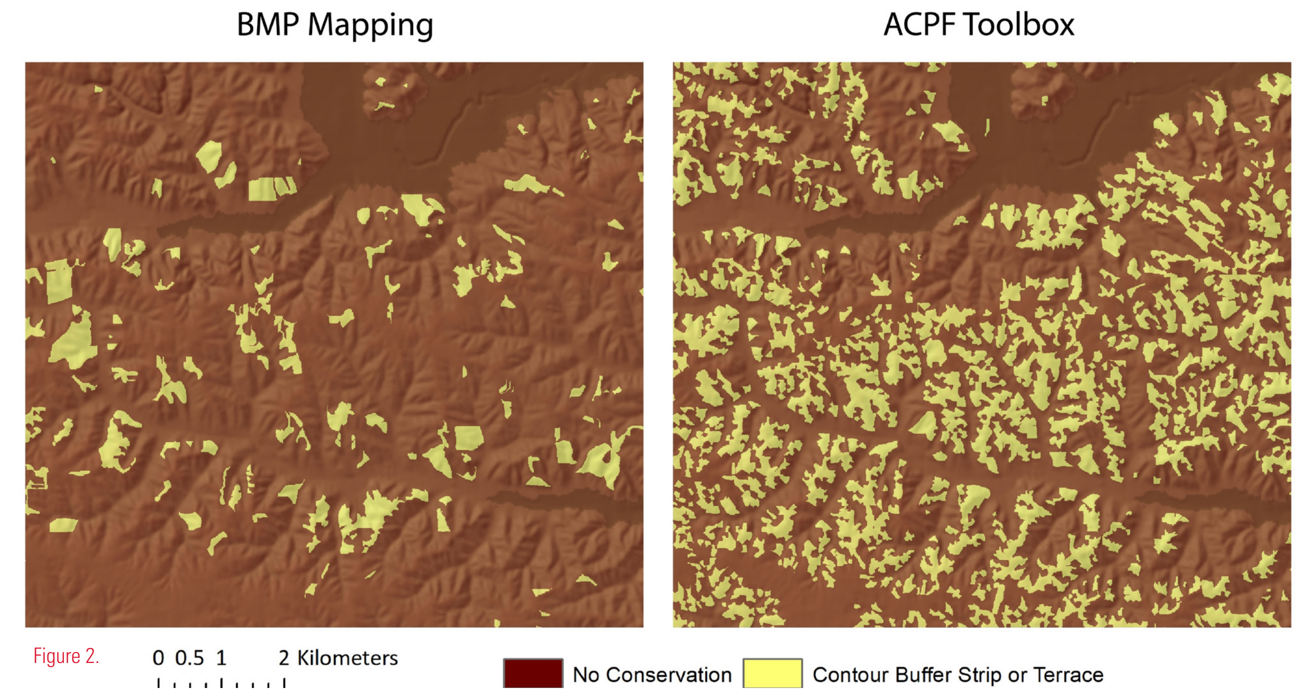


Figure 2.

was used to make predictions about potential future reductions in soil erosion if new BMPs are installed.

In order to estimate TSS within each study stream, turbidity sensors were installed, which collected continuous data in the English River and Rapid Creek headwater subbasins. Furthermore, total phosphorus concentrations were measured regularly from the Rapid Creek watershed near its outlet. Turbidity and total phosphorus data were then converted to TSS using a calibration curve developed using Iowa Department of Natural Resources ambient water quality data from the nearby Old Man's Creek watershed (Iowa Department of Natural Resources 2019).

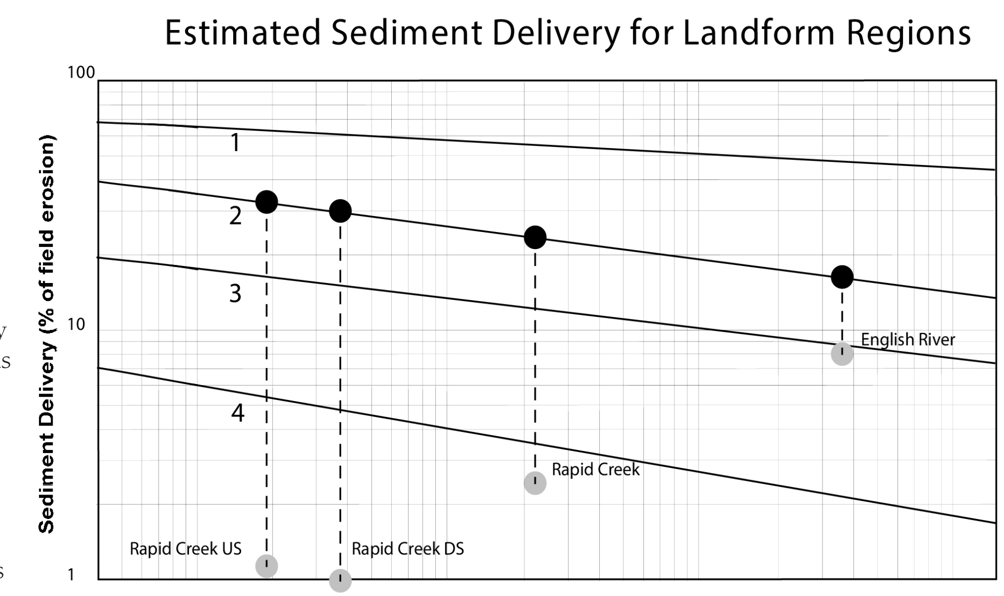


Figure 3.

The ratio of RUSLE estimated soil erosion using new estimates of conservation practices and rainfall to estimated TSS provides significant insight about the state of soil conservation in Iowa. We found that SDRs from our study were significantly lower compared to previous estimates made by the USDA in their 1998 field office technical guide entitled "Erosion and Sediment Delivery" (Figure 3) (USDA NRCS 1998). Furthermore, we found that the construction of thousands of additional conservation practices within the study watersheds would not make a significant impact on lowering soil erosion. However, the ability of the proposed conservation practices to trap detached soil sediments could significantly reduce overall sediment export.

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I want to journey by your side and see the bridges with their towering metal skeletons stretching across your banks.

Where Have You Been?

By Jane Taylor, Spirit of the Water Essay Winner

Water is able to light up our houses with energy in the darkest of nights, yet gentle enough to cradle a fragile boat of popsicles built by a child. It is a constant, flowing force in our lives. What sights would we see if that simple boat could take us along on its journey? Where would your swirling currents carry it? I see you in every subdued brook, in the sandy lakes of my childhood, in the drips and drops that paint the spring grass a vibrant shade of green. The drumbeats on my window from rolling thunderheads tell of you. You are steady. Is every sunrise a new adventure, a new thrilling voyage? Let me follow where you go and see the sights that you pass along the way. If you were given a polaroid and some film, the things you would show us.

I have seen you as a gentle soul. Take me to warm, sleepy meadows where the muted drone of pollinators sings a harmony to your ramblings. Where fat rays of sunshine warm you and hit the surface like diamonds. The grasses that reach up, up to the lazy sun, cover you and hide you away for wandering wildlife to come across; a wonderful secret. You form habitats around yourself and construct a place of growth in the surrounding ecosystems. My brother and I have followed you into hushed forests where you wind through the saplings and ferns. The dark, dappled shade plays on the banks as we strip off our socks, roll up the cuffs of our muddy jeans, and wade across

the smooth stones that you meander around. Take me there. You bring peace and the thought that everything is how it should be.

As steady as a rock, you flow on, your mighty currents keeping time to the heartbeat of our land. Huckleberry Finn can testify to the power of The Mighty Mississippi. I want to journey by your side and see the bridges with their towering metal skeletons stretching across your banks. Simply imagining the weight that you hold makes me wonder at your strength. You bear heavy-laden barges weighed down by thousands of pounds of steel without a second thought. The impossibility of carrying these metal ships doesn't seem to bother you as you roll on by. Do you know the importance you hold in these waterways? Everything from generating the vital sparks of electricity, ensuring fresh drinking water, to the billions of dollars of commerce that the waters of this river brings, we can thank you for. Tell me how deep, how wide, how powerfully you run your course.

You are mighty, but please, dear friend, give me a warning if you feel your temper rising. You are fearsome. I have borne witness to the awful rage that can shake a building and crack trees in half. I know of the towns you have blown through, leaving high tides and stagnant flood water in your wake. Alton, Rock Valley, and Hull all tell these tales. Waters rise and strip the land of its life. Grasses leave a map of the flood as trees and powerlines are pulled from their foundations. Let me know if you feel the winds starting to rumble-- let me search for a shelter from the storm.

However, in a wonderful, swirling contrast, we know the vitality you give, the happy drops that come from the farmer's irrigation rigs and the gardener's sprinklers.

You flow to the crops that sustain our agricultural practices, ensuring that the corn grows high, the soybeans yellow and mature in time for harvest. However, all too often, your importance goes unrecognized. The groundwater that feeds the wells and irrigation systems may dwindle as the dependency of manufacturing, food processing, and livestock producers are placed on your shoulders (Water Resource Management). Irresponsible farming practices result in corruption of your streams, and watersheds that are filled with pollution (Water Quality Protection Practices). Problems arise, blooming like an invasive species as they choke plant life with their contagious spread. Toxic algae sweeps through the rivers and lakes and contaminants run down the waterways into the "dead zone" in the Gulf of Mexico--a place where the oxygen levels of the water are so low that the deeper parts are unable to support marine life. The devastation wreaks havoc on food chains, habitats, and aquatic ecosystems. It is vital that we recognize how crucial you are to agriculture, and protect the resources that we build our lives around.

And so, as I walk down a wooded trail, reveling in the winter-crisp air, I pause. A small stream crosses my path. A moment passes; the wind curls through the trees and the birds quiet down. Where has the winding flow been before running along this snow-spotted forest floor? It trickles over brittle leaves and crystals of ice that haven't yet melted on this unusually warm January day. How many small animals has it provided for along the way? Where is it going? What destination does it seek out with such determination? The small trickle of water passes by me on its way, unconcerned with my wondering, and I know that though its trip is long, it is the driving force-- the lifeblood of this region.

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Improving digital soil mapping for variable rate of fertilizer and lime applications at the field scale

By Caner Ferhatoglu, PhD Student, Iowa State University

Soil spatial variability has been recognized since 3000 BCE. However, the first soil maps appeared in the 1700s, and the first soil models were used in the 1880s. Accumulation of knowledge about soils, confluence of computing, GIS, and remote sensing (RS) technologies, in the 1970s, led to the development of digital soil mapping (DSM). DSM allowed soil mappers to explain soil spatial variation quantitatively and inexpensively. DSM characterizes soils as a function of soil-forming factors (climate, organisms, relief, parent material, and time). Remote sensing datasets (environmental covariates) are used to characterize these soil-forming factors. In DSM, predictive machine learning models are built based on the relationships between environmental covariates (e.g. RS satellite images, digital terrain attributes) and georeferenced soil lab measurements. Environmental covariates act as predictors in machine learning algorithms. They are supposed to explain complex soil-landscape relationships governing soil spatial variation. One of the most important benefits of explaining soil spatial variation by DSM is that digital soil maps can easily be converted to prescription maps for amendment applications. A tractor equipped with global positioning systems (GPS) and automated sprayers can use those prescription maps to apply variable rate applications (VRA) of fertilizer or lime in a site-specific fashion. This has several potential benefits such as optimization of input-use efficiency, yield, and environmental quality. However, the utility of this technology depends on the ability of digital soil maps to provide accurate information on which to base the variable fertilizer rate prescriptions. Fineness of digital soil maps used in VRA directly influences the accuracy of amendment applications.

Caner Ferhatoglu

Growing availability of potential covariates with finer spatial resolution has created great opportunities for improving digital soil maps. Using finer spatial resolution of covariates in DSM is important because the resolution of the input covariates directly affects the resolution of the resulting soil property map. The resolution of the soil property map, in turn, controls the level of detail that can be included in prescription maps for the VRA. Some of the potential covariates with fine spatial resolution include national agriculture imagery program (NAIP) imagery, Sentinel-2 imagery, Digital elevation models (DEMs), and their derivatives. The NAIP has been taking aerial images at a resolution of 1-meter during the growing season in the US with red-green-blue and near-infrared (NIR) bands. Another example, Sentinel-2 satellite mission has been active since 2015 supporting vegetation and environmental monitoring with a resolution of 10-meter. The revisit frequency of every single Sentinel-2 satellite is 10 days, and the combined constellation revisit is 5 days. Using temporal covariates such as Sentinel-2 images provides the benefit of being able to capture changes in the conditions of crops, soil, and residue. Digital elevation models (DEMs) and their derivatives such as aspect and slope also make valuable covariates to map soil properties as they provide information about the topographic surface of the Earth ground. Other potential covariates include predicted parent material maps and spatial climate maps. These usually have a coarser spatial resolution than the other covariate types mentioned. Although they may retain valuable information, they can be more suitable for mapping larger areas such as state, country, or the whole earth.

As a case study, two soil properties, buffer pH (BpH: buffer pH is the soil property to calculate liming rate in Iowa) and potassium (K), were modeled in two Iowa fields (Table 1) using DSM. Cross-validation (CV), a statistical method, was used to evaluate the models. CV involves evaluation of different partitions of the training dataset further into sub-training and sub-validation sets with averaged metrics (such as R2) calculated from all the different partitions to estimate the overall model performance. For the machine learning algorithm used to model BpH in Field-1, ten-fold-CV- R2 was 0.62 (Fig. 1-B). In Field-2, the model performance for K was 0.66 for ten-fold-CV- R2 (Fig. 1-D). If the fields were managed solely based on soil measurements, we would create management polygons like in Fig. 1-A and –C covering a certain area around the sample locations. These polygons can provide only coarse information about the spatial variation of soil properties. Digital soil mapping, on the other hand, is very promising for creating fine resolution soil maps for VRA along with the growing availability of better RS datasets (Fig. 1-B and –D). Plus, DSM can be statistically evaluated. In summary, the purpose of this publication was to demonstrate the level of details that a digital soil map, created by using covariates from DEMs, NAIP, and Sentinel-2 imagery and state-of-the-art machine learning algorithms, can include.

Field	Soil Property	n	Min	Median	Mean	Max	SD	CV	Skewness	Kurtosis	Year
1	BpH	135	6.2	6.7	6.77	7.1	0.22	0.03	0.44	2.23	2020
2	P_2O_5 (ppm)	42	8	25.5	26.21	46	10.18	0.39	0.2	2.16	2019

Table 1. Descriptive statistics of soil samples for P2O5 (John-F only) and BpH (Cad only) with sampling year. Abbreviations: n is the quantity of soil samples; CV is coefficient of variation.

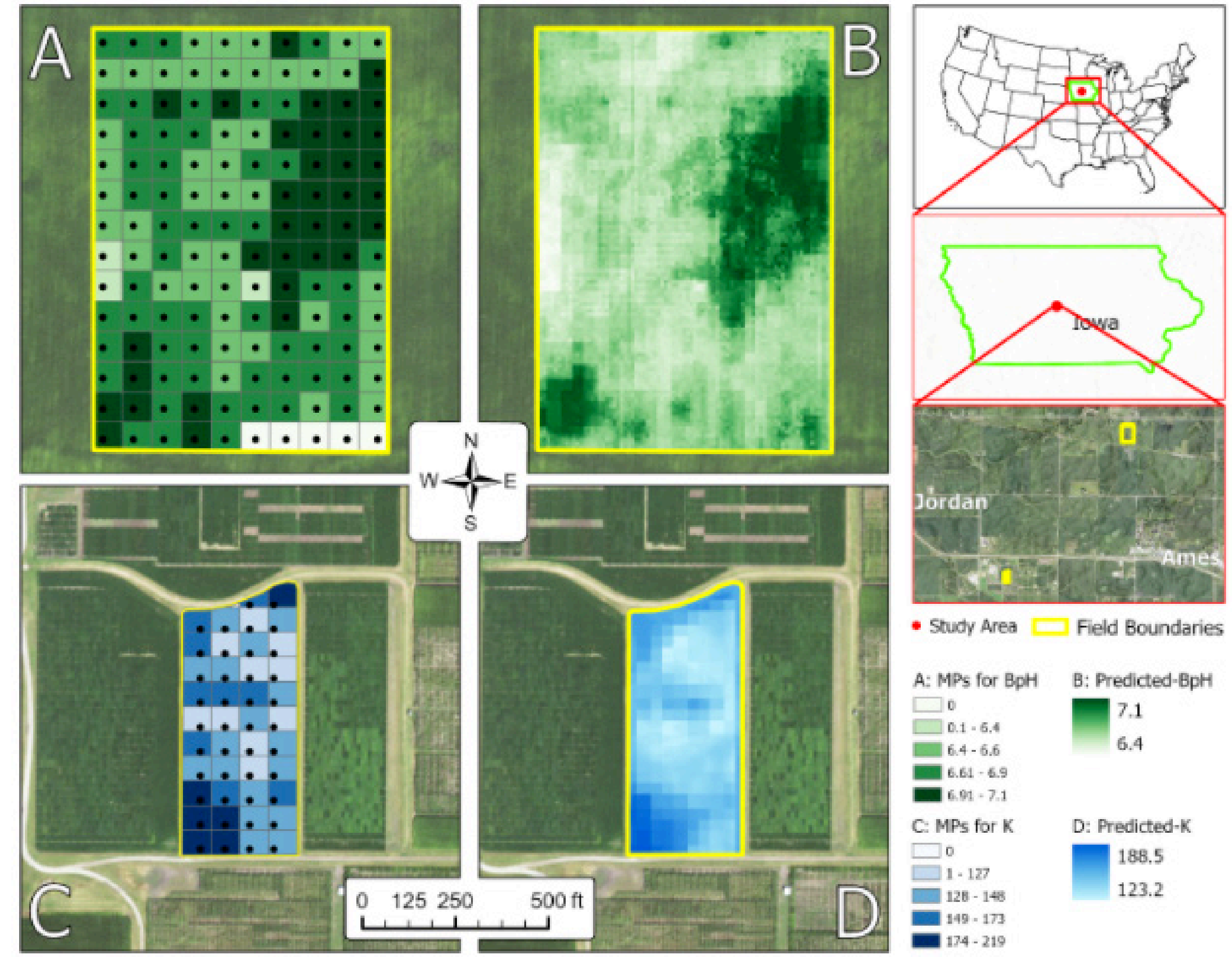

Fig. 1. A: management polygons (MPs) for BpH in Field 1. B: Machine learning prediction map for BpH in Field 1. C: management polygons (MPs) for K in Field 2. D: Machine learning prediction map for K in Field 2. Management polygons are solely based on georeferenced lab measurements and their surrounding polygons. Black points in A and C are the soil georeferenced soil samples used to create the maps in A-D.

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An Open Textbook for Soil and Water Conservation

By Colby Moorberg, PhD, CPSS, PWS, Associate Professor of Soil Science, Kansas State University

As most students can attest, textbooks are expensive and costs keep going up. Open textbooks are a proven way to combat rising textbook costs and keep course materials affordable for students. I was well aware of the impact of high textbook costs on students when I began teaching the AGRON 635 – Soil and Water Conservation course at Kansas State University in 2015. However, at that time the cost was not the biggest textbook problem. The commercial textbook that had been used in that class was relatively affordable. What I found was students were buying the book, but they weren't reading it. In addition, the content of the most recent edition was out of date, there was no new edition in the works. I started looking for alternatives for a new textbook as a result. I found the relevant existing textbooks were too expensive, too advanced, or did not adequately cover the course content I needed. Luckily there is a wealth of extension and government publications on soil and water conservation, which I was aware of and wanted to leverage for my course. Ultimately I decided to develop the textbook, Soil and Water Conservation: An Annotated Bibliography (Moorberg 2019) with the help of 25 chapter co-authors, 20 of which were students from my course.

The textbook was published in December of 2019 by New Prairie Press, the open access digital press at Kansas State University. It is openly licensed under a Creative Commons Attribution 4.0 international license (CC BY 4.0). My first goal for this textbook was to create an up-to-date resource for soil and water conservation students and practitioners. The second goal was to familiarize students with credible, technical information sources for soil and water conservation. The third goal was to reduce cost and increase accessibility of textbooks for students. Once completed, over 700 resources were cited in the annotated bibliography, including extension publications, government reports, technical bulletins, and more. Each citation was accompanied by an annotation that described the resource, provided a short summary, and included any additional contextual information as needed.


Colby Moorberg, PhD, CPSS, PWS

One of the inspirations for using an annotated bibliography as a textbook was my desire to have the AGRON 635 - Soil and Water Conservation course be based on in-class discussions rather than traditional lectures. The students would need to actually read the reading assignments prior to class to facilitate those discussions. What I've found is the students enjoy and prefer the variety of information sources being used as reading assignments compared to assigned readings from more traditional textbook chapters. Extension publications, for example, are generally concise and written for a general audience. This makes the readings easier to comprehend and more likely to be read by students prior to class.

The aspect of developing Soil and Water Conservation: An Annotated Bibliography that was most rewarding was collaborating with students as chapter co-authors. I used an "open pedagogy" approach to create portions of the textbook. Open pedagogy involves teaching in a way in which students are engaged as content creators for their course, and that content ultimately gets published as an open educational resource, such as an open textbook. My approach was outlined in a case study (Moorberg 2020). In short, students wrote annotated bibliographies for a topic of their choosing as a graded assignments. The students had the opportunity to give written consent to include portions of their annotated bibliography in the textbook after it was edited by myself and a technical editor. Those students were credited as co-authors for the chapters in which their annotated bibliography topic was included. This approach was popular among the students, and all of them agreed to include their work in the textbook. I plan to continue making improvements and additions to the textbook with future contributions from students enrolled in the course, and these additions will be published in new editions of the text.

The textbook can be found at https://newprairiepress.org/ebooks/30/, and is available as a PDF, a web book, and various e-book formats. It has been downloaded over 1,100 times in the two years since it was first published. An estimated $11,000 is saved each year collectively by students who are enrolled in soil and water conservation courses at six different institutions where the instructor has adopted Soil and Water Conservation: An Annotated Bibliography as a course textbook. This amount of savings is expected to increase as the textbook is adopted for use by additional instructors each year.

Rural, urban and suburban Iowans agree on the grand vision of abundant crops, healthy soils and clean water for the state, but are challenged by how to attain it.

The Influence of Food Web Structure on Lake Resistance and Resilience to Nutrient Loading

By Tyler Butts, Ph.D Candidate, Center for Limnology, University of Wisconsin-Madison

The frequency and intensity of storm events have been increasing in Iowa and across the Midwest due to climate change. Severe storms mobilize nutrients from watershed soils and release them into inland waters, often boosting concentrations of key nutrients such as nitrogen and phosphorus (Carpenter et al., 2018). In agricultural watersheds, storms coinciding with fertilizer application can cause substantial nutrient loading to nearby lakes. Interactions between storms and agricultural practices are a concern for water quality in Iowa, where row-crop production dominates watershed land use for 78% of publicly-significant lakes across the state (113 lakes; Arbuckle and Downing, 2001). Combined with increasing global temperatures (IPCC, 2021), storm-driven nutrient loading will fuel algal blooms, often dominated by cyanobacteria. Large blooms of cyanobacteria reduce water clarity, trigger fish kills, and may produce harmful toxins that threaten animal and human health. Reducing overall watershed nutrient loading is crucial to avoid worsening cyanobacteria blooms that are a significant risk to Iowa's economic and public health. However, how lakes respond to nutrient inputs may vary depending on the fish, plants, and microscopic organisms that live there, known as the food web.

Tyler Butts

The number and pattern of interactions between predators and prey within a lake – or food web structure – may determine whether nutrients added to the lake spark algal blooms or whether the nutrients are cycled throughout the rest of the food web. Food web structure has been hypothesized to increase lake resilience and resistance to nutrient loading (Pelletier et al., 2020; Calizza et al., 2019). In this case, resilience describes how quickly a lake can return to baseline conditions following a disturbance (e.g., return to low algal biomass following an algal bloom), whereas resistance describes how well a lake can maintain its state following a disturbance (e.g., never trigger an algal bloom in the first place). Lake food web structure is commonly composed of two food chains, one pelagic (i.e., open water) with algae at its base and one benthic (i.e., related to the bottom of the lake) with decaying material and algae bound to surfaces at its base. Fishes that feed on a variety of prey across both benthic and pelagic food chains generate more food web linkages and increase food web complexity. This benthic-pelagic coupling within food webs may facilitate greater resistance and resilience in lakes by providing more pathways for energy and nutrients to cycle, thereby reducing the likelihood of nutrient loading triggering a large algal bloom (Rooney and McCann, 2012; Vander Zanden et al., 2011). However, our understanding of how food web structure affects lake responses to disturbances remains limited to small-scale experiments and theoretical conceptualizations.

As the frequency and intensity of 'flashy' precipitation events are likely to increase in the future (Prein et al., 2017), attaining a better grasp on the relationship between food web structure and lake resistance and resilience to pulses of nutrient loading is crucial. Addressing this knowledge gap has been a central goal of my graduate research. With support from the Iowa Water Center, our research team was able to empirically test whether a food web structure with greater benthic-pelagic coupling could (1) mediate lake responses to pulsed nutrient loading and (2) facilitate greater lake resistance and resilience. To do so, we used large experimental ponds at the Iowa State Horticultural Research Station simulating natural shallow lake conditions. We established different food web structures ranging from low to high benthic-pelagic coupling, each replicated in two ponds, using largemouth bass and fathead minnows as mobile generalist consumers to increase benthic-pelagic coupling (Figure 2). To simulate storm-driven nutrient loading we then subjected one pond with each food web structure to two separate nutrient pulses of nitrogen and phosphorus. We sampled the ponds daily over the course of the summer, monitoring changes in algal biomass, animal abundances, and nutrient concentrations (Figure 3).

Early data show that greater benthic-pelagic coupling led to increased resistance to pulse nutrient loading in our experimental ponds. The response of algal biomass was slower and less responsive to both of our nutrient pulses during the summer in ponds with the greatest benthic-pelagic coupling. However, our analyses of ecosystem resilience were less clear and require further analysis. Over the next year, we will begin to analyze the dynamics of the organisms within each experimental pond including the fish, zooplankton, and benthos to gain a better understanding of the food web dynamics over our experiment. Incorporating food web structure into adaptive lake management is vital to address new and continuing challenges for Iowa's lakes.

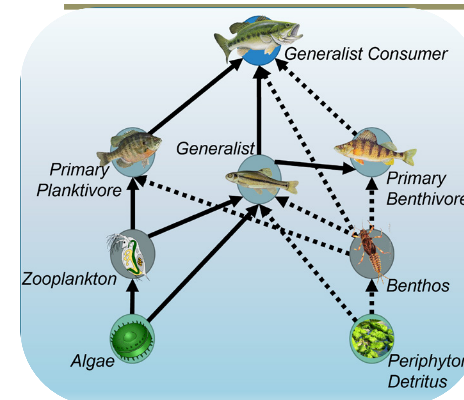

Figure 1. A conceptual diagram of a food web structure with benthic-pelagic coupling with largemouth bass and fathead minnows as generalist consumers, bluegill as planktivores, and yellow perch as benthivores.

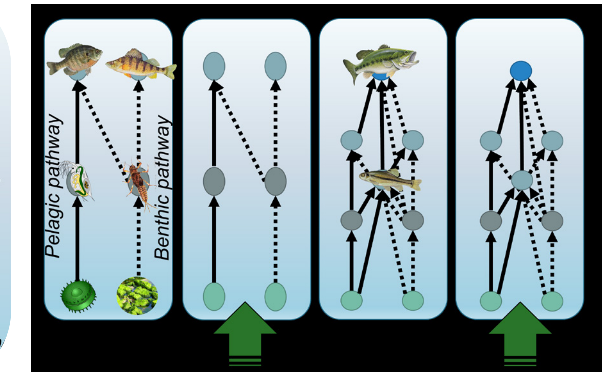

Figure 2. A conceptual diagram of the experimental design we established in the Iowa State Horticultural Research Station ponds depicting low benthic-pelagic coupling with no generalist consumers (left) versus high benthic-pelagic coupling with two generalist consumers (right).

Figure 3. Experimental ponds at the Iowa State Horticultural Research Station (top), Michael Tarnow ('20) collecting a zooplankton sample at the ponds (bottom left), Matthew Kremer ('23) processing a zooplankton sample (bottom middle), and Tyler Butts preparing to add a largemouth bass to the ponds (bottom right).

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We developed a client-side web-browser based software to lower code barrier for hydrologic data visualization and evaluations.

Hydrovise: Open-Source Software for Hydrologic Model and Data Visualization and Evaluation

By Navid Jadidoleslam, Postdoctoral Research Fellow, Georgia Institute of Technology

Science communication is an imperative element of the research process for making impactful changes;however, it has been overlooked in this process. Nowadays, the internet and web technologies have become inseparable parts of our lives. For example, we use smartphones to check the weather, traffic, and other information to make life easier. These technologies could also help researchers share their findings on online platforms.

We are living in the Big Data era!

In recent years, we have witnessed a boom in sensor technologies, leading to more Earth Observing Satellites (EOS), field sensors, and the Internet of Things (IoT). These platforms provide unprecedented opportunities for researchers to understand the water and energy cycles. However, the challenge is transforming the large volume of data into meaningful and helpful information for the public good. Data visualization and analysis are the first steps towards better understanding the physical processes and creating conceptual models for solving earth system science problems.

Moving towards open science.

Open science is a way to increase the outreach of the scientific research process to a broader community. The critical elements of this framework are accessible, transparent, and reproducible research. Developing web-based applications for an open science framework is a great approach, however, it could be time-consuming and challenging for non-experts.

Navid Jadidoleslam

How could we address this challenge?

We have developed open-source software that lowers the barrier for web-based and interactive data visualizations for hydrologic data called Hydrovise. Iowa Water Center supported this project through Graduate Student Supplemental Research Competition. Hydrovise creates visualizations and analyzes hydrologic and environmental data on the browser. Hydrovise users could create visualizations without prior knowledge of web technologies and web development.

How does Hydrovise work?

Hydrovise uses a configuration file to generate a Graphical User Interface (GUI) for the user's application. The project configuration file is a JavaScript Object Notation (JSON) file containing a set of information/definitions about data sources (e. g., traces, space-time data, marker locations, etc.), control elements in the GUI, and the styling of the visualizations.

The Graphical User Interface is a web browser-based interface created dynamically by the initialization module. The content of the GUI depends on the information stored in the project configuration file. It consists of a map, a canvas for visualization of time-series and spatial data, and other control elements that allow navigating data in different dimensions. Fig. 1 shows a schematic of the GUI and structure of the configuration file. The configuration objects are numbered with their corresponding elements on the GUI.

What can be done with Hydrovise?

In the following few paragraphs, I describe some example use cases of Hydrovise.

1. **Time-series data visualization and evaluation**
Time-series data is helpful to understand how a variable changes over time. For example, streamflow

	example_config.json
-	{"page":{},
1	"data_part":{},
7	"traces":{},
7	"modTraces":{},
8	"timeSlider":{},
7	"horizontalGrid":{},
6,14	"mapMarkers":{},
2-5	"controls":{},
7,8	"plotlyLayout":{},
11	"mapLayers":{},
6,12,13,15	"map":{},
6	"customBaseMap":{},
9,16	"spatialData":{},
9,10	"timeSelectorLayout":{}}

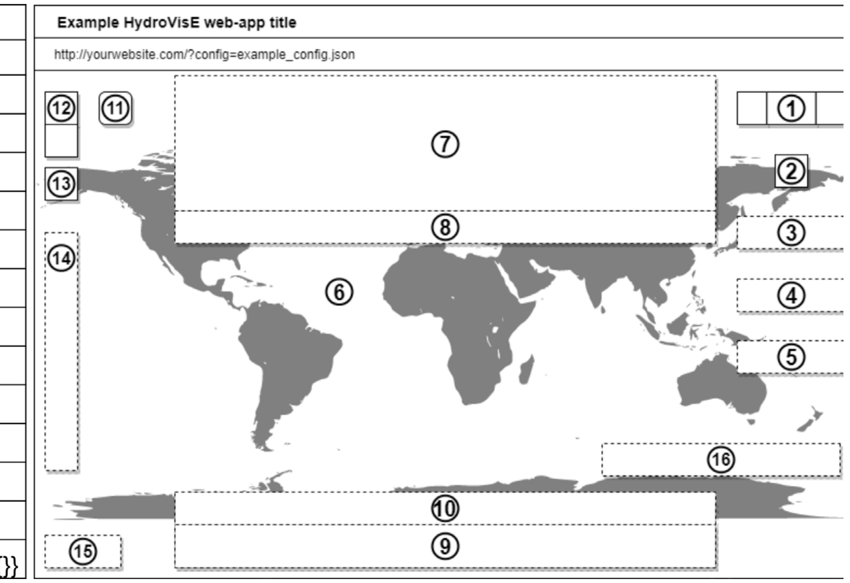

Fig. 1. A schematic of the Hydrovise Graphical User Interface (GUI) and configuration objects corresponding to elements in the GUI.

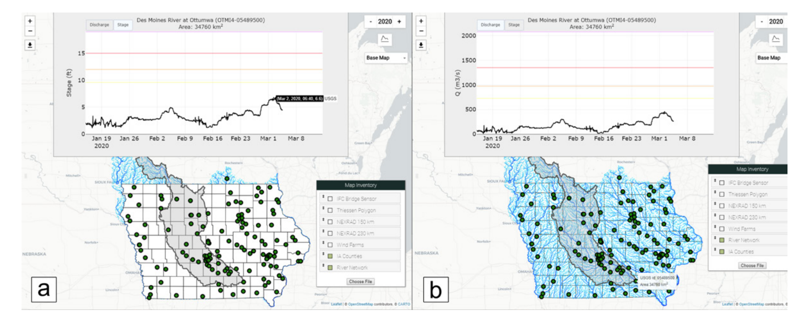

Fig. 2. Example real-time data browser for USGS observations with National Weather Service (NWS) flood categories and stage-discharge conversion. (a) Stage observations (ft) and (b) converted streamflow (m3.s–1) at the USGS gauge at Des Moines River at Ottumwa.

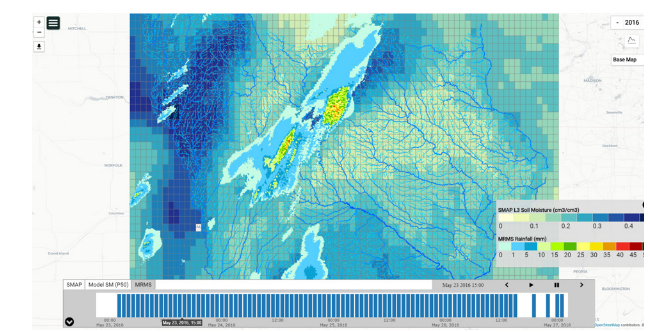

Fig. 3. Example grid-based maps for SMAP satellite-based soil moisture 6:00 PM May 23, 2016 and (Multi Radar Multi Sensor) MRMS hourly radar-based rainfall for 3:00 PM May 23, 2016.

observations from the United States Geological Survey (USGS) help us monitor water availability in the streams or flooding conditions. Hydrovise can visualize streamflow time series with relevant information about the observation location on the map to provide more context. Furthermore, it can compare streamflow predictions from a model with the observations. It offers qualitative and quantitative measures on the model predictions for a user-selected period. This information helps water resources engineers to improve model predictions for early flood and drought warnings (e.g., Fig. 2).

2. **Maps of hydrometeorological data**
Visual maps of hydrometeorological data (e.g., soil moisture, rainfall, etc.) help identify the regions with drought and flooding conditions. For example, providing the data source to Hydrovise can visualize soil moisture maps for a user-defined area such as Iowa. These maps could help understand the current and past conditions for agricultural productivity. Soil Moisture Active Passive (SMAP) and Soil Moisture Ocean Salinity (SMOS) are two satellite missions that provide soil moisture information in space and time (e.g., Fig. 3).

3. **Visualizing streamflow and soil moisture forecasts**
Iowa Flood Center provides streamflow and soil moisture forecasts for Iowa for the next ten days that update every fifteen minutes. Hydrovise facilitates visualizing soil moisture and streamflow forecasts, and allows users to navigate historical data over time as well as future predictions.

How can I use Hydrovise?

Hydrovise is client-side and portable software. In other words, users only need a Hypertext Transfer Protocol (HTTP) server and a web browser.

Is Hydrovise free?

Yes! Hydrovise is free and open-source, and it is distributed under MIT License. Everyone can access Hydrovise source code on GitHub, read the documentation and use it for visualizing their data. Interested readers can visit www.hydrovise.com for more information.

Building Watershed and Water Quality Awareness in Iowa

By Steve Konrady, Western Iowa Basin Coordinator, Iowa Department of Natural Resources

What watershed do you live in? It was a question asked of me on one of my first days as a water quality professional. It is a simple question, in theory: We all live in a watershed – more than one actually. So why did I immediately and reflexively grab my chin to help me ponder that question?

In the broader picture, I knew I lived in the Des Moines River watershed at the time, but I had to admit to myself that I did not know the name of the creek down the street. Luckily, with a few minutes on the Internet I knew that the part of Des Moines's Drake Neighborhood I lived in was in the Ravine Creek watershed. I had driven over Ravine Creek hundreds of times and not known its name, something my colleague Steve Hopkins pointed out as a common theme among many people in last year's article about creek signs (Getting into Soil & Water 2021).

Since then, I have made it a point to figure out which watershed I am in for longer than a pass-through, just in case any colleagues ambush me with that kind of question again. It is an essential opening message for many of our water quality outreach and awareness campaigns in Iowa, too. Water Rocks!, a program the Iowa Department of Natural Resources (DNR) sponsors at Iowa State University (ISU), addresses it in the many versions of their song We All Live in a Watershed. The U.S. Environmental Protection Agency (EPA), among other agencies, ask "What is your watershed address?" Many of the referenced EPA/DNR funded creek signs across the state include identification of source waters for lakes and larger river watersheds that make identifying the bounds of improvement projects easier, a first step in driving interest in those projects among decisionmakers and landowners.


Steve Konrady

What watershed you are in is, therefore, often the starting point of many conversations about water and water quality. More than merely a physical location, your watershed invokes a connection to all of the land humans occupy that has a large part in determining the quantity, quality, and peculiarities of the water that run through and over it. The nesting doll-like watershed tapestries of Iowa are diverse, beautiful, and oft troubled, but yet serve us with abundant drinking water, wildlife habitat, recreation, conveyance (of stormwater and cargo, alike), and provide a myriad of other benefits to our wellbeing as a society connected via both land and water.

Collaborations across the state have sought to leverage these connections to foster stewardship. Watershed projects rely on that collective watershed identity to implement best management practices (BMPs) that improve water quality for local and downstream users and consumers. Targeting these BMPs around impaired waters, an EPA designation, is the mission of the Clean Water Act Section 319 Grant that funds our work. Demonstrating successful efforts of BMP implementation and resulting water quality improvement, and promoting that demonstration, is done via education and awareness campaigns and is a key component of both Iowa's Nonpoint Source Management Plan and Nutrient Reduction Strategy.

Each watershed project and their education and awareness efforts rely on contributions from statewide partnerships like ISU's Iowa Learning Farms and Water Rocks!, and also contributions from non-governmental organizations and other partner agencies and at the local, state, and federal levels. Watershed and water quality awareness is not just important where there are active watershed projects, however, and the DNR and partners also work to bring these messages to the broader public.

The Polk County Rain Campaign, in the most populous county in Iowa, is one such effort to educate all Iowans about their place in a watershed and impact on the water. A sister effort was established in the Iowa City/Coralville metropolitan area, and DNR is committed to helping other regions of the state build off of these successful strategies. The results of the two pilot projects show that communities are interested in learning about individual actions that can reduce stormwater runoff, which collectively can show meaningful reduction of peak and sustained storm flows. A study of a single drainage basin at Polk County's Easter Lake showed these homeowner actions led to a 20 percent reduction in runoff over four years.

Watershed and water quality awareness starts with a simple question like "What watershed do you live in?", but goes on to ask each of us what actions we can do to improve the watersheds all of us live in and rely on. Iowa is well served by all the water-focused partnerships, stewards, and educators that help us gain awareness and move us to action.




At left, clockwise from top left: BMP outreach event in Ankney, BMP signage example at Rathbun Lake; Experiential Water Quality Art - Rain Campaign, Iowa State Fair; the Des Moines River in downtown Des Moines.

At bottom left, BMP signage example, Wallace Building, Des Moines.

Basic Concepts of a Wet Soil

By Julie McMichael, State Compliance Soil Scientist


Julie McMichael

The more we understand about soils, the better we can make decisions to deal with the world around us. There are many reasons to understand the soils beneath our feet. If we don't consider the soils, we are likely to get stuck in the mud. There are many different soil conditions, including healthy and unhealthy soils, nutrient rich soils and soils depleted of all nutrients, to as simple as being wet or dry. This concept of a soil being wet or dry soil is what I want to address here.

How to Define a Wet Soil

First, a wet soil is not simple to define. For a farmer it is a wet spot that needs to be managed to produce a crop. Soil scientists call a wet soil a hydric soil. The National Technical Committee for Hydric Soils defines a hydric, or wet, soil as one that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part of the profile. Anaerobic soils are soils that lack adequate oxygen. By Federal Regulation 7CFR Part 12.2 a hydric soil is defined as a soil that, in its undrained condition, is saturated, flooded, or ponded long enough during a growing season to develop an anaerobic condition that supports the growth and regeneration of hydrophytic vegetation. A wet soil is also a way to conserve or sink water into the ground. Management is important to all when understanding wet soil.

Do I Have a Wet Soil?

To answer this, it is best to consult a local soil survey for the area. This can be done by going to the Web Soil Survey (https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm), which is the official soil map provided by the US Department of Agriculture. Instructions for accessing the data and maps and finding information for your location can be found on the first page of this website. Once an area (AOI) is defined it will tell all about the soil at the location including detailed maps. Clicking on the Soil Data Explorer> Suitabilities and Limitations for use> Hydric Rating tab, will give data about Hydric Rating of the area selected. Another important table is the Depth to Water Table. This table is also in the Web Soil Survey under Soil Data Explorer> Soil Properties and Qualities> Water Features> Depth to Water Tables. If trying to make decisions on how to make the soil dry this is very important. It helps to understand the expected ground water levels of the area. Another key point to understand is the surface water and how that affects the soil. Soil Texture and Soil health can play an important role here in how the water infiltrates into the soil profile. Soil texture is related to soil particle size; the smaller the soil particle the longer it takes to drain the soil because of a soil's ability to hold the water in the profile. This is found in the web soil survey as well in Soil Data explorer> Soil Properties and Qualities> Surface Texture. This will tell how tight the clay soils are in the area.

How to Manage a Wet Soil

There are two choices to manage a wet soil; to keep it wet or to dry it out. Keeping a soil wet is the cheaper choice but may also lower return on the revenue generated by the ground to make the ground profitable or at least pay for the taxes and break even. Usually, wet soils are high in organic matter as well. They can be farmed in drier years but, as with most aspects of farming, this involves risk. Make a note that some wet soils are federally protected. This may prompt the decision to keep a wet soil wet. If you opt to try and dry a wet soil, make sure to check the regulations before doing any planning or work.

If you can "dry" out your wet soil, there are many choices to accomplish drying it out. Making soil drier is often accomplished by tile. Clay content and water table are directly related to how effective tile can be. If you have a high clay content, you will need a tile close together to effectively drain and dry out the area. It is best to consult an engineer to get the correct depth and grade of tile. You can also dry out a soil by improving its soil health. A healthy soil has better infiltration of water and therefore holds and releases water better and is more manageable.

The Natural Resources Conservation Service (NRCS) is a federal agency that is part of the US Department of Agriculture that can assist in understanding your soils more. NRCS has 100 field offices throughout Iowa, located at USDA Service Centers. The NRCS offers one-on-one conservation planning assistance to farmers and other rural landowners and conservation programs to help improve the sustainability of the land through conservation practice implementation. The NRCS also can assist in implementing soil health practices and giving technical assistance with the soils that are both wet and dry. So, the next time you find yourself stuck in the mud, think of these basic concepts.