2018 Edition

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

Soil&Water Conservation Club

GETTING INTO

SOIL & WATER

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We Are Proud to Present Our 2018 Publication

Hannah Corey, Lindsay Brown and Jacob Wright
2018 Editors

In its ninth year, Getting into Soil and Water is packed full of great articles that we are excited to share with you. The goal of this year's publication is to showcase the diversity of opportunities within soil and water. Our team of three co-editors is made up of Hannah Corey, Lindsay Brown and Jacob Wright. We wanted to share with you a little bit about ourselves and what soil and water conservation means to us.

Hannah Corey: I am a junior in agronomy with a minor in entrepreneurial studies, and have been a member of the Soil and Water Conservation Club since the spring of 2016. While growing up on a farm in Northwest Iowa, water quality issues at home sparked my interest in soil and water quality. I have not looked back since. Serving as a co-editor of this publication has given me the chance to help spread quality information across Iowa and beyond. Whether you are working in industry or government, a student or a professional, it is my hope that Getting into Soil and Water 2018 will open your eyes to the opportunities in soil and water.

Lindsay Brown: I am a senior in biology and environmental science and joined the Soil and Water Conservation Club in the fall of 2016. Soil and water have recently peaked my interest because of their importance to life. I am passionate about the environment, specifically water quality and its processes, and being in this club has allowed me to meet people with similar interests and gain information on current issues. I have expanded my knowledge about soil and water conservation by being a co-editor of this publication and reading the perspectives, research and ideas various professionals have to offer. I hope our readers gain fresh perspectives and broaden their understanding over multiple topics regarding soil and water conservation.

Jacob Wright: I am a sophomore in agronomy and environmental studies and joined the Soil and Water Conservation Club in the spring of 2017. Growing up on a dairy farm in Virginia, I always saw numerous articles and heard discussions about nutrient contamination in the Chesapeake Bay. This peaked my interest for soil and water conservation, and being a part of this club and publication has allowed me to learn more about current research and issues in this field of study. I have learned a lot from co-editing through reading different research studies and seeing the diverse perspectives and ideas that came together to showcase the variety of opportunities in soil and water conservation.

We want to send out a big thanks to all of our committee members: Dr. Rick Cruse, Dr. Bradley Miller, Costas Hatzipavlides, Leah Ellensohn, Brian Jenson and Shannon Breja. This publication could not have happened without the help of their creative thinking and scientific knowledge. They are essential to this publication, and we cannot thank them enough.

Lastly, we want to thank our readers. Your continued support is why this publication has almost reached its tenth year. We strongly believe that the articles included will allow you to dive deeper into the field of soil and water.

We hope you enjoy (and learn from) *Getting into Soil and Water 2018*!

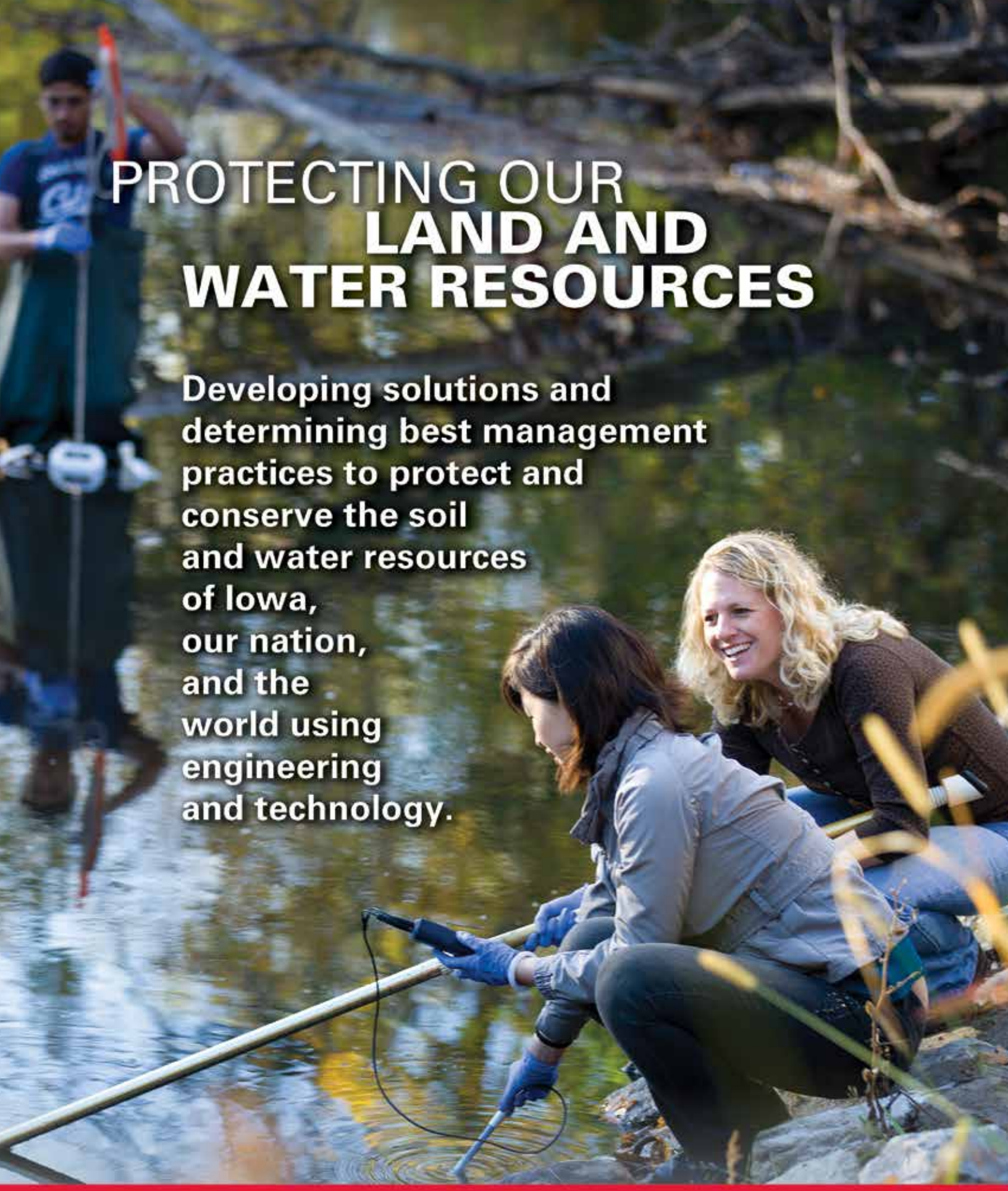

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FIG. 2 Sediment discharge from a construction site.

FIG. 1a Standard installation failure.

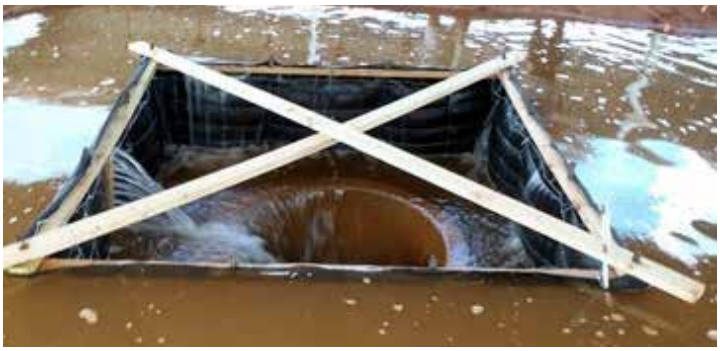

FIG. 1b Improved practice with structural reinforcement.

Managing Construction Stormwater Runoff

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Since the implementation of the Clean Water Act in 1972, the Environmental Protection Agency has been able to curtail pollution to waterways from many point sources. However, pollution impacts from non-point source stormwater runoff continue to increase. Stormwater management has become an increasingly important topic in the state of Iowa with a large focus on finding ways of improving agricultural runoff, which pollutes streams and rivers with high nutrient and sediment loads. While the vast majority of land in Iowa is dedicated to agricultural production, there is another major culprit to non-point pollution sources: construction sites.

Construction activities generally involve heavy earthmoving activities that disturb several acres of land at a time. Due to the nature of construction activity, sediment is the predominant pollutant of concern during the clearing and grading stages, which typically exposes large un-vegetated and unstabilized land areas to erosive elements. The lack of ground cover during construction results in land areas being susceptible to increased rates of soil erosion. Other pollutants associated with land development include: fertilizers, pesticides, petrochemicals, construction chemicals, wash water, paper, garbage and sanitary waste. As stormwater runoff flows over unprotected areas on construction sites, it can suspend and transport pollutants causing significant physical, chemical and biological water quality impacts, and impairments to nearby receiving waters (1).

Soil Loss: By the Numbers

Stormwater induced erosion occurs when rain droplets impact unprotected soil, creating dislodgement and transport. Raindrops fall at 20 miles per hour and with equivalent impact energy of 10,000 tons of T.N.T. per square mile (2). Poorly managed construction activities can create a major source of pollution. In fact, sediment runoff rates from construction sites have been estimated to be 10 to 20 times higher than those of agricultural lands and 1,000 to 2,000 times greater than forested lands (3). Construction sites have measured erosion rates of approximately 20 to 200 tons per acre per year (4). Construction generated sediment washes into waterways in the U.S. at a rate exceeding 80 million tons per year. To put it into perspective, that amount of soil would be able to load 4.9 million dump trucks; enough dump trucks to completely fill a nine-lane highway between New York and Los Angeles.

FIG. 3 Typical construction site erosion and sediment control practices.

Managing Construction Site Runoff

The state of Iowa manages construction generated pollution through the National Pollutant Discharge Elimination System (NPDES) General Permit. This permit requires all construction activities that disturb one or more acre of land at a time to implement stormwater management practices. These practices include providing measures to reduce erosion, capture sediment and minimize other pollutant sources.

The most effective way to minimize sediment loss from construction sites is to prevent soil from dislodging and washing away in the first place. This can be accomplished by reducing the amount of area disturbed at one time and by reducing the total amount of time that disturbed areas are left exposed. For example, an effective pollution prevention plan would limit the disturbance to a single residential lot at a time, rather than clearing and grubbing an entire subdivision plat as is common practice in home building.

Erosion control practices focus on providing cover to unvegetated areas and protecting areas from surface runoff. Cover practices include straw mulching, erosion control blankets, and temporary and permanent vegetation. These practices act to absorb the impact of raindrops, increase infiltration, reduce runoff and slow runoff velocities. Other erosion control practices focus on managing surface runoff to prevent dislodgement of soil caused by high velocity and shear forces flowing through ditches, swales and channels.

The last line of defense on construction sites are sediment control practices. These practices are designed to capture and promote sedimentation on-site. Common sediment control practices include: sediment barriers, inlet protection practices and sediment basins. These practices function by temporarily impounding and detaining runoff allowing large, rapidly settleable particles to fall out of suspension through gravitational forces.

Active treatment methods can also be used to further improve stormwater prior to offsite discharge. These treatment practices generally rely on applying flocculants to encourage particle settlement and can include advanced treatment methods such as sand filtration.

An effective stormwater pollution prevention plan implements a combination of erosion and sediment control practices along with effective communication and management of work activities to minimize environmental impacts.

Research

Researchers at land grant universities such as Iowa State University, Auburn University and North Carolina State University are developing ways to improve the tools and technologies used on construction sites to help manage stormwater runoff and minimize the impact to our nation's water bodies. Researchers evaluate practices under large-scale conditions to simulate runoff and sediment loads that are typical to construction sites. These simulated storm conditions allow practices to be evaluated under the same conditions to which they would be subjected in the field. This type of large-scale testing allows researchers to document how practices fail and can then provide installation improvements. Technology and treatment methods developed by researchers are helping construction site operators implement more effective tools to help manage stormwater runoff and reduce the amount of pollutants entering our water bodies.

[1] Maxted, J. R., and E. Shaver. The Use of Retention Basins to Mitigate Stormwater Impacts to Aquatic Life. Presented at National Conference on Retrofit Opportunities for Water Resource Protection in Urban Environments, Chicago, IL, 1998.

[2] Georgia Soil and Water Conservation Commission. Manual for Erosion and Sediment Control in Georgia, 2016.

[3] United States Environmental Protection Agency. Effluent Limitations Guidelines and Standards for the Construction and Development Point Source Category. Publication EPA-HQ-OW-2008-0465, 2009.

[4] Pitt, R., S. E. Clark, and D. W. Lake. Construction Site Erosion and Sediment Controls: Planning, Design and Performance. DEStech Publications, Lancaster, Pa., 2007.

A Midwestern Ag Student's Experience Abroad in Ghana

Daniel P. Brummel
Masters student in Soil Science at Iowa State University

After graduating with a bachelor's degree in agronomy at Iowa State University (ISU), I packed my bags and flew to the West African country of Ghana. With the completion of my degree at ISU, I immediately started graduate school in the hope of getting a master's degree in soil science. I was quickly shipped off to Ghana to complete my field research in the summer of 2017. Through this article I describe my experiences in Ghana, focusing on the differences in agricultural production as compared to the Midwestern United States, and how technology is improving agricultural production in Ghana. After all, one would expect many changes when traveling halfway around the world.

Ghana is located on the coast of West Africa just north of the equator, bordering the countries of Côte d'Ivoire, Burkina Faso and Togo. Although the country is approximately the size of the state of Illinois, Ghana is impressively the second largest producer of cocoa in the world and produces a large variety of other staple food crops. Luckily for myself, Ghana's primary language is English and there are many regional languages found scattered throughout. According to an estimation by the United Nations, as of 2017 Ghana has a population of around 29 million ("Ghana Population", 2017). Ghana is home to many large cities; the most densely populated is the capital city of Accra.

Upon arriving in the capital city of Accra I was perplexed by the agriculture found in the city. Goats, sheep, chickens and cows could be found wandering the neighborhoods of Accra. Large, lush banana and plantain plants were planted beside homes, with their produce for sale on the street. However, outside the city and in the rural communities the agriculture production was extensive.

One of the first farms I visited was an

Farmers everywhere, including those in Ghana, are trying to increase production and feed the world. It is truly an exciting time to be in agriculture.

onion farm in the Greater Accra region. The field was located on a sandy beach just thirty yards away from the crashing waves of the ocean. The onion field was roughly an acre, and boarded by a pepper and okra field. The majority of the vegetable farms were around one to two acres. The water table was very shallow, so the farmers dug a shallow well and used a sprinkler system to irrigate the fields. All of the crops were sold locally, including coconuts and native mangos that grow in the region.

When moving north to the central part of the country, dense jungle begins. Bananas, plantains, mangos and other tropical fruit dominate the agricultural market. In the bush, there are many large snail farms, a common staple for the area. Women can be seen on the roadside selling live snails to passing cars. Wild antelope and grass-cutters are another local favorite, however, like the rest of the country, chicken, beef and goat are the most commonly consumed protein.

Most of my time was spent in the northern region of Ghana where the primary crops are corn, sorghum, millet, beans and rice; these are crops that I was luckily more familiar with. I spent my time researching the use of new technologies to try to improve management of corn fields. All of the fields were planted by hand either in rows or just broadcasted throughout. The planting is very labor intensive and would usually take at least two to three days to complete. The average size of the fields was around twenty to thirty acres, much smaller than what I was used to back in the Midwestern United States.

The fields were typically broadcasted with a dry fertilizer that was directly placed on the soil surface, relying on rain to make the nutrients available for the plant. Spraying herbicides and hand weeding were both common practices to control weed pressure. Insecticides are being introduced, but insect control remains a major challenge for the farmers in the area. With the amount of time it takes to add fertilizer and pesticides to the field, it is common for parts of the field to go unfertilized and unprotected from pests. The corn fields are typically harvested by hand over two or three days. The corn is then mechanically shelled and laid out to dry.

As new technologies are being introduced, the cropping systems continue to improve and become more efficient. It is exciting to see the potential for increased production that these areas have.

Recently, small rice combine harvesters have been introduced and are now becoming common practice in rice production. Ghana and other African countries with large agricultural production could look a lot different in the near future. Farmers everywhere, including those in Ghana, are trying to increase production and feed the world. It is truly an exciting time to be in agriculture.

"Ghana Population (LIVE)."
Ghana Population (2017) - Worldometers, 10 Dec. 2017, www.worldometers.info/world-population/ghana-population

Considering a Career in Soil Science?

Ross Bricklemyer, PhD
Environmental & Spatial Analytics Lead
Monsanto Co.

I learned much throughout my university education. First, I learned the fundamentals of soil science in my Bachelor's program. That sparked my interest to "dig deeper" (pardon the pun) for understanding soil organic matter dynamics in semi-arid agriculture during my Master's research. From there I developed a passion for understanding soil spatial variation as it pertains to row crop production and soil health, and researched the topic for my Doctoral work. I also started understanding the working cultures in academic and government research institutions through the many collaborative projects I worked on over the years.

As I progressed through higher education, attending scientific conferences, reading and writing peer-reviewed journal articles, and networking with colleagues across the globe, it appeared that academic or government research organizations were most likely my future employers. Then, I got the email!

I started looking for full-time jobs towards the end of my PhD program. At the time, there were few academic and government research opportunities for someone with my skill set and interests. I submitted a few applications to universities and the USDA-ARS, had a phone interview with one university and was awaiting communication from a couple more. One way I learned about job opportunities was by maintaining a membership in the Soil Science Society of America and subscribing to email lists for my divisions of interest. I received an email one morning about a job opportunity at a company I knew primarily for manufacturing seeds and herbicides. Yes, Monsanto. Monsanto was looking for a soil scientist? The job description highlighted preferred skills that read just like a page out of my resume! After the initial shock wore off about finding a job opportunity that seemed to have been custom written for me, the questions started… What does a soil research position look like in a global agribusiness company? Was the culture going to be a good fit? What sort of freedom will I have to explore my research interests and develop new skills? I had to find out, so I applied!

I have been working at Monsanto for more than four years now. It has been an amazing experience and wonderfully fulfilling. Working for a company with a global footprint has provided many opportunities to expand my soil knowledge more broadly than I expected. Soil research at Monsanto has broad applications. For example, applications like better understanding how our seed products perform, testing potential environmental impacts of current and next generation crop protection products and making recommendations to reduce environmental impacts. Ultimately, soil science can help improve agro-environmental sustainability within our business and across the broader agriculture community.

I have no doubt that the culture and focus of soil research is different in private industry, than it is within an academic setting. That does not mean there is less freedom to explore research interests, rather it challenges me to think differently about the application and potential impact of the work. My work not only benefits the business, but aims to provide valuable products and insights to our farmer customers, and ultimately benefits consumers of agriculture products. Monsanto has provided me with many opportunities to explore my research interests and develop myself as a leader in my field.

The agriculture industry is ever-evolving. Working at Monsanto has provided me many opportunities to continue developing new skills and interests. Developing new technical, professional and leadership skills is not only encouraged at Monsanto…it is expected! This is one way that we foster innovation. From our core businesses, Monsanto provides industry leading seed

products, crop management solutions, and new technology in precision agriculture and data science. Thanks to Monsanto's culture of continuous development, I am now using cutting edge soil science to generate new insights that will influence new technologies that will help the entire industry. Monsanto, and the agribusiness industry in general, is a career option that should not be overlooked for aspiring soil scientists.

I will end with a few thoughts about preparing for a career in industry as a soil scientist. First, people are the greatest resource for a company. You need to be able to clearly communicate the business value of your skills and effectively work with people with diverse backgrounds and perspectives. Second, embrace technology and analytics.

Technology is changing how we collect data, and analytics are changing the way we turn data into decisions. Consider developing technical skills in Geographic Information Systems, spatial analysis or data science. Lastly, never stop challenging yourself to learn something new! What you learn in school is just the beginning. Be an expert in soil science and leverage all the tools and technologies to make an impact and improve people's lives.

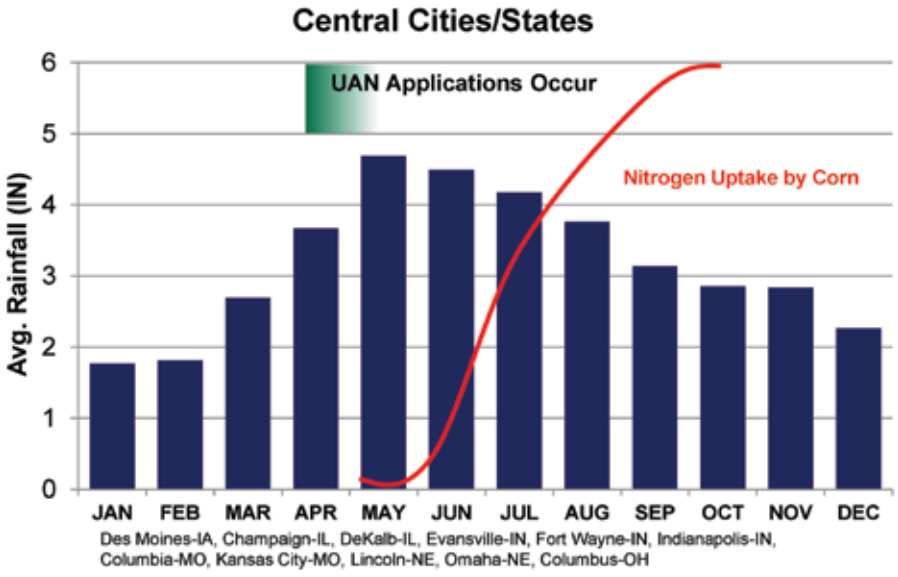


FIG. 1 Average 30-year Rainfall - Central Cities/States (Source: Dr. Eric Scherder)

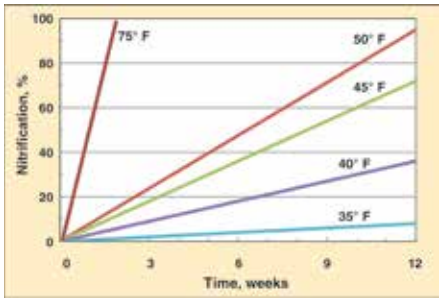


FIG. 2 Generalized rated of nitrification at various soil temperatures (redrawn form Western Fertilizer Handbook, 2012)

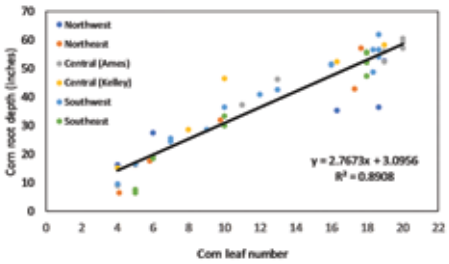


FIG. 3 Corn root growth progression from the 4th to 20th leaf stages at the in-row sampling location at six field locations across Iowa. Each point represents an average of three replications. (Source: Archontoulis, S., and M. Licht. 2017. How Fast and Deep do Corn Roots Grow in Iowa? https://crops.extension.iastate.edu/cropnews/2017/06/how-fast-and-deep-do-corn-roots-grow-iowa)

The 5 R's: The Right Nitrogen Stabilizer

Kenny Johnson, CCA
Kenny is a Certified Crop Adviser and the U.S. product manager for nitrogen stabilizers at the Ag Division of DowDupont. He earned a B.S. in economics from West Point, an MBA from the University of Michigan and an M.S. from the University of Michigan School of Natural Resources and Environment.

The 4 R's— the right source, the right time, the right rate and the right place— have challenged conventional wisdom and sparked a movement to think more broadly about nutrient management. More farmers are implementing new management practices for nitrogen— such as split applications, variable rate nitrogen and late-season applications of nitrogen, to name a few— which can be good management options to improve nitrogen efficiency. However, yield is determined by three factors: the genetic potential of the selected seed, the management practices used on one's operation and the environment. Two of the three factors can be controlled; conversely, the environment is a wild card that can impact the timing and one's ability to implement any of the aforementioned nitrogen management practices. Growers can manage or hedge uncertainty of environmental conditions by implementing the fifth R— the right nitrogen stabilizer.

Right Source

All forms of nitrogen are susceptible to loss through three different pathways — either through volatilization (above soil surface), denitrification or leaching (below soil surface). When evaluating nitrogen stabilizers, it is critical that farmers are accurately assessing stabilizer effectiveness at either inhibiting urease enzymes (urease inhibitors) or nitrosomonas bacteria (nitrification inhibitors). Urease inhibitors keep nitrogen fertilizer in the urea form rather than the ammonium bicarbonate form that is susceptible to converting to ammonia and volatilizing. Urease inhibitors are only effective above the soil surface, and they work only until fertilizer is incorporated either mechanically or by ¼ inch of rain. Nitrification inhibitors keep fertilizer in the ammonium form rather than the nitrate form, which is arguably the most important feature because ammonium is not susceptible to loss whereas nitrate is highly mobile in the soil, affecting water and air quality. Using the right nitrogen stabilizer can have a significant impact on improving water and air quality.

Right Time

There has been a movement to apply nitrogen fertilizer closer to the time in which corn will use it, which is a good practice. But is there still a need for a nitrogen stabilizer? Two factors can answer this question. Corn consumes approximately 50 percent of its total nitrogen needs between V6-VT. Therefore, it is critical that it has enough nitrogen to hit yield goals. However, during this developmental period, typically in late May or early June, Iowa has two factors that drive nitrogen loss: rain and warm soil temperatures converting fertilizer quickly from ammonium to nitrate (see figures 1 and 2). Because one inch of rain can move nitrate six to twelve inches in some soils, it does not take much rain to move nitrogen below corn root mass (see

Figure 3).* According to Iowa State research, there is a strong correlation between root depth and leaf number, and that corn root depth at four-leaf corn is only approximately one foot deep.** Also, there is no guarantee that a farmer can get back into the field in a timely manner for late-season nitrogen application due to wet soil conditions that lead to compaction and nitrogen shortages. Finally, late-season applications have the potential of injuring corn due to the growing point of corn being above the soil after V6. The growing season is laden with uncertainty and risk. However, using the right nitrogen stabilizers can be just as effective as later or split nitrogen applications, without the risk of delayed nitrogen application due to unforeseen weather conditions.

*Camberato, J., and B. Joern. 2006. Nitrate-Nitrogen: Here Today Gone Tomorrow? https://www.agry.purdue.edu/ext/corn/news/articles.06/NLoss-0519.html

**Archontoulis, S., and M. Licht. 2017. How Fast and Deep do Corn Roots Grow in Iowa? https://crops.extension.iastate.edu/cropnews/2017/06/how-fast-and-deep-do-corn-roots-grow-iowa

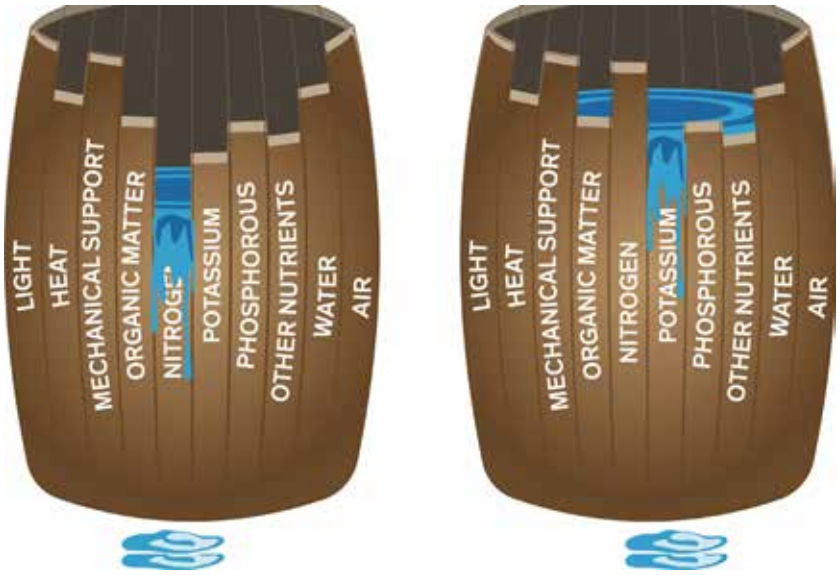


FIG. 4 Liebig's Law of the Minimum: Yield Limiting Criteria

Right Rate

Fertilizer prices have dropped significantly over the past year, making the option to simply add more fertilizer an attractive choice over adding an effective nitrogen stabilizer to protect the nitrogen investment. However, this is simply an unspoken acknowledgment that nitrogen loss is happening. Adding more pounds of nitrogen under-optimizes one's nitrogen use efficiency, and the practice is neither good for the environment nor the wallet. Applying the right rate with the right nitrogen stabilizer protects the environment and the fertilizer investment.

"Growers can manage or hedge uncertainty of environmental conditions by implementing the fifth R—the right nitrogen stabilizer."

Right Place

The Right Place R is aligned with keeping nutrients where crops can use them — in the root zone. In the context of nitrogen stabilizers, how does a farmer know if the stabilizer kept nutrients in the right place? Is it simply by looking at the yield monitor or weigh wagon? No. In order to assess if nutrients are staying in the right place, it is absolutely critical that complete soils tests are taken in the fall and at pre-sidedress to determine both ammonium and nitrate levels in the soil. Without this test, farmers cannot effectively determine if a stabilizer was efficacious or not. Sometimes, farmers will use a nitrogen stabilizer and may not see a yield increase. Was the stabilizer ineffective? Maybe. Or perhaps soil pH was too high or phosphorus or potassium levels were not optimized. Perhaps micronutrient levels were imbalanced. Bottom line: Without a soil test it is nearly impossible to determine what the yield limiting factor was. Therefore, it is impossible to assess the effectiveness of the stabilizer (see Figure 4).

Nitrogen stabilizers are effective tools; however, the market is saturated with options, and it can be difficult to determine which one to use. We suggest you use three criteria in determining the right nitrogen stabilizer:

- **University Supported**: Use stabilizers that have been rigorously tested by universities. Ask your retailer to produce academic research that supports the claims that are being touted.
- **EPA Approved**: Use stabilizers that are EPA registered. The EPA mandates by law that if a stabilizer is in fact a stabilizer, it must be labeled. To date, there are two products that follow the law: Instinct® and N-Serve® nitrogen stabilizers.***
- **Value Over Price**: The current economics of farming are not as rewarding as a few years ago, and every penny matters. What is worse than low commodity prices? Low yield. Car insurance only pays when you have an accident. You would not drive without insurance just because you have not had an accident in a few years. The same analogy can be used for stabilizers. Nitrogen may not be your limiting factor every year; however, when it is, you want to be protected.

***U.S. Environmental Protection Agency. Nitrogen Stabilizer Products that Must Be Registered under FIFRA. https://www.epa.gov/pesticide-registration/nitrogen-stabilizer-products-must-be-registered-under-fifra

"® Trademark of The Dow Chemical Company ("Dow") or an affiliated company of Dow."

Instinct is not registered for sale or use in all states. Contact your state pesticide regulatory agency to determine if a product is registered for sale or use in your state. Do not fall-apply anhydrous ammonia south of Highway 16 in the state of Illinois. Always read and follow label directions.

FIG. 2 One of four automated and manual rain gauges to measure precipitation (Erin Bush (left; 2016 summer intern) and Dr. Nathan Nelson (right)).

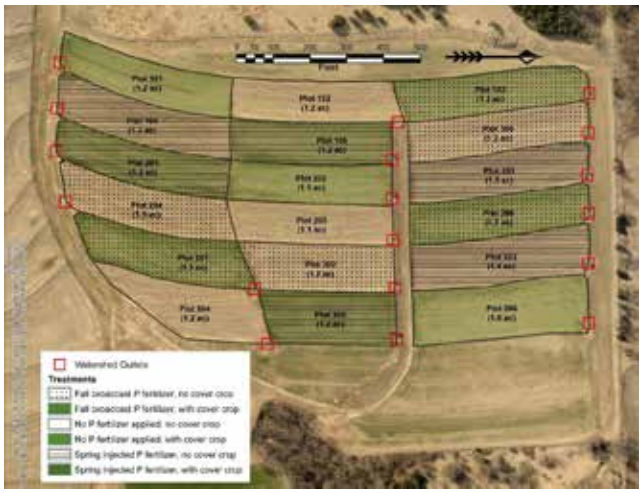


FIG. 1 Field map and treatment currently imposed at the KAW Field Laboratory.

FIG. 3 Watersheds with and without cover crops in April 2016 prior to cover crop termination and soybean planting.

Kansas Agricultural Watershed Field Research Facility

Kathy Gehl
Project Administrator/Extension eUpdate Editor, Kansas State University Department of Agronomy Research Staff

Peter Tomlinson, PhD
Assistant Professor, Kansas State University Department of Agronomy

Midwestern row-crop agriculture is recognized as being highly productive, but is also cited for impairing surrounding ecosystems and impacting environmental quality. Water quality is a key metric utilized to characterize the health of an agricultural watershed. Therefore, it is important to know how new or alternative management practices impact water quality. With this in mind, the Kansas Agricultural Watershed (KAW) Field Laboratory was created in 2014 to study the effects of agricultural systems on water, sediment and nutrient losses. The goal of the KAW field lab is to evaluate and develop sustainable conservation practices that protect water quality, maintain yield and profitability and provide producers with flexible options for management of crops and nutrients.

Research Site

The KAW Field Laboratory is a 22-acre site located in northeast Kansas. It consists of 18 small watersheds each roughly the size of a football field. A watershed is an area of land that drains all surface water to a common outlet (Fig. 1). Each watershed is equipped with a flume and automated instruments to measure runoff from natural rainfall and collect samples for water quality analysis. The site is also equipped with four automated rain gauges (Fig. 2).

Current Projects

Current research at the KAW is focused on learning more about how water quality is impacted by methods of phosphorus fertilizer application and the integration of cover crops into a no-till corn – soybean production system. Phosphorus is essential for crop production, but when lost from fields it can cause problems in lakes and reservoirs. Cover crops are non-harvested crops grown for the protection and enrichment of the soil (Fig. 3 and 4). They can be beneficial to the environment and farmers in a variety of ways including reducing loss of soil by erosion, improving soil quality and suppressing weeds. Dr. Nathan Nelson, the project leader,

FIG. 4 Cover crop emerging in corn residue after the 2017 corn harvest.

said "toxic algae blooms in reservoirs are partially caused by phosphorus in runoff. We are developing best management practices (BMPs) that producers can implement to reduce runoff and phosphorus loss." Understanding how management decisions affect runoff, phosphorus loss and soil health are overarching themes of this research (Fig. 5).

Project 1: Minimizing Phosphorus Loss with 4R Stewardship and Cover Crops

The goals of this project are to improve our understanding of how phosphorus fertilizer management and cover crops can help protect water quality and maximize nutrient use efficiency. The results are advancing 4R nutrient stewardship recommendations: applying the Right fertilizer source at the Right rate at the Right time and in the Right place. Specific research questions that the team is answering include:

How does phosphorus loss from fall surface-applied fertilizer compare to phosphorus loss from spring injected fertilizer, the current recommended BMP?

Will cover crops reduce phosphorus losses and does this depend on the method and timing of phosphorus fertilizer application?

What are the agronomic, environmental and economic effects of winter cover crops in a no-till corn-soybean production system?

Project 2: Protecting Surface Water with Healthy Soils and Cover Crops:

The goals of this project are to help us understand how improvements in soil health can influence water, sediment and nutrient losses. Dr. Nelson recently reported at the Agronomy department Field Day that, "total runoff has not changed but cover crops are reducing the peak runoff and extending the duration of runoff for most events compared to the no-till plots without cover crops." The research team has also begun to quantify impacts of cover crop use on soil health parameters by measuring different physical, chemical and biological indices in the soil.

FIG. 5 Water leaving a watershed in the spring of 2017.

As part of this project, the KAW was expanded to include an on-farm demonstration study with a co-operating producer where we are measuring many of the same parameters.

Staying up-to-date on the KAW

You can stay up-to-date on current research findings at the KAW by visiting the project website at http://www.k-state.edu/kaw/. The website includes additional information about the current projects as well as presentations and publications from the ongoing research.

The KAW field laboratory research team is led by Dr. Nathan Nelson, professor in the Agronomy department at Kansas State University. Other K-State team members include Drs. Kraig Roozeboom, Gerard Kluitenberg, Peter Tomlinson and DeAnn Presley from the Agronomy department and Dr. Jeff Williams from the Agriculture Economics department. Research at the KAW field lab is funded by the 4R Research fund, the USDA Natural Resource Conservation Service, the Kansas Soybean Commission, the Kansas Corn Commission and Kansas State University.

Working to Reduce Farm Nutrient Loss in Iowa

Malcolm Robertson
Program Coordinator and Lecturer, Iowa Nutrient Research Center, Iowa State University

The Iowa Nutrient Research Center (INRC) was established in the College of Agriculture and Life Sciences at Iowa State University by the Iowa Board of Regents in response to legislation passed by the Iowa Legislature in 2013. More information is available at https://www.cals.iastate.edu/nutrientcenter.

The center pursues a science-based approach to nutrient management research. Through its work, the performance of current and emerging nutrient management practices is evaluated, new nutrient management practices are developed and recommendations are initiated for implementation of nutrient management practices.

The primary role of the center is to fund science-based research that explores innovative approaches that identify gaps and needs in nitrogen (N) and phosphorus (P) research to address Iowa's water quality issues.

Center research evaluates the performance of current and emerging field practices and develops tools to help farmers and landowners adopt effective management practices. Successful research outcomes will minimize the loss of nutrients into Iowa surface and groundwater. Through this research, the INRC will test the performance of current and advanced farmland management, land use and edge-of-field practices on reducing N and P loss.

The center will also develop tools that aid in decision-making and promotions for the adoption of new technologies and creative solutions for more sustainable management practices.

Working with researchers and farmers, the Iowa Nutrient Research Center funded more than 50 research projects from 2013 to 2017, led by more than 80 scientists at Iowa's three Regents universities. The center's competitive grants program has awarded nearly $6 million for research since 2013.

These funds are highly leveraged by water-quality scientists, who have successfully brought in over $17 million in grants from many federal and state agencies across five years.

Some key results from center-funded research to date include:

- Field and lab experiments are improving the understanding of winter cover crop management and impacts on corn yield.
- Saturated buffers are evaluated to better assess their ability to remove nitrates from tile flow.
- Research is evaluating the effectiveness of practices implemented around the edges of fields, such as planting strips of prairie and restoring stream banks.
- Work is underway to better understand farm profitability impacts of precision conservation and grazing cover crops.
- Intensive research at a watershed in Boone County is providing new insights on the contributions of stream bed and bank erosion to phosphorus transport.
- Research is more precisely examining the movement of nutrients to surface waters.

- How trading nutrient credits may benefit cities and farmers - and water quality - is explored in a pilot project watershed near Dubuque.
- Work on research farms and in farmers' fields is evaluating types of native perennials for prairie strips to reduce soil erosion and nutrient loss.
- Research is seeking to improve performance and reduce costs of bioreactors, the practice that filters field drainage water with wood chips.

In 2017 the center funded 12 projects with a total award value of almost $550,000. Below is a list of the projects awarded in 2017:

- Total Phosphorus Loads in Iowa Rivers and Estimation of Steam Bank Phosphorus Contribution
- Water Quality Evaluation of Prairie Strips across Iowa
- Woodchip Bioreactors for Improved Water Quality
- Limiting Nitrogen Immobilization in Cover Crop Systems
- Amounts and Forms of Dissolved Phosphorus Lost with Surface Runoff as Affected by Phosphorus Management and Soil Conservation Practices
- Delivery-Scale Evaluation and Modeling of Nutrient Reduction Practices
- Improving the Effectiveness of Conservation Programs through Innovative Reverse Auctions and Sensible Enrollment Restrictions
- Baseline Assessment of Geisler Farm Site: Collection of Pre-BMP Monitoring Data
- Does Quantity and Quality of Tile Drainage Water Impact In-stream Eutrophication Potential? Evidence from a Long-term Biofuel Cropping Systems Experiment
- Successful Voluntary Watershed Improvement Projects: Do Short-Term Adoption and Outreach Lead to Attitude Changes and Long-Term Sustainable Practice Adoption?
- Impacts of Cover Crops on Phosphorus and Nitrogen Loss with Surface Runoff
- Evaluation of Measurement Methods as Surrogates for Tile-Flow Nitrate-N Concentrations

In addition to these projects, the center also allocated $367,000 to the University of Iowa to fund a network of water-quality sensors deployed throughout eastern Iowa. These advanced remote sensors collect water-quality data that are relayed back to IIHR-Hydroscience and Engineering every few minutes. The data are disseminated on a public website.

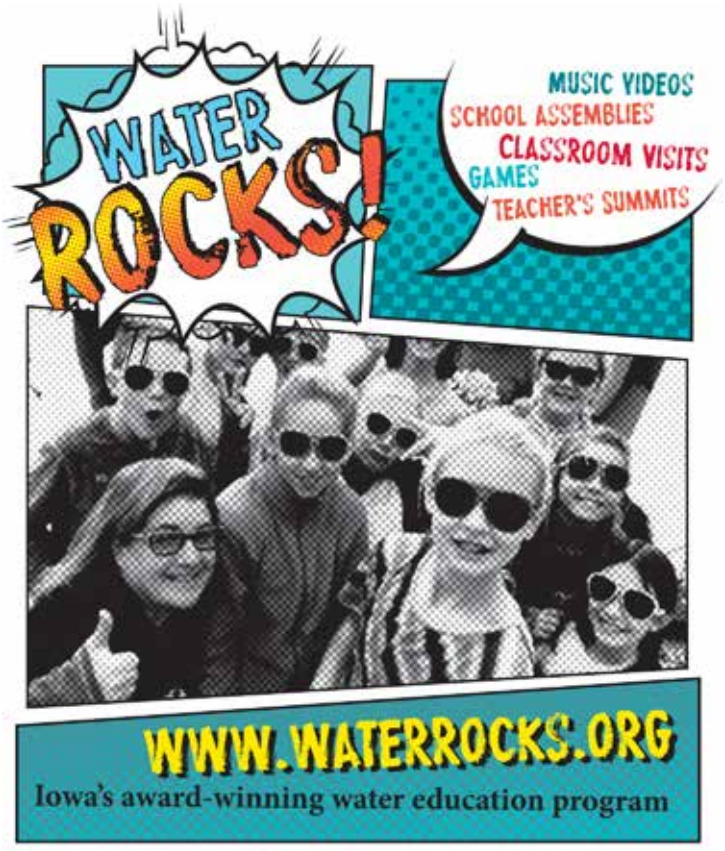
The Iowa Nutrient Research Center is dedicated to supporting impactful research in nutrient reduction. As new information, data and science become available, the center believes that the adoption of in-field and edge-of-field practices will increase, resulting in improved water quality through reduced nitrogen and phosphorus losses.

Background to the Iowa Nutrient Research Center's Work

Scientifically Proven Effective Practices. Iowa leads the nation in corn and soybean production. Research has shown that a variety of management practices can mitigate the loss of nutrients from crop field soils. The goal is to get more of these scientifically proven practices implemented. The Iowa Nutrient Reduction Strategy science team, led by Iowa State University scientists, developed a list of in-field and edge-of-field practices that could reduce nutrient loss from farm lands (http://www.nutrientstrategy.iastate.edu/presentations). Nutrient and soil management practices conducted within field boundaries to mitigate nutrient loss from row-cropped acres, and are known as in-field nutrient management. These in-field nutrient management practices are done at various stages before, during and after the annual growing season. Edge-of-field practices tend to be structural and help prevent the loss of nutrients from the boundaries of agricultural fields.

Nutrient Loss Reduction – Nitrogen. There are a number of practices that reduce nitrogen loss, including in-field nitrogen management practices such as fertilizer application timing, fertilizer source, application rate, nitrification inhibitors, cover crops and living mulches. Additional in-field practices that reduce N loss include land use changes such as the addition of perennials, extended rotations and pastures for livestock. Edge-of-field practices may take a variety of forms and include practices and/or structures such as drainage water management, shallow drainage, wetlands, bioreactors and buffers.

Nutrient Loss Reduction – Phosphorus. There are a number of in-field phosphorus management practices that may be adopted to reduce P loss, include fertilizer application, source and placement; erosion control or land use change practices such as tillage, crop choice, perennials and terraces. Wetlands, buffers and sediment control are edge-of-field practices that have been shown to reduce phosphorus loss.



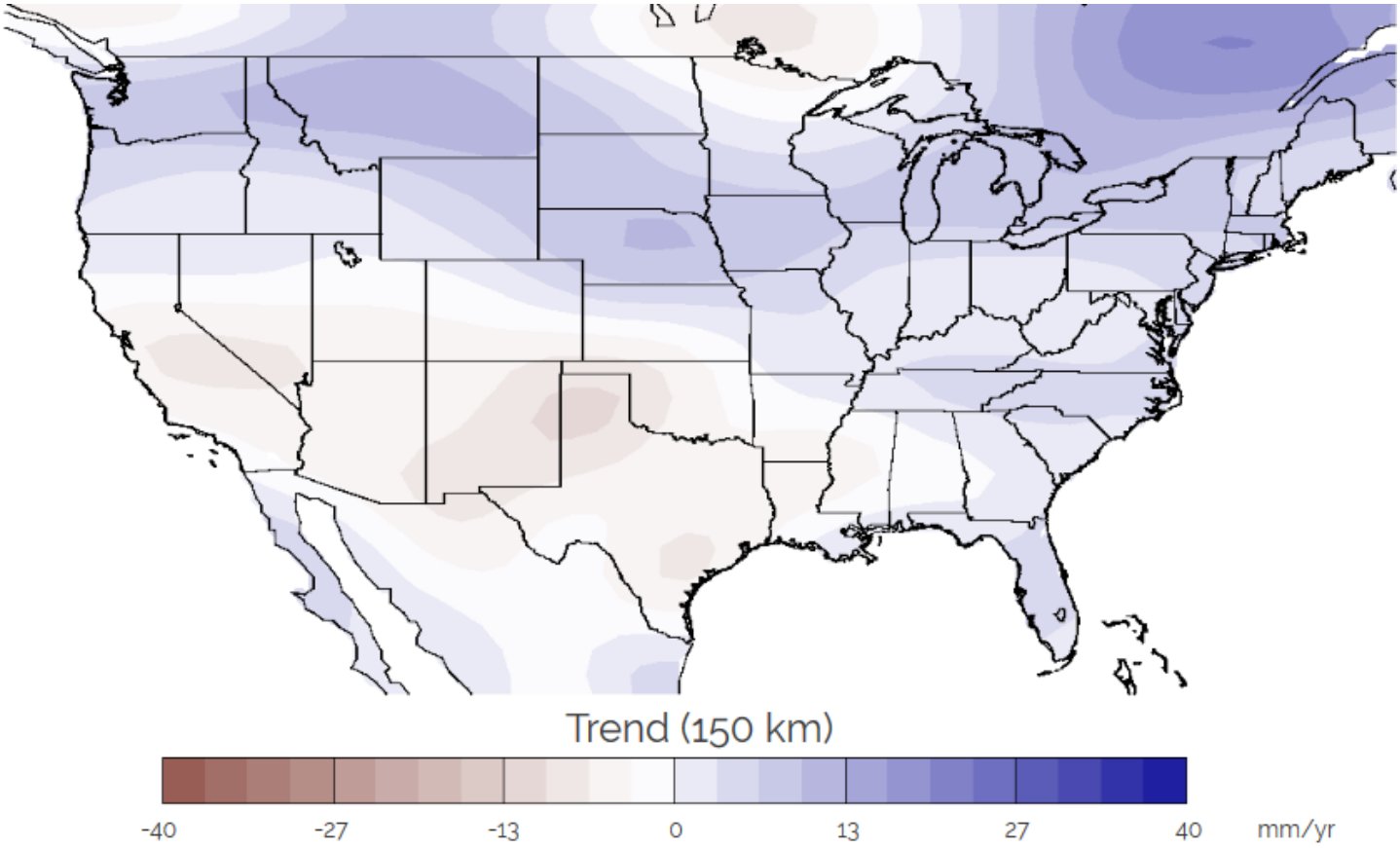


FIG. 1 Average rate of change of terrestrial water storage during 2002-2016 as observed by GRACE, as an equivalent height of water in mm per year.

The Importance of Groundwater and How to Monitor it From Space

Matthew Rodell, PhD
Chief of Hydrological Sciences Laboratory, NASA Goddard Space Flight Center, Greenbelt, Maryland

When water from rainfall and snowmelt enters and saturates the soil column, some of that water flows to streams, some evaporates and some is absorbed by plant roots. The rest drains downward to recharge underground aquifers, where it can remain for months, years or even millennia. If you dig deep enough, groundwater can be found almost anywhere, even beneath the Sahara Desert. Groundwater is vital to both people and ecosystems because of the ability of aquifers to store water during wet periods for use during dry periods. It supports domestic, municipal, industrial and especially agricultural usage in places where surface waters are not available, and it sustains streams and rivers, via contributions to baseflow, in between precipitation events.

Groundwater may be widespread, but it is not unlimited. In places where groundwater consumption continually exceeds groundwater recharge, aquifers can be depleted. Potential consequences include wells running dry, streamflow being diminished, phreatophytes (deep rooted plants) suffering, groundwater quality worsening, the aquifer compacting and the land above subsiding. Further, climate change may reduce or enhance recharge depending on how it affects rainfall and snowfall intensity and totals. Therefore it is critical that groundwater storage changes be monitored. While certain U.S. states and the USGS maintain networks of groundwater monitoring wells, which enable fair to good assessments of groundwater variability, other states and most of the rest of the world have sparse observations or do not make their data available to the public.

What if there was a way to measure groundwater storage changes from space? In 2002, NASA launched the Gravity Recovery and Climate Experiment (GRACE) satellite pair. Instead of "looking" downward and measuring emitted or reflected electromagnetic radiation (e.g., microwaves, visible light) like most remote sensing satellites do, the twin GRACE

"...by monitoring the separation and locations of the GRACE satellites every 5 seconds, scientists were able to construct a new global map of Earth's gravity field each month."

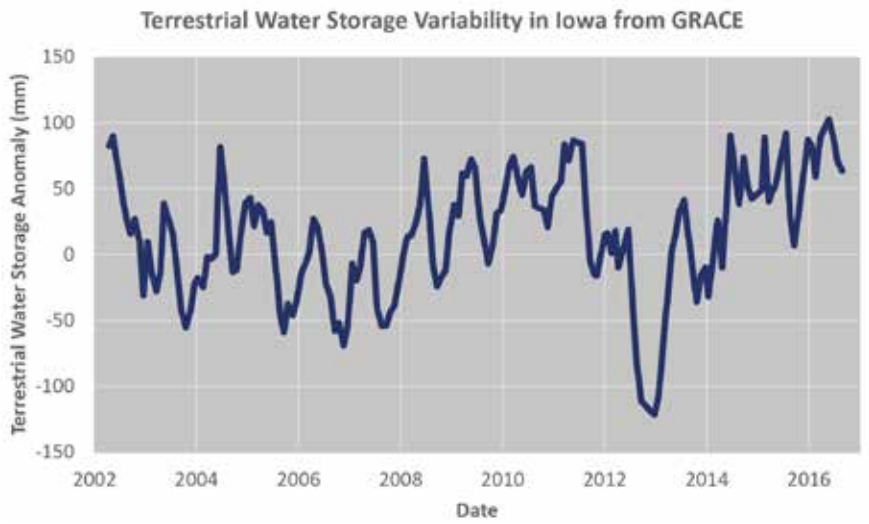


FIG. 2 Monthly time series of terrestrial water storage anomalies in Iowa as equivalent heights of water in mm.

satellites used a K-band microwave link to measure the distance between each other (roughly 200 km) with micron-scale accuracy (a red blood cell is about 5 microns in diameter) as they orbited the Earth, one following the other. Heterogeneities in Earth's gravity field, related to the uneven distribution of mass near Earth's surface (consider a mountain range), perturb the orbits of satellites in a predictable way. Hence by monitoring the separation and locations of the GRACE satellites every 5 seconds, scientists were able to construct a new global map of Earth's gravity field each month. From month to month, those maps changed due to the redistribution of mass, in particular, atmospheric and oceanic circulations and changes in the amount of water stored on and in the land surface. The mass circulations were simulated and removed using data-integrating models. What remained were mass changes associated with terrestrial water storage (TWS) – the sum of groundwater, soil water, surface waters, ice and snow. As before, changes in soil water, surface water and snow can be estimated and removed using data-integrating models, enabling scientists to isolate groundwater storage changes from the GRACE measurements.

Not convinced? Consider that GRACE data have been used to quantify the mass losses of the Greenland and Antarctic ice sheets and glaciers in Alaska, to monitor droughts and to "close the water budget" by providing a measurement of TWS change to balance precipitation, evapotranspiration and runoff in large river basins.

GRACE is not perfect – the smallest area it can resolve is about the size of Iowa (145,000 km2), and it cannot tell us the total quantity of water available at a location, only how it changes from month to month – but it has enabled a revolution in groundwater monitoring. GRACE revealed severe groundwater depletion in northern India and detected and quantified groundwater losses in northeastern China, Saudi Arabia, the Middle East and California's Central Valley, among others.

How has Iowa fared? During 2002-2016, TWS increased across Iowa at an average rate of about 3 mm/yr due to natural variability. Figure 1 shows a map of TWS trends in the continental U.S. and Figure 2 shows the monthly time series of TWS for Iowa. We can infer from the latter that a large amount of groundwater was lost from Iowa during the severe drought of 2012, and that wet weather from 2013 through early 2016 raised water levels to above normal.

The GRACE mission concluded in October 2017. While the end was sad, the satellites survived ten years longer than planned, and NASA's GRACE Follow On mission is scheduled to launch in March 2018 to extend the incredible data record provided by GRACE.

What makes an agricultural social media page successful? We, the editors of "Getting Into Soil and Water" were curious and thought our readers might be as well. So, we asked the people behind two successful agriculture-based social media pages; the Peterson Farm Bros and the "Sassy Agronomist" Sam Krhovsky, their thoughts on the subject. Here is what they had to say!

A Q&A With Some Familiar Faces

Greg Peterson, One of the Peterson Farm Bros

Please give a short bio about yourself and your role in agriculture.

I grew up and still work on a 5th generation family farm. I've always wanted to farm in some capacity but chose to major in agricultural communications and journalism at Kansas State University to help tell the story of farmers. This led to an idea I had to make a music video with my brothers about farming that received 5 million views in a week. Over the last five years, our social media platform has grown and we do our best to advocate for agriculture on a worldwide scale.

What motivated you to start a social media page?

I started our YouTube channel with the idea that we would post videos from our farm. I had uploaded about three videos in six months before I uploaded our first music video. I wanted to show our friends and others online what our farm looked like and some of the things I found most interesting (e.g. auto-steer). As soon as our first video went viral I was able to start a Facebook, Twitter and Instagram account as well. My motivation for that was to leverage our success as much as I could to broaden our platform and reach more people. The motivation has always been to reach as many people with our message as I can.

Describe the mission/goal of your page.

Our page produces entertaining and educational content to help educate people about agriculture. Our goal is to give people a glimpse of what a real Midwest family farm operation looks like.

Why do you believe your page has been successful?

I think our page has been successful because we connect with people. We are a family farm. The videos are primarily with three brothers in them. There are animals. Music. Equipment. Information. We try to include something that is relevant for everyone. Furthermore, I try to be as consistent as possible in how often I post and the content I post. Many people follow our daily posts and look for our music videos because we post a new one every few months.

Do you have any cool examples/stories about how your page has impacted agriculture?

We receive messages every day from people. Some messages thank us for how our videos have inspired them as farmers to take pride in what they do. Some messages thank us for educating people who did not know anything about farming before following us. Some messages thank us for being role models to the youth. These are all things that really keep us going and help us stay motivated to produce content.

What advice do you have for somebody looking to start their own page?

Try to find something you love to talk about or are really passionate for. Then start posting content. It is important to relate to your intended audience. Humor is one of the most important tools along with relating that humor to something that is related to pop culture. Once you've built your audience a little, make sure to retain them by keeping your content fresh and intriguing.

How can our readers find you on social media?

- Facebook: Peterson Farm Bros
- Twitter: @petefarmbros
- Instagram: @petefarmbros
- YouTube: Peterson Farm Bros
- Snap: @petefarmbros

Do you have any suggestions of other good agriculture or conservation-focused pages to follow?

I am Agriculture Proud, Dairy Carrie, The Farmer's Life, A Farmer's Wife

Sassy Agronomist

Please give a short bio about yourself and your role in agriculture.

I am a district sales manager with DEKALB/Asgrow in Michigan. Previously I was an agronomist with Monsanto for four years. I grew up in rural Indiana with a non-farm background and attended Purdue University for my bachelor's degree and Oklahoma State University for my master's degree.

What motivated you to start a social media page?

Social media has became one of the main news sources for the general public. Good or bad, right or wrong, most information is now found online and is extremely easy to navigate. Members of the agriculture world have done a fantastic job in the last 10 years advocating for farming, trying to help educate the public on GMOs, antibiotics, safe food practices, life on a dairy, pesticides, etc. I wanted to be a part of that conversation and I was pretty much guaranteed to become part of the conversation working for a company like Monsanto. I wanted to promote agronomy because I felt that most pages I followed skipped over the basics…agriculture on the crop side tends to automatically default to GMO or pesticide discussions. I wanted to help communicate the inbetween—what are farmers doing during the crop season? What is an agronomist? What kinds of issues are we dealing with when it comes to growing corn and soybeans? I also wanted this page to hit multiple audiences as well: farmers, women in ag, agriculture professionals, non-agriculture, etc.

Describe the mission/goal of your page.

Sassy Agronomist was designed to educate members of the agriculture and non-agriculture communities on agronomy related to corn and soybeans in Michigan. Followers can see my adventures working in corn and soybean fields as a crop salesman, agronomist and crop scout, hopefully learning a little more about what it takes to bring food to the table and enjoy a few laughs and sarcasm along the way.

Why do you believe your page has been successful?

I think this page has been successful purely on the comments and feedback I receive from followers. It's not the number of followers that mean much to me, it's the fact that I get questions from farmers asking for advice, messages that say things like "I can totally relate to this!". It's seeing someone tag a friend in a post and the friend commenting back "I didn't know this!". Teaching one person one thing in the hundreds of posts I make is completely worth it.

Do you have any cool examples/stories about how your page has impacted agriculture?

I've found that a lot of my followers are females in agriculture, which is amazing. Sometimes my posts are probably more relatable to women farming or in similar jobs that I'm currently in. I always enjoy when conversation sparks interest and feedback. I'm sure there would be a difference in opinion on how impactful my posts are, but my favorite has to do with what most girls love: manicures.

That's right, I'm that plant geek that had my nails painted with three corn growth stages and three soybean growth stages on my fingernails. I posted a picture of my nails with the title "Uh Miss, you're gonna get those nails dirty" and talked about my experiences as a woman working in a man's world with painted fingernails, how quickly we (men and women) are to judge another, and of course, there are still some boundaries that need to be kept to be professional. 36,782 people reached, 82 shares. I was never expecting that.

What advice do you have for somebody looking to start their own page?

Make some social media friends. Get friends to like your accounts, ask them to share, make friends with some of the known social media Agvocates to help get the word out. Farm Babe, Farmer's Daughter, Farmer's Life….they have THOUSANDS of followers. And are usually more than happy to help out a fellow advocate by sharing your page.

DON'T BE A TROLL. People are going to make you angry, say things that are not true, try to hit every button you have when it comes to your posts. Block people that are trolls, be respectful of other people's opinions (even if you don't agree), quietly agree to disagree.

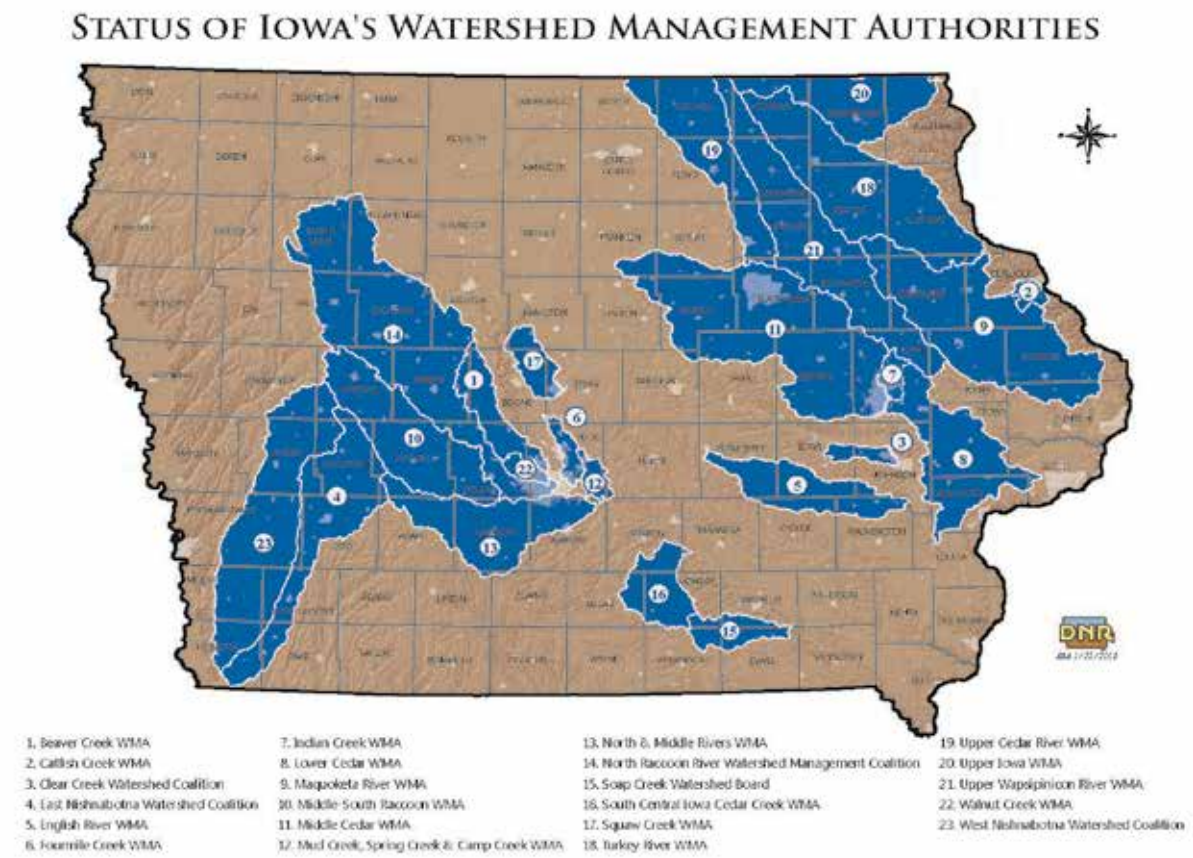
Find a little humor as you go. Facts and hard information is fantastic, but I've found that for every informative post I write, I have to through in a few sarcastic or funny things as well. Otherwise the interest in your account starts to disappear. Followers need to relate to you in your job and as a person.

How can our readers find you on social media?

- Facebook: Sassy Agronomist
- Twitter: Sassy Agronomist
- Instagram: Sassy Agronomist

Do you have any suggestions of other good agriculture or conservation-focused pages to follow?

Farmer's Daughter USA, Farm Babe, The Farmer's Life, AgDaily, your local University Extension, US Farm Report….most major agriculture organizations are online now. They are always great to follow to help have stories to share for your page.



Building Youth Leadership Capacity Through Project-Based Learning

Melissa Miller
Associate Director of the Iowa Water Center

"The world needs people who can lead others to make a change for the better if anything is gonna change for the better."

This is a reflection from a Davenport North High School junior, one of the first students to experience environmental science education through a pilot program called "The Watershed Project," sponsored by the Leopold Center for Sustainable Agriculture and administered by the Iowa Water Center (IWC).

From 2014-2016, three faculty members at Ames High School conducted the Bluestem Institute, a "school within a school" that used project-based learning (PBL) methods to engage youth in three-dimensional learning while meeting Next Generation Science Standards. Staff from IWC and the Iowa Stormwater Education Partnership (ISWEP) interacted with the 2015-2016 Bluestem Institute cohort while they were studying the complex nature of watersheds. This experience inspired the creation of The Watershed Project. The Watershed Project is a flexible framework that replicates the learning experience of the Bluestem Institute for implementation in any high school in Iowa. The objective is to address the intersection of science, government, sociology, economics and art as they relate to decision making regarding water and land use at local levels.

The project, which began in December of 2016, has three phases: first, the Ames High faculty who created the Bluestem Institute developed resources and schematics to capture the methodology of a Gold Standard project-based learning classroom, which will be available free of charge via the project website, thewatershedprojectiowa.org. In phase two, a Davenport North High school teacher, Laura McCreery, is adopting the framework for her environmental science course, a nine-week dual-enrollment course that earns students four college credits toward an associate's degree. In phase three, Angela Mesenbrink will do the same for her students at Storm Lake High School. Throughout the pilot, the framework and other resource materials are continuously critiqued and revised. As more schools embark on the project, the website will host a portfolio of activities, products and lessons learned.

Implementation

Ames High faculty Mike Todd, Joe Brekke and Chad Zmolek intend for The Watershed Project framework to be flexible, as all schools, teachers, students and watersheds are unique. However, there are

some key components in this "choose your own adventure" style that all adopting schools will follow. Each teacher starts with $5,000 of seed money for professional development, travel and supplies. Intensive planning, learning the principles of project-based learning and building community partnerships are imperative to project success.

Planning

Planning for implementation begins up to a year before conducting the course: the teacher and school agree to participate (following the pilot project, there will be a competitive application) and the teacher registers for PBL World, an immersive seminar held in Napa Valley, California each June. Just before attending the workshop, the teacher meets with in-state mentors – teachers who have previously flipped their classroom to project-based learning – and brainstorms how The Watershed Project might work in their community.

Learning About Project-Based Learning

At PBL World, the teacher learns Gold Standard Project-Based Learning principles while generating project ideas and refining them through peer critique, as well as establishing assessment tools for the projects and gaining skills for managing a project-based learning classroom. After attending PBL World in June of 2017, Davenport North's McCreery reflected, "Too often I want students to learn the material first and then apply the material to a project. The conference showed me that the longevity of the material is greater when the students have to learn the material through a meaningful project." McCreery also discovered, and later corroborated, that a good "launch" (introductory activity) to a project cycle is instrumental.

Community Partnerships

Prior to attending PBL World, McCreery engaged Davenport Public Works communications and preparedness manager Robbin Dunn, who secured funds from her employer to travel with McCreery to Napa to develop their plan together. Collaborating early with someone in the community gave McCreery critical support right from the start. Dunn connected McCreery's first cohort of students to experts in the community as they developed small group-led watershed improvement projects. The students culminated the course by pitching their proposals to a team of Public Works employees, who determined which students would receive funding to implement their project.

Interacting with the community is key to the authenticity of project-based learning. One student commented that the most enjoyable part of the project was "seeing how many people in the community were willing to help." Another mentioned "listening to adults react to our knowledge about this project" as the most rewarding. Not all students chose to implement their project after the course ended, but several did. Of those that did, the community came through once again. To date, the class has accumulated over $10,000 of in-kind donations from local businesses.

Lessons Learned

Because McCreery's class was dual-credit, she had to adapt The Watershed Project framework to fit learning objectives of both the high school and the local community college. She also had to race through the project-based learning cycle at an intense pace: the Bluestem Institute seminar lasted an entire academic year, McCreery's, just nine weeks. Overall, it was worth it. McCreery reported that she is experimenting with flipping some of her other science courses to project-based learning, in addition to the two other cohorts that will come through environmental science this year.

The reflections from the first cohort of students were also promising. Post-project surveys indicated the entire class positively associated the experience with making them aware of their individual impact on water quality, and nearly all intended to apply lessons learned to reduce their personal impact on the watershed. Many students felt they made an impact on educating a large number of people in the watershed, and most also felt the project influenced how they understood the complexities and life skills involved in planning and executing an idea. Several of the students even indicated they were considering a career in soil and water conservation. When asked the most important thing they learned in the project, one student responded, "how easy and helpful it is for a student to be involved in the community," while another stated "how the watershed is affected – I never knew what a watershed was."

The next steps for the project are to repeat the nine-week cycle in McCreery's classes in the spring while compiling and organizing resources for the Storm Lake implementation. Additionally, IWC and ISWEP staff are working on a plan to scale up and sustain the seed funding for schools that want to implement The Watershed Project. As with the projects the students themselves are implementing, community partnerships are welcome in this endeavor.

Bringing Our Soils Back to Life

Fred Kirschenmann, PhD
Distinguished Fellow at the Leopold Center for Sustainable Agriculture at Iowa State University, Professor in the Department of Religion and Philosophy, President of the Stone Barns Center for Food and Agriculture

Two transformations, which have already begun, may put us on a path to significant changes in the way we relate to our soil and water in the future.

The first transformation is being initiated by the increase in costs of the many inputs required to sustain our current, input-intensive, food and agriculture system and therefore the way we have managed our soil for most of the past century.

That input-intensive system, which was exceptionally dependent on cheap fossil fuels, minerals and irrigation water, enabled us to produce large quantities of food and fiber without giving much attention to soil health or soil preservation. Soil mostly was simply regarded as a "material to hold a plant in place." The fact that soil is a living community of microbes (there are more microbes in a single tablespoon of soil than the number of humans on the planet!) which could enhance the health and regenerative capacity of soil, while reducing the need for inputs, was hardly considered.

However, as the cheap inputs are now in a state of depletion, the costs of fuel, fertilizer and irrigation continue to go up, making it increasingly difficult for farmers to thrive economically. Consequently, some farmers are already transitioning to production systems that "bring soil back to life," as David Montgomery has demonstrated in his new book, Growing a Revolution; Bringing Soil Back to Life, 2017. These farmers have discovered that bringing soil back to life can significantly reduce their input costs and therefore increase their net profits.

A second transformation is being initiated as a result of some of the negative, unintended consequences of the input-intensive system, especially the loss of water quality. The combination of applying large quantities of nitrogen (N), phosphorus (P) and potassium (K) in order to sustain crop production, at the same time that the loss of soil health reduced the soils capacity to absorb rainwater, most soils now only absorb ½ inch of rainwater an hour, causing rain water to flush excessive N, P and K into water bodies with significant negative impacts on water quality. Water quality problems have now reached a point where they have increasingly become intolerable.

Again, as David Montgomery's research discovered, the increase in soil health, resulting from reduced tillage, inclusion of cover crops and significant increase in biodiversity, reveals that some of the farmers who have adopted such soil health enhancing attributes now find that their soils absorb as much as eight inches of rainwater an hour! The positive benefits to water quality, such as water holding capacity, enable soils to absorb more rainwater during heavy rainfalls and makes more soil moisture available during drought periods. Consequently, such increases in soil health may also mitigate some of the negative impacts of the more unstable weather patterns, which already seem to be more common, due to the impact of climate change.

However, as Montgomery's research seems to indicate, most farmers who have adopted changes including reduced tillage, inclusion of cover crops or dramatic increases in biodiversity, have made such changes because of the economic squeezes they experienced. This sticks them between low commodity prices and expensive costs of the input-intensive systems, which leaves them economically devastated! Nevertheless, it now seems clear that the resulting soil health from such changed practices have significant soil and water benefits for society.

Advertorial

Passionate Iowa Farmer Values Soil Health and Conservation

With two college degrees in soil science, it's no surprise that soil health and conservation are top priorities on Elyssa McFarland's farm near Columbus Junction. McFarland loved her time growing up on a farm, but it wasn't until attending Iowa State University that she decided she wanted to become the fifth generation to be involved on her family's farm. She raises corn and soybeans with her father and they also have a cow-calf operation. They have made adding conservation practices to their operation a priority to help protect the land that they farm.

"The soils are literally our farm," she says. "That's our top resource and I'm very passionate about taking care of and protecting that resource."

"Conservation is very important to both my father and me," says McFarland. "It's an essential part of our operation in maintaining the soil resources that have been here for generations."

The McFarlands have terraces, grass waterways and cover crops on their farm and they do a lot of no-till farming as well. Elyssa is an Iowa field manager for the Soil Health Partnership (SHP), a National Corn Growers Association initiative that is helping farmers implement cover crops and get data to show the soil health benefits of this practice. Through the SHP, she has had the opportunity to learn from other farmers who have implemented cover crops and has taken that knowledge back to her farming operation.

"I started by having conversations with my dad about areas on our farm that could benefit the most from cover crops," explains McFarland. "Whether it's increasing organic matter in our sandy soils or protecting the fields that have more hills and highly erodible soils, the cover crops play a unique role in several areas of our farm."

Like with any career, a lot of challenges can also be some of the greatest opportunities. McFarland says that the new technologies that are available to farmers can be overwhelming, but she looks at it as an opportunity to do her research and use her resources to learn about the new tools available to her and see what would be most beneficial to her farming operation. Ultimately, she has relied on the advice from those who she looks up to in the industry.

"The best advice given to me was when my dad told me that I wouldn't know for sure if I wanted to make farming a career unless I had 'skin' in it myself," says McFarland. "Having the opportunity to rent land of my own as a junior in college really allowed me to feel the pressure, along with the excitement, that comes with each growing season."

Now that she is back on the farm and also working with the SHP, McFarland feels very fortunate to have the opportunities that she has and also knows the responsibility that comes with farming. That's why she knows the importance of using environmentally sound practices and doing the best she can to care for the land and natural resources.

"The soils are literally our farm," she says. "That's our top resource and I'm very passionate about taking care of and protecting that resource."

Along with her father and other farmer mentors, McFarland turns to several other resources when she has questions about soil health and conservation on her farm. One of those resources is the Iowa Corn Growers Association, which she is a member of.

"Iowa Corn does a great job of supporting farmers and helping them tell their story, especially as it relates to soil health and conservation. I love any opportunity to tell my story and I'm thankful for avenues that allow me to do that."

Become an Iowa Corn Stewardship Advocate

Iowa Corn Growers Association members are invited to join the Iowa Corn Stewardship Advocate program. As an Advocate, you'll be the first to know about hot topics, news events and upcoming stewardship activities that are relevant to your farming operation. You will receive:

- **Monthly email updates** from Iowa Corn Sustainable Program Manager Ben Gleason and other experts on the topics of soil health, conservation and water quality
- **Latest information** on stewardship topics impacting your farm
- **Regulatory updates** that may impact your farm
- **Special offers** that apply to your soil health efforts
- **The scoop** on upcoming Iowa Corn stewardship activities and events

You will also have the opportunity to hear directly from Iowa farmers, ask questions and join the discussion about conservation in Iowa. For more information about the program and to sign up, visit **iowacorn.org/water**.

IOWA CORN

Our STATE | Our FIELDS | Our WATER

iowacorn.org/water

Easing the Conservation Conversation

Jessica Van Horn
Physical Science Technician, Agroecosystems Management Research, National Laboratory for Agriculture and the Environment

"Story Maps are powerful tools that consolidate wide spread information to convey a focused conservation plan. They also facilitate sharing information and data, which is useful at all stages of conservation planning."

The conversation about conservation can be a difficult one. The first struggle is bringing the necessary stakeholders together. A successful team may require land owners, operators, watershed coordinators, economists, scientists, technicians and engineers coming together to construct a solid conservation plan and practice design. While the information brought by each member is invaluable, there are difficulties in filling the knowledge gaps in a time-efficient manner. This introduces the second struggle: Communication and ultimately, decision making. There is never just one correct solution, and with an overabundance of information it can hamper the start of conservation planning.

One thing that connects all involved, however, is the land. Starting the conservation conversation with an objective analysis of the physical landscape can reaffirm mutual concerns about water and soil health in agricultural systems. What better way to get busy people in the landscape than with maps?

Story Maps

Story Maps knit together maps with multimedia content, such as narrative text, images, video and other digital material. Maps have long been used to tell stories about our surroundings. As a conversation piece, they can help clarify information and explain trends by orienting a person within the data. Today, creating and viewing Story Maps is simple and accessible to anyone with an internet connection, making them a complete and powerful tool to share a conservation story.

How to go about it…

Anyone can create an Environmental Systems Research Institute (ESRI) Story Map. ESRI Story Maps range from a simple design using a provided template and data to bringing in personal GIS layers or web coding. To begin developing your own Story Map, you will first need to determine what ArcGIS Online account type will best suit your needs. In general, there are public and organization accounts. Public accounts are free but have some usability limitations, and organization accounts are flexible and user friendly, but costly (opportunities are available for non-profits, coordinators associated with Soil and Water Conservation Districts and other public entities).

Once your account has been set up, you may immediately start creating a Story Map using one of ESRI's templates. An abbreviated version of the workflow is as follows: 1. Under your 'My Content', choose to 'create', and select 'using a template' (for a Story Map) 2. Follow their guided steps to title and adjust settings, and 3. Start adding media and text to your story. 'Media' can range from images, an embedded web page, videos, a map with GIS layers and much more. Following step 3, it is up to you to decide what content and at what level of detail to include in your story to present a strong conservation plan.

Story Maps are powerful tools that consolidate wide spread information to convey a focused conservation plan. They also facilitate sharing information and data, which is useful at all stages of conservation planning. Whether you are introducing

a conservation plan, designing where to place practices, educating the public on the impacts of agriculture and land management or simply starting the conservation conversation, a Story Map can be a great resource.

Where are they being used?

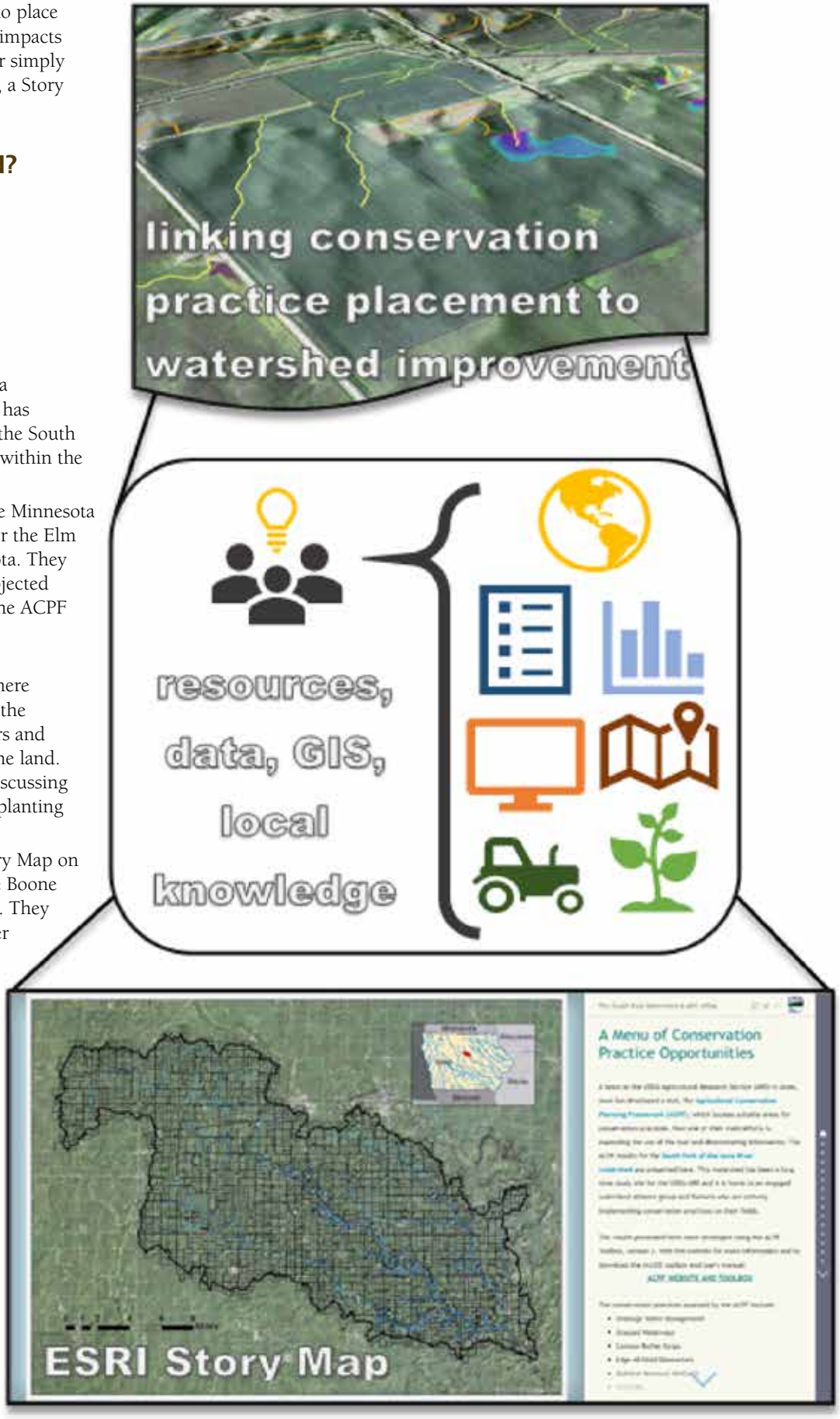
There are conservation focused Story Maps popping up throughout the Midwest. A team at the USDA-Agricultural Research Service recently developed an ESRI Story Map that shows the results of a conservation practice siting tool, (Agricultural Conservation Planning Framework (ACPF)) for the South Fork of the Iowa River watershed. This ESRI Story Map has been used to share information about the South Fork and future conservation projects within the watershed.

A similar story was developed by the Minnesota Center for Environmental Advocacy for the Elm Creek Watershed in southern Minnesota. They use the story to report current and projected water quality status and to showcase the ACPF results.

The USDA-NRCS began a web map series called "Fridays on the Farm", where they aim to share real-world stories of the NRCS working with farmers, producers and landowners to improve the health of the land. Two of these stories are Iowa-based, discussing no-till alternatives and the benefits of planting pollinator species.

The USDA-NRCS also created a Story Map on a farmer's conservation initiative in the Boone River Watershed in north central Iowa. They use it to introduce the Mississippi River Basin Healthy Watershed Initiative (MRBI), and to demonstrate how one farmer's conservation efforts have impacted a local waterway.

I encourage people from all backgrounds to explore Story Maps and more, and try their own hand at spreading the importance of conservation using maps, images and more!



Sources

A Menu of Conservation Practices: http://arcg.is/4Lfj8
Targeting Agricultural Best Management Practices for Water Quality: Elm Creek Watershed: http://arcg.is/urrXD
Fridays on the Farm: https://arcg.is/08Prq8
Stepping Up for a Cleaner Mississippi: http://arcg.is/LHuOv

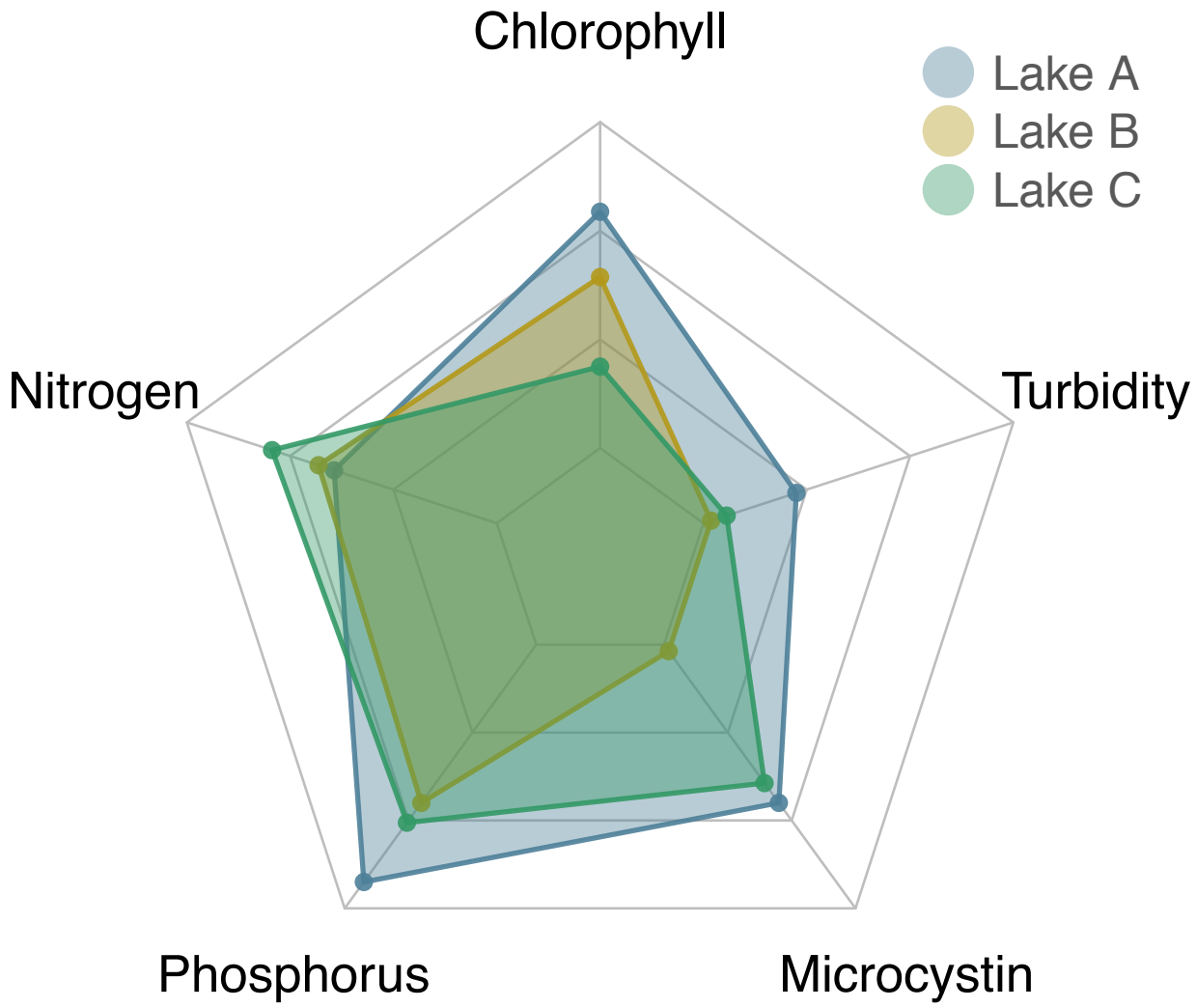


FIG. 1

'Is This Lake Healthy?' And Other Difficult Questions to Answer

Grace Wilkinson, PhD
Assistant Professor in the Department of Ecology, Evolution and Organismal Biology (EEOB) at Iowa State University

Whether fishing, swimming, boating, birdwatching or simply taking a walk along the shore, Iowa's lakes are valuable recreational ecosystems. Iowan's care deeply about maintaining the viability of our lakes, which often leads to the questions, "Is this lake healthy?" or "Is the water quality good?" While seemingly straightforward questions, water quality and ecosystem health are anything but simple.

In order to determine if a person is healthy, a doctor would consider factors such as their blood pressure, cholesterol, diet, exercise regime, sleep habits and mental health. All of these variables contribute to the overall health and wellness of a human being. Similarly, numerous variables contribute to the overall health of an ecosystem. For example, the nutrient concentrations, amount of algae, turbidity, invasive species, the level of harmful bacteria and toxins and the ability to support thriving sport fishing are all components that influence the quality of a recreational lake.

Nutrient concentrations in surface waters have become a key focus in Iowa as recognition that our state contributes substantially to the dead zone in the Gulf of Mexico grows. The large emphasis on reducing the nutrients leaving the state has made water quality nearly synonymous with nutrient concentrations. While nutrients are the underlying reason behind many of the phenomena that contribute to water quality issues such as harmful algal blooms, they are not the only component of a healthy lake ecosystem. When we focus on only one water quality variable, we are likely to misjudge how well a lake is

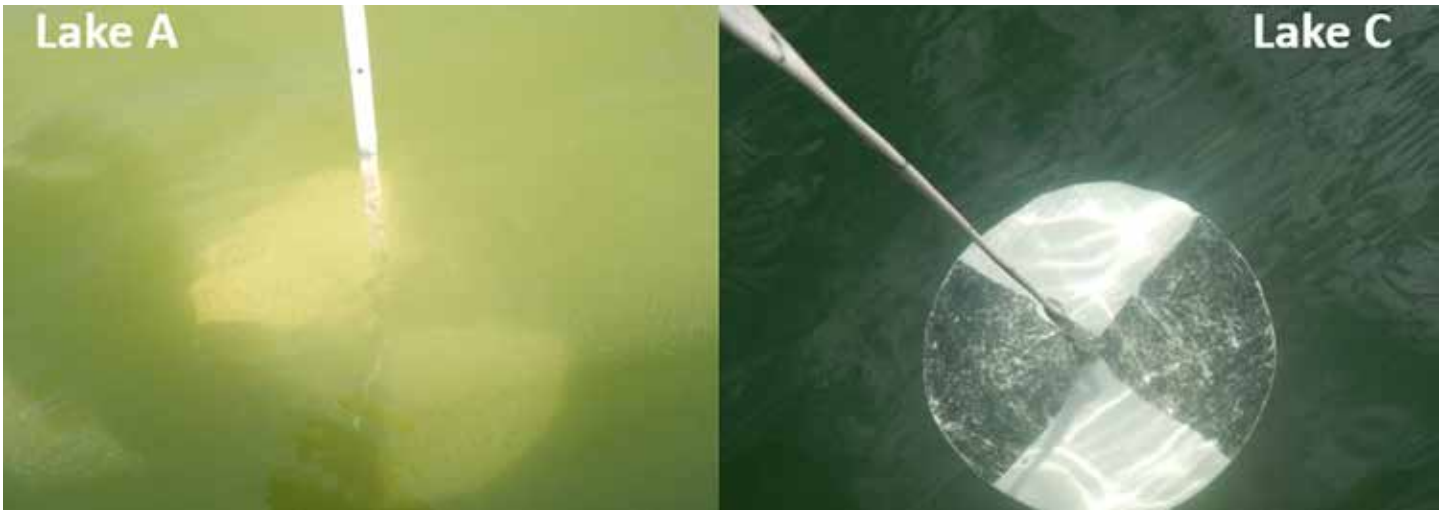


FIG. 2

functioning.

For the past 17 years Iowa's recreational lakes have been routinely monitored for a suite of physical, chemical and biological variables that are used to characterize the water quality. Each one of the 130 publicly-significant recreational lakes is visited during the spring, mid-summer, and late-summer periods every year by a team of scientists to quantify the state of the lakes. The data collected during these surveys helps managers and scientists understand how the lakes in our state are functioning and how to best manage them.

Data from this past summer's lake survey illustrate the importance of considering multiple variables when characterizing lake water quality (Figure 1). Lake A had high total nitrogen, total phosphorus and chlorophyll a (an indication of the amount of algae) concentrations. The water in this lake had a green tinge and surface scums of algae formed periodically (Figure 2). While these conditions would be fine for fishing, the high concentrations of algae in the water would be unpleasant for swimmers, limiting the recreational quality of the lake. Additionally, the lake had moderately high microcystin concentrations. Microcystin is a toxin produced by some species of blue-green algae, also known as cyanobacteria. Exposure to this toxin in high concentrations poses an immediate threat to human, domestic animal, and wildlife health. It is clear to see, from both the data and the lake's appearance, that the water quality in Lake A is poor.

Characterizing the water quality in Lakes B and C is much more difficult. All three of the lakes have similarly high nutrient concentrations. The differences in their water quality lies in the biological response to those nutrients. The amount of algae in Lake C was substantially lower than Lake B (Figure 2). Visually, Lake C appears to have better water quality and would be more attractive to swimmers. However, Lake C also had a moderately high concentration of the toxin microcystin which threatens swimmers' health. On the other hand, Lake B had higher algae concentrations but no detectable microcystin. From a swimmer's perspective, Lake B might be less visually appealing even though it is the safer choice.

Ultimately, water quality and ecosystem health are multifaceted and user-defined. The conditions that may constitute acceptable water quality for fishing and boating are not necessarily the same conditions that would constitute "good" water quality for swimming or waterfowl habitat. Regardless of the use, water quality for recreational water bodies is clearly not definable by one measurement or variable alone. It is best characterized by numerous variables and interpreted through the lens of the user. Routine monitoring of those water quality variables remains one of the best ways to inform management and preservation of our state's recreational lakes.

So, the next time you are wondering about the health of a lake, consider the variables beyond nutrient concentration that characterize how that lake is functioning and the recreational opportunities it provides.

Fish Habitat in Iowa's Streams

Jeff Kopaska
Biometrician at the Iowa Department of Natural Resources
President of the Iowa Chapter of the American Fisheries Society

The first surveys of Iowa indicated that the land was "one of great beauty. … In every part of this whole District, beautiful rivers and creeks are to be found, whose transparent waters are perpetually renewed, by the springs from which they flow. Many of these streams are connected with lakes; and hence their supply of water is remarkably uniform throughout the seasons. All these rivers, creeks, and lakes, are skirted by woods, often several miles in width, affording shelter from intense cold or heat to the animals that may there take refuge from the contiguous prairies. … of Fish there can never be any scarcity. Every stream is filled with them; and among them may be found the pike, the pickerel, the catfish, the trout, and many other varieties" (Lea, 1836).

Similar descriptions were provided by early settlers along the Skunk River north of Ames. "The banks bordering the river were not very high. Either side of the river was a bottom land heavily timbered with black walnut, butternut, ash, oaks and other hard woods. … The woods were full of game, such as squirrels, rabbits, wood chucks, raccoons etc. The streams were swarming with fish of many kinds. We caught them in large numbers with hook, spear, net, seines and traps. … There were pike, pickerel, bass, redhorse suckers, large blue catfish, boolponts (bullheads), sunfish, eels, etc." (Kegley, 1936). Early accounts of Grundy County were similar, "Between the watersheds and at distance of two or three miles from one another were little clear brooks with banks of black sod, their waters flowing on floors of bright colored glacial pebbles; their expansions little pools covered with the pads of the yellow pond lily or lotus. These streams could be stepped across almost everywhere. They were beautiful little brooks, so clear, so overarched with tall grasses and willows, so plaided with the colors of the pebbles in the sun, so dark and mysterious in the shade; with secret pockets under the soddy banks for the shiners, pumpkinseeds, dace, chubs and other small fish which populated the pure waters" (Quick, 1925).

These accounts do not resemble the wide, shallow streams with muddy banks

"As the quality of fish habitat in Iowa's rivers and streams degraded, fish communities changed also."

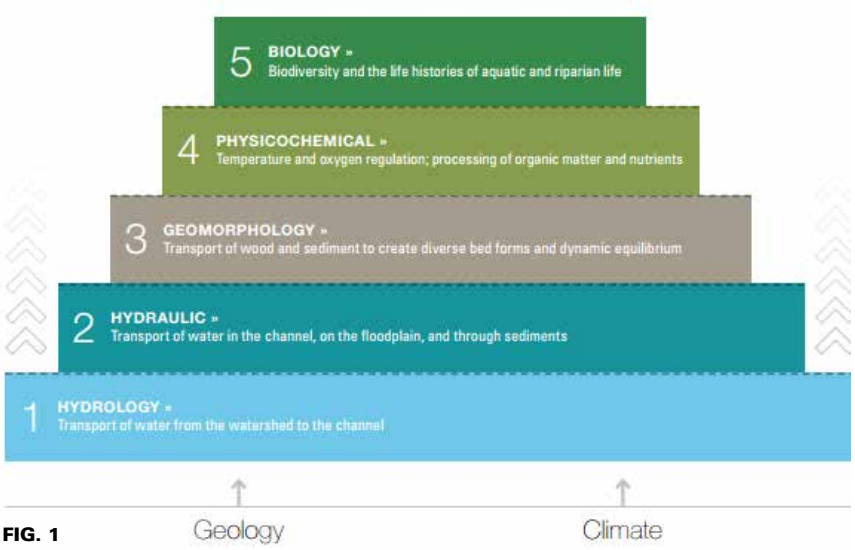


FIG. 1

and turbid waters that generally persist in Iowa's rivers and streams today. In fact, these changes to current conditions began long ago. "I have been informed that many streams, formerly deep and narrow, and abounding in pickerel, bass and catfishes, have since grown wide and shallow, while the volume of water in them varies greatly in the different seasons, and they are now inhabited only by bullheads, suckers and a few minnows. The breaking of the native sod for agricultural purposes has especially affected the smaller streams in the respect, while the construction of ditches and the practice of underdraining have had their effects upon the larger ones. Moreover, the constant loosening of the soil, in farming, tends to reduce it to that condition in which it is readily transported by the heavy rains to produce muddy currents" (Meek, 1892).

As the quality of fish habitat in Iowa's rivers and streams degraded, fish communities changed also. Early accounts, included above, mention more game fish, while Meek's account illustrates the transition. Menzel (1981) noted that by 1900, Iowa streams had experienced "the replacement of desirable food and game fishes by ecologically tolerant rough fishes," likely resulting from agricultural land use practices, hydrologic alterations, unmitigated sewage export from urban areas and unlimited fishing. These observations are supported by recent research that indicates human-induced sedimentation alters stream fish communities (Sutherland et al., 2002). Fortunately, improved soil conservation in watersheds and regulation of point source pollution have resulted in certain parameters showing improved stream water quality by the end of the 20th century, as outlined in recent publications (Jones and Schilling, 2011; Schilling and Drobney, 2014).

These documented improvements in water quality could lead to the logical conclusion that fish habitat and fish communities should also be responding positively. Unfortunately, that is often not the case, because sedimentation from eroding fine materials still blankets stream bottoms and the altered hydrology has resulted in extremely "flashy" systems. This "fishy" problem is a battle being fought against an issue of historic proportion. Recent studies have documented post-settlement soil losses of ~70 tons/acre in Des Moines lobe watersheds (Yan et al., 2010; Heathcote et al., 2013), and substantial amounts of those eroded upland soils currently reside as alluvial deposits in downstream floodplains. The 2012 issue of Getting Into Soil and Water shows a photo of this phenomenon (Tomer, p. 27), illustrating many feet of sediment deposited next to the stream channel, and a bare bank ready to erode at the next high water "flash".

While similar research has not been undertaken in all of Iowa's ecoregions, it is fair to assume that greater rates of erosion and alluvial deposition have occurred in the other, more hilly ecoregions than has transpired in the mostly flat Des Moines lobe. Thus, areas where research has documented significant issues may be the least impacted areas of Iowa.

Other types of research conducted at broader scales show high quality fish habitat is a limited resource in Iowa. A 2015 nationwide assessment of fish habitat indicated that 69% of stream miles in Iowa were categorized as having a high or very high risk of habitat degradation (Crawford et al., 2016). This remotely-sensed assessment is corroborated by recent field observations made in Iowa's rivers and streams.

Research studies indicate that river and stream substrates are of poor quality (67% fine materials v. 33% coarse materials), 40% of streambanks are comprised of bare soil, 88% of the fish assemblage (by weight) is comprised of nongame fish, and stream channels (width-depth ratio x=78) are disturbed, overly-wide, and subject to accelerated bank erosion (Gelwicks, 2013; Rosgen and Silvey, 1996; Vermont ANR, 2009).

Data shows that fish habitat and fish community metrics are not improving, while some water quality parameters may be (Schilling, 2016). The "why" of this conundrum brings us to the concept of the stream ecosystem function (Figure 1, Harman et al., 2012). Holistic restoration of streams and rivers can only be accomplished when all aspects of the system are included – hydrologic, hydraulic, geomorphological, physiochemical and biological – not just water quality (physiochemical). River restoration professionals routinely examine stream channel width to depth ratio to assess stability of channels and watersheds. Stable, high quality streams generally are deeper and narrow (like the ones originally reported in Iowa), with width to depth ratios less than

20 (Rosgen, 1996); recall that on average, Iowa's are 78. Channels with high numbers tend to have increased hydraulic stress against streambanks, accelerating bank erosion. As banks erode, channels become wider, shallower and less able to transport sediment; instream deposition occurs, further accelerating bank erosion, and the cycle continues (Vermont ANR, 2009).

Recent research at Walnut Creek in the Neil Smith National Wildlife Refuge, a watershed with ecosystem restoration in progress, shows extensive streambank erosion during extreme flow events and residual sediment export following instream deposition after the large flow events (Palmer et al., 2014). While substantial upland restoration has occurred in the watershed, the most upstream portions are still in row crop agriculture, thus agricultural drainage continues to affect stream hydrology. No specific streambank stabilization efforts occurred, thus historic streamside alluvial deposits were readily available for "removal."

Since these alluvial sediments are also rich storehouses of phosphorus, the detrimental impacts of continued bank erosion are two-fold: fish habitat remains degraded from sedimentation, and phosphorus flux from watersheds continues to be problematic.

There are some interesting examples in Iowa of how streams could respond to "restoration". Onstream impoundments of Iowa rivers, especially those with longer hydraulic residence times, allow sediment and phosphorus to deposit in the pool above the dam, support limited denitrification in the pooled water and generally temper the extreme flow rates of large events. For many years, Lake Delhi on the Maquoketa River in northeast Iowa acted in this manner. The stretch of river below the dam supported a quality Smallmouth Bass fishery. Stream substrate sampling from 1998 revealed 85% coarse materials versus 15% silt and sand (fine materials), the average depth was 0.75 meters and the width-depth ratio was 49. Following the flood-related dam failure in 2010, until replacement in 2016, the Smallmouth Bass population was reduced by 74% (by number) and 81% (by weight), substrates were 82% fine materials, average depth decreased to 0.39 meters and width-depth ratio increased to 122. Sampling in 2016 revealed improvements in the Smallmouth Bass population, but it remained below pre-dam failure levels. Substrates have started to be cleansed; 60% of substrate is once again coarse materials, average depth has increased to 0.48 meters and the width-depth ratio is 78 (Gelwicks, 2012; Gelwicks, 2015; Gelwicks, 2017). This information is not meant to advocate for more impoundments on rivers, as they are not a long term solution. However, it does indicate how systems can respond when sediment flux is radically reduced.

Improving fish habitat in streams and rivers is a worthy conservation goal for Iowa, and it coincides with the need to significantly reduce phosphorus flux as outlined in the Iowa Nutrient Reduction Strategy. Streambank erosion is a substantial source of sediment. It may be contributing 40-80% of phosphorus to Iowa's waterways (Iowa Nutrient Reduction Strategy, 2016), and streambank stabilization/riparian buffer strips have been shown to reduce these loses in comparison to row cropped riparian areas (Zaimes et al., 2008). Utilizing streambank stabilization practices from the Iowa Nutrient Reduction Strategy, especially if applied in a concerted manner from upstream to downstream locations, would dramatically enhance fish habitat and fish populations in Iowa's rivers and streams.

Further Reading

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I'M AN
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SOIL SUPERSTAR

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At Iowa State, I'm learning what it means to use science to study soil. I'm learning how soil is a non-renewable natural resource that produces food and fiber, creates bioenergy, and filters and stores our water. That's why I'm studying how to protect our soil, and therefore, our environmental quality for years to come. So I can become an agronomist. So I can make an impact on future generations.


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