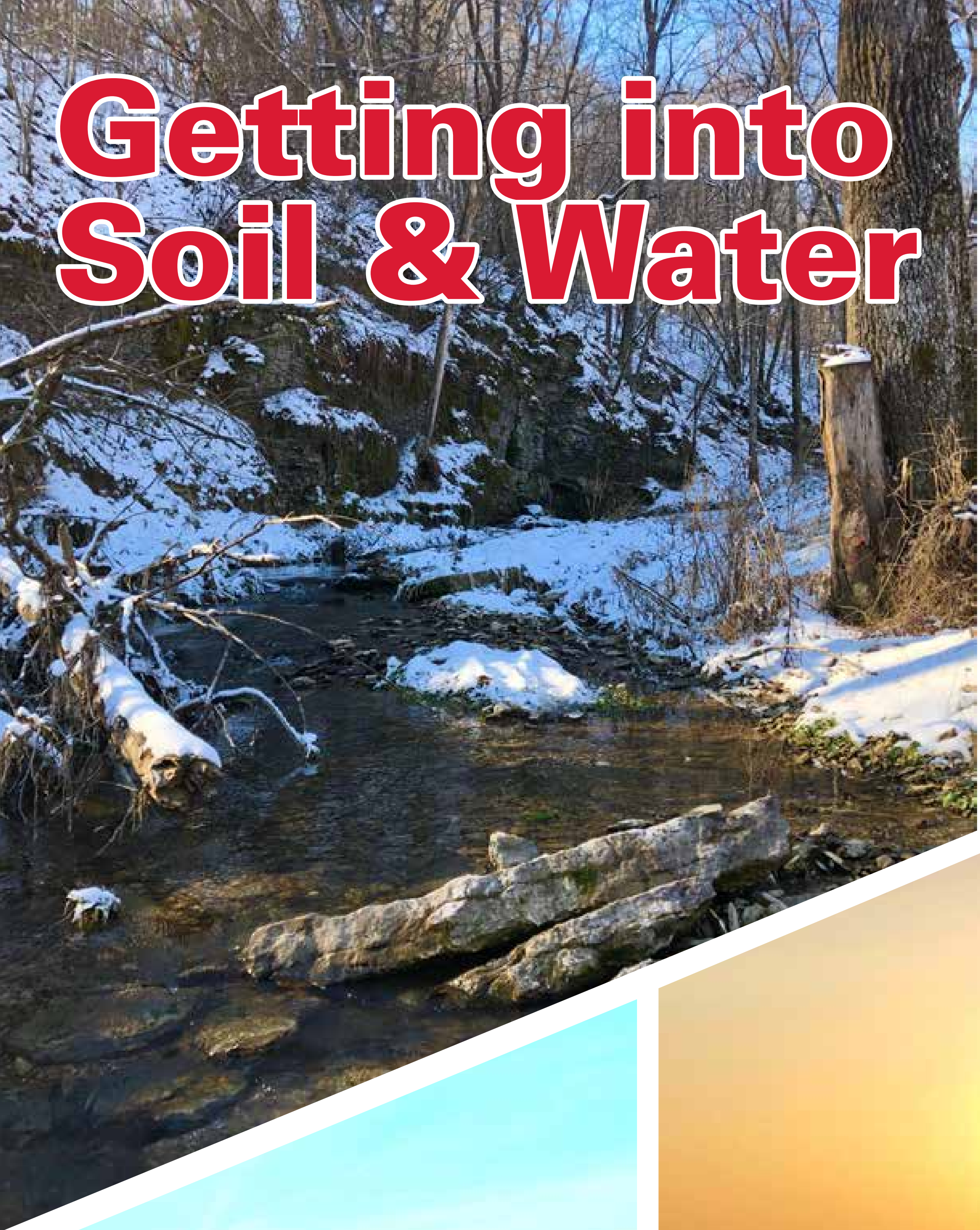
Getting into Soil & Water



2021 Edition

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

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We Are Proud to Present Our 2021 Publication

Chris Morris, Madison McDermott, Megan Blauwet, Rebekah Muench and Evelyn Planter, 2021 Editors

We are proud to present the twelfth annual edition of the *Getting Into Soil and Water* publication presented by the Iowa State University Soil and Water Conservation Club. This year presented a unique set of challenges in bringing this publication to print given restrictions related to the COVID-19 pandemic, but we had a fantastic team that creatively overcame these challenges to bring this edition to our readers. This year's publication presents a diverse set of informative articles highlighting cutting-edge research, policy, history, and public outreach, but what all of these articles have in common is showcasing the strong commitment of conservation professionals to conserving Iowa's natural resources for today and future generations. Our team of five co-editors is made up of Chris Morris, Madison McDermott, Megan Blauwet, Rebekah Muench, and Evelyn Platner. We would like to share with you a little bit about ourselves and what soil and water conservation means to us.

Chris Morris

I am a first-year PhD graduate student co-majoring in Sustainable Agriculture and Rural Sociology, and I joined the Soil and Water Conservation Club during my Master's program in 2018. Being a member of the club has been an important avenue for networking with other students with similar interests as well as having the opportunity to learn from conservation professionals outside of the classroom. Being a co-editor for this publication has been an incredibly rewarding experience, both for getting to learn about the latest research in conservation as well as getting to work with an amazing team to bring it all together.

Madison McDermott

I am a sophomore in Agricultural Engineering, and I joined the Soil and Water Conservation Club in the fall of 2019. I grew up in Monticello, Minnesota, and have always had a passion for the outdoors and how systems operate. Since arriving at Iowa State freshman year, my interest in conservation and sustainability has grown. The club has allowed me to gain more perspective on the world of agriculture and push myself to become involved in making a difference. Being a co-editor of Getting Into Soil and Water has helped me expand my professional network and become more attached to my studies. I hope while reading this publication you learn something new and gain more admiration for the practices which preserve nature's resources.

Megan Blauwet

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

Rebekah Muench

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

Evelyn Platner

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

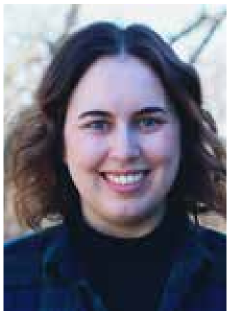
> "...what all of these articles have in common is showcasing the strong commitment of conservation professionals to conserving Iowa's natural resources for today and future generations."

This publication would not exist without the help of our committee members and authors. We would like to thank them for their dedication to making this publication unique and informative. We would also like to thank our advisors, Hanna Bates, Dr. Rick Cruse, Dr. Bradley Miller, and Heidi Ackerman, for their knowledge and support throughout the publication process. They have been essential to the publication, and we are grateful for their guidance. We are also incredibly appreciative of our sponsors, without whom this publication would not be possible. Special thanks also goes to our graphic designer Andrew Zalasky with Hazel Creative, who for many years has created the magazine's beautiful layout that you see before you.

Finally, we wish to send a huge thanks to you, our readers. Your support has given us the opportunity to create the twelfth edition of Getting Into Soil and Water, and we are excited to continue these publications for years to come.

Community, Conservation, and Agriculture

Emily Martin
Conservation Programs Coordinator



Emily Martin

With my eyes closed, I can see everything clearly. A 160-acre field in Dickinson County, Iowa that was farmed edge-to-edge, now a diverse system that provides for humans and wildlife alike. I see prairie, alfalfa, cover crops, corn, and a restored wetland. I see all of these practices working in unison, building a farm that is resilient to climate change. In 2018, this was just a dream. In 2021, it's a reality. How did we get there?.

Iowa Natural Heritage Foundation (INHF) was presented with the opportunity to work on farming resiliently when two private donors and the Dickinson County Water Quality Commission helped us acquire 160 acres on the north shore of Big Spirit Lake. That property is now known as Wallace & Bowers Nature Area. Since 1979, INHF's work has evolved to meet the needs of conservation in Iowa. In our latest strategic plan, climate change became a focal point of our work.

Iowa's soil and water resources are being stressed by climate change, and action needs to happen now to conserve our resources. It is vital that Iowa finds ways for agriculture and conservation to work in tandem to rebuild our natural resources before climate change worsens. INHF is investigating the role that resilient farming can play in not only conserving, but regenerating our natural resources.

That's where Wallace & Bowers comes in.

Wallace & Bowers was a property that presented unique challenges – a farm field that drains directly into Big Spirit Lake through the Shore Acres neighborhood. When we acquired the land in summer 2018, INHF met with local agencies, partners, friends, and neighbors. With all of their expertise, we knew we could create a solid plan. Internally, we set goals:

1. Have a positive impact on water quality and quantity.
2. Record data as we make changes.
3. Build partnerships and learn from each other.

Perhaps the most important meeting we had was with Jake and Gary Johnson, longtime tenants of the property. Together, we formulated the plan for Wallace & Bowers. The Johnsons needed 50 acres of alfalfa. The homeowners needed less water runoff and snow inundating them. INHF wanted to integrate prairie to build organic matter and help catch water running off of the property. There was a wetland in the northwest corner wanting to re-emerge. With respect to everyone's needs, we drew on a map where we felt these practices should best be put into place.

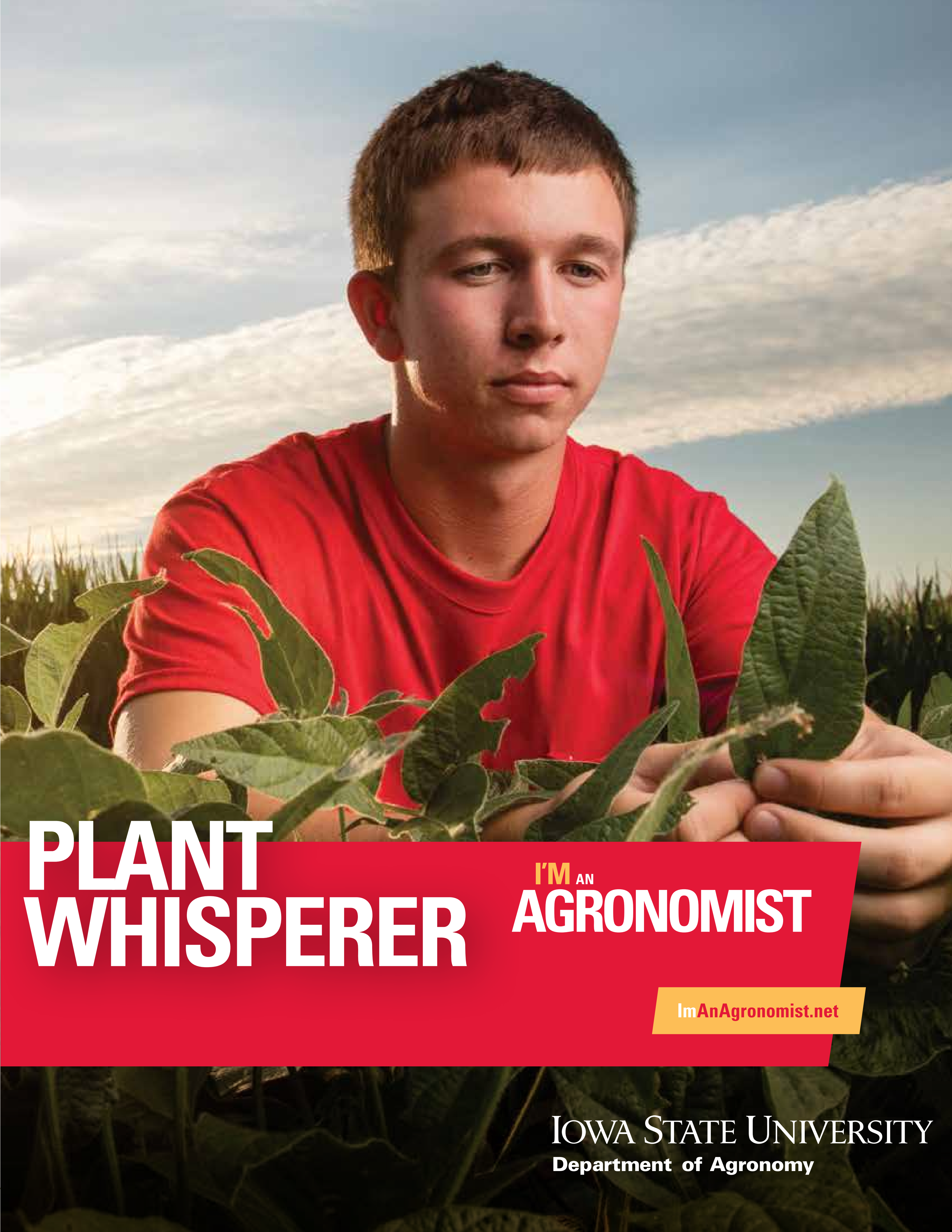
> Iowa's soil and water resources are being stressed by climate change, and action needs to happen now to conserve our resources.

Thanks to conversations with partners, we quickly found funding for implementation. Dickinson County NRCS is providing funding through the Environmental Quality Incentives Program (EQIP), which received special funding through the National Water Quality Initiative. With funding in hand, our vision was realized from 2019 to 2020.

Flash forward to today. The Johnsons still farm 90 acres of commodity crops, and now they put cover crops down in the fall. They have 50 acres of alfalfa. INHF planted a 10-acre local ecotype prairie buffer, which will give our Shore Acres neighbors a view just as beautiful as the lake. At the end of 2020, a seven-acre wetland was restored in the northwest corner, rounding out our first phase plans.

Along the way, Iowa Lakeside Laboratory has been sampling on the property and in the lake to measure our impact as changes continue to be made. Amber Anderson and Dr. Lee Burras gathered baseline samples of the soil to see how carbon is stored in both the surface and deeper layers over time. Shore Acres neighbors have reported positive impacts anecdotally, letting us know in early 2020 that they are already seeing less water runoff through their homes. INHF and our partners will continue to collect water and soil data as we make changes to demonstrate clearly how conservation practices affect Iowa's natural resources. In future years, we will reassess local needs and create a phase 2 plan for the property that continues resilient farming and incorporates regional perspectives.

Turning Wallace & Bowers into a well-researched resilient farm took hard work and patience. This 160-acre farm is the future of Iowa – conservation, agriculture, and communities working together with scientific data to show quantitative results alongside qualitative. The most important action INHF took in this process was to bring everyone along with us, from the tenants to the neighbors to agencies and other longtime partners. Iowa has tremendous opportunity to provide land-based climate solutions. To get there, we need bold, resilient communities who can stand together in the face of climate change, advocating for conservation practices that better the lives of everyone.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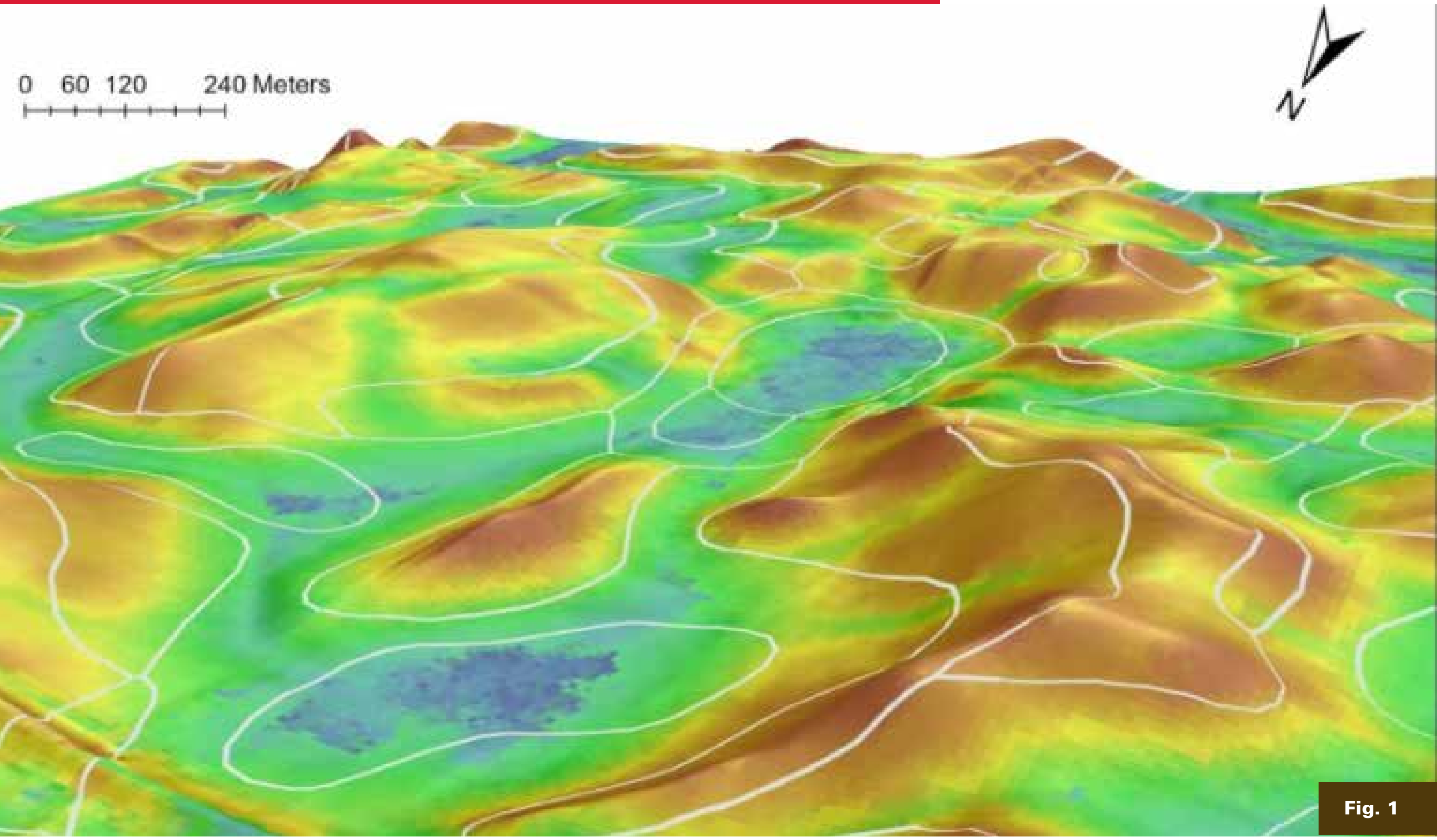

Fig. 1

Precision Land Surface Analysis and Machine Learning for Enhanced Soil Maps

Meyer Bohn
Ph.D. Student/Graduate Research Assistant

There is a tremendous opportunity to enhance the accuracy and detail of soil maps to support research that improves agronomic efficiency while mitigating soil and water degradation. Predictive agroecosystem models rely on soil map data to target solutions for soil and water quality issues by monitoring and simulating the efficacy of sustainable land management practices..

The challenge with these agroecosystem models is that they are sensitive to the quality of their input data. This becomes problematic due to the prevalent drawbacks of current soil maps. The maps are outdated, and the average soil map in Iowa is over 30 years old. Decades of intensive agriculture and drainage have significantly altered soil organic matter, texture, and water table depth. Accelerated erosion has depleted organic matter in steep areas and caused accumulation in low-lying areas. Erosion has preferentially sorted finer particles downslope while coarse particles remain in higher landscape positions[4]. Moreover, tile drainage has significantly lowered water tables, promoting rapid oxidation and increased organic decomposition[1].

Current soil maps generalize the landscape at a coarse resolution unsuitable for precision modeling and management. The average map delineation in central Iowa is about 25 acres. Yet poorly drained soils can be tens of meters away from well-drained soils. Although these soils require different management, the current soil map cannot capture the fine details of variability due to landscape complexity and mapping technology limitations[3].


Meyer Bohn

The technologies used to make the traditional soil maps were made by overlaying paper base maps of topography, geology, and aerial photographs and then drawing lines according to field observations. However, these methods lacked the ability

Fig. 2

Fig. 3

Fig. 4

to quantitatively synthesize a tremendous amount of geospatial information now available via Geographic Information Systems (GIS). Also, soil property predictions were based on ranges of observational frequency distributions rather than mathematical equations we are now able to produce with machine learning.

Digital soil mapping (DSM) is the solution to enhancing the accuracy and resolution of soil maps. DSM synthesizes environmental data correlated with soil properties to make mathematical spatial predictions of soil properties. These environmental data are collected through remote sensing of the land surface and reflect state-factors governing soil formation, i.e. climate, biota, parent material, and topography. Within a GIS, derivatives from the remotely sensed data are calculated to further quantify soil-landscape complexity. For example, slope and catchment area derived from a digital terrain model are used to calculate a wetness index (Fig. 1), which performs well in soil prediction. Spectral data can indirectly measure soil moisture and estimate crop health, both of which are effective predictors of soil properties. Land surface derivatives serve as predictors in combination with soil point data to train machine learning algorithms. Machine learning can parse the immense complexity of the soil-landscape and is ideal for agroecosystem modeling because stochastic models give estimates of uncertainty so the user can determine suitability for application.

My project targets soils of the Des Moines Lobe (DML) in Iowa, a region characterized by soils formed in glacial deposits, known as till. These soils are differentiated by topsoil thickness, organic matter, texture, and water table depth. These properties are of high interest because they are crucial to agricultural modeling2, have changed over the past 50 years4, and can be mapped across large extents.

This project is novel to most DSM studies for several reasons. A comprehensive database has been compiled with thousands of legacy soil samples and nearly 200 new field samples (Fig. 2). In addition, over 500 land surface derivatives have been generated with an emphasis on unique fine-resolution terrain derivatives (Fig. 3). Subsequently, the maps will generate predictions at a 3-m resolution for surface soil properties as well as several depth intervals down to two meters. The mathematical predictions will be created via two highly successful machine learning algorithms, Cubist and Random Forests. Finally, the experimental design questions the presumed homogeneity of the DML with paired northern and southern study regions (Fig. 4). The DML has several subregions differentiated by multiple glacial advances with variable till deposits, topographic patterns, and climate. This study will determine if models created in specific subregions of the DML are transferable to other regions.

The project is slated for completion in December of 2021. With their estimates of uncertainty and accuracy metrics, the soil maps will be freely available for download on our website at glsi.agron.iastate.edu.

I would like to thank the Iowa Water Center for funding this study and all the Iowa farmers who have greeted me with tremendous generosity.

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Fig. 1. Topographic wetness index at 3-meter resolution overlain on a 3D bare earth elevation surface in SW Dickinson County. Redder areas indicate steeper slopes with small catchment areas. Deeper blues show level slopes with large contributing catchment area. The white lines are current soil map delineations to demonstrate the improved precision attained with high-resolution land surface derivatives.

Fig. 2. Meyer Bohn sampling with a Giddings hydraulic soil probe on a floodplain soil near Melvin, IA.

Fig. 3. Vertical distance to channel network calculated for the DML region of Iowa. This land surface derivative determines the relative relief above a local stream and mathematically describes the regional scale degree of drainage network development. White and light green areas approximate where poorly drained soils occur. Note the concentric, u-shaped, banding with areas of higher relief. These are end moraines that have hummocky topography and well-drained soils.

Fig. 4. The physiographic regions of Iowa with the northern and southern paired study areas outlined in dashed yellow. These study areas include Osceola, Clay, Dickinson, Emmet, Boone, and Story Counties and are designed to representatively sample different physiographic subregions of the DML and its margins.

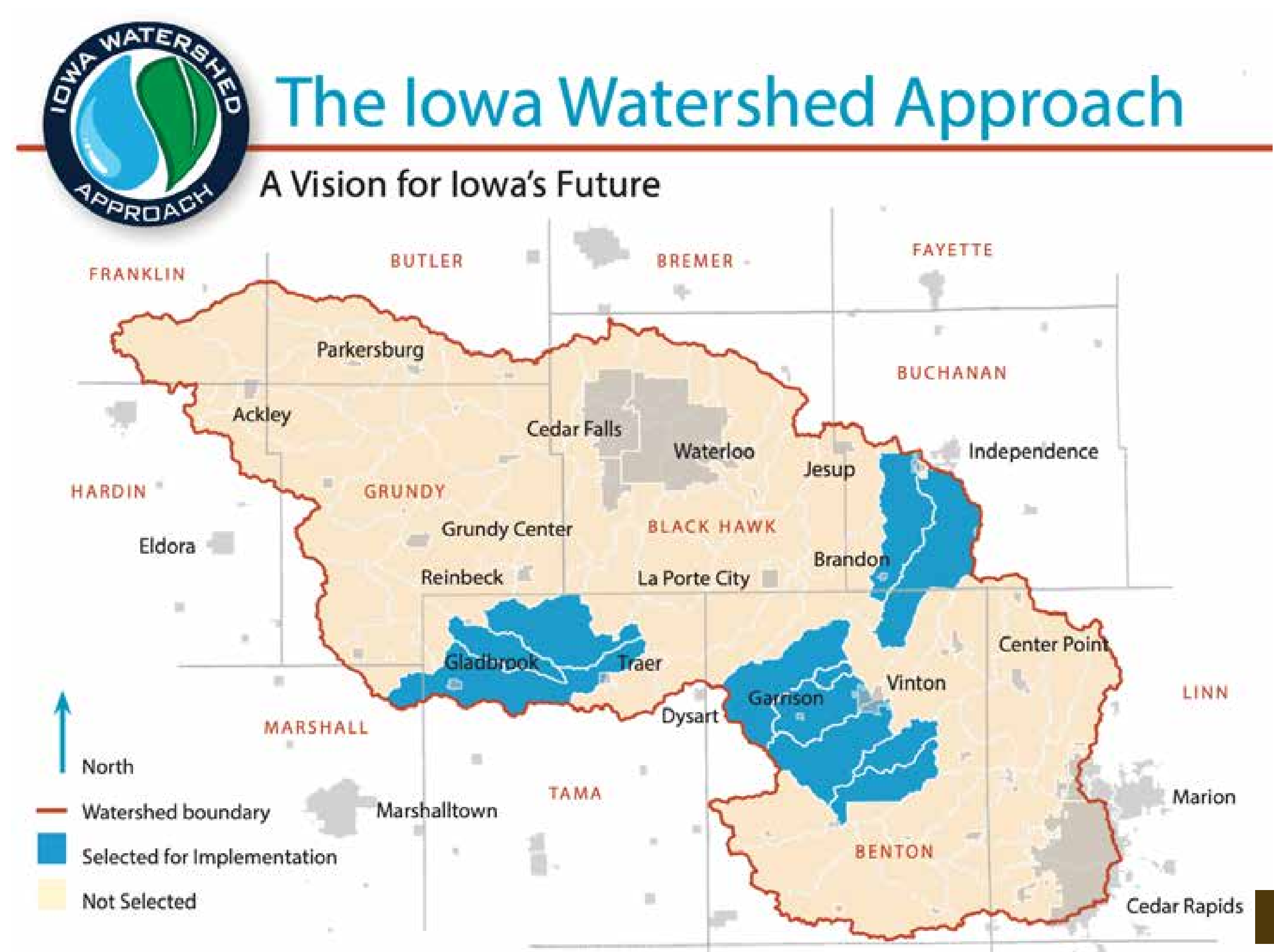


Fig. 1

Middle Cedar Watershed Practice Implementation

By Megan Blauwet
Agronomy Student, Iowa State University

The Iowa Watershed Approach (IWA) is about Iowans helping Iowans become agricultural stewards to protect and conserve our environment. The goal is to reduce the impacts of flooding, which is becoming a more common problem in our state. This, in turn, can increase water quality, resilience, and overall quality of life. The Middle Cedar vision statement is, "Water will be valued as a shared resource to be nurtured and managed for the long-term benefit of the people living in the Middle Cedar Watershed and the ecosystem upon which they rely."

All of the water that rains on an area that drains to the same water body is called a watershed. People, animals, roads, and weather are a few of the things that can impact a watershed. Watersheds support all the local streams, creeks, and aquifers. Taking steps to protect the watershed helps all the aspects of the environment in the area. It is critical to make sure that we preserve watersheds in order to ensure a good quality of life.

The Middle Cedar River Watershed is found in Eastern Iowa, spanning 1.5 million acres in ten counties (Figure 1). Iowa comprises eight other watersheds, but the Middle Cedar is one of the largest (Figure 2). The area includes the cities of Waterloo, Cedar Rapids, and Cedar Falls. The land found in this watershed is primarily gradual hills with an established stream network. Most of the land is farmed in row crops. The Middle Cedar River Watershed is a part of the

Megan Blauwet

Cedar River Basin, which runs into the Iowa River.

In 2017, a Middle Cedar watershed plan was created. The intent was to build a management plan for projects in the next twenty years to conserve the watershed and its surrounding environment. The Iowa Nutrient Reduction Strategy classifies the Middle Cedar watershed as a priority. Funds from surrounding businesses and cities have allowed the watershed to start on projects to greatly improve their water quality.

Constructing wetlands or ponds is one of the ways local farmers can improve their watersheds. Ponds and wetlands help control erosion and the effects of flooding. Sediment runoff is greatly reduced along with nutrient removal. Grass waterways, terraces, and buffers can also be implemented to help with the impacts of erosion. The edges of the fields can be stabilized, which prevents further erosion into fields. All of these practices can be put into place with the collaboration of the farmers, landowners, and the IWA.

Implementing ponds and wetlands comes with challenges, as some landowners do not realize the large footprint the ponds or wetlands will take up. Farmers are often not willing to give up time, space, and money for these projects. In a year such as this one, not all farmers have the money available to create these ponds or wetlands on their land. Land values are high, so losing some of that to these projects is a financial burden that not everyone can take on. However, the Iowa Watershed Approach supplies 90% of the funds for these practices and asks that the farmers contribute the other 10%. This is only possible through collaborations with universities, non-profits, agencies, and municipalities.

The IWA has $9 million to spend in three years but needs willing participants to use that money. Getting information to prospective participants is hard, especially in COVID times. Site tours are no longer an option and are now replaced by virtual tours. Meeting with landowners and spreading awareness throughout the community remains a challenge.

Implementation involves working with the local people and community. The watershed involves both rural and urban. Reaching out to communities and keeping people educated on what is going on in their watershed is important. Success stories will be shared to encourage more people to participate in the Middle Cedar projects. Although it takes time for these projects to show their worth, they prove to be helpful to the watershed and environment.

The ponds and wetlands that have already been implemented show great success. One single pond can remove around 3,000 pounds of nitrate a year. A wetland can remove around 50,000 pounds. The water quality benefits are significant and help show that the ponds and wetlands are working well. These nature areas also provide secondary benefits such as hunting, fishing, and public access to lands. Once these projects are installed, the long-term benefits far outweigh the short-term costs.

To find more information, you can visit the Iowa Watershed Approach website. The Middle Cedar River Watershed is one of nine watersheds in Iowa. Information on the other watersheds is also found on the IWA website at https://iowawatershedapproach.org/. As many of the watershed's projects are newly implemented, there is much more success to come.

Fig. 2

Fig. 1. The Middle Cedar Watershed is located in Eastern Iowa and comprises 1.5 million acres. The blue areas represent where projects are planned to take place. You can see the larger cities of Cedar Rapids, Waterloo, and Cedar Falls location in this watershed (Iowa Watershed Approach).

Fig. 2. Map of the watersheds in Iowa classified by the IWP and IWA. The Middle Cedar Watershed is found in east-central Iowa (Iowa Watershed Approach).

Fig. 1

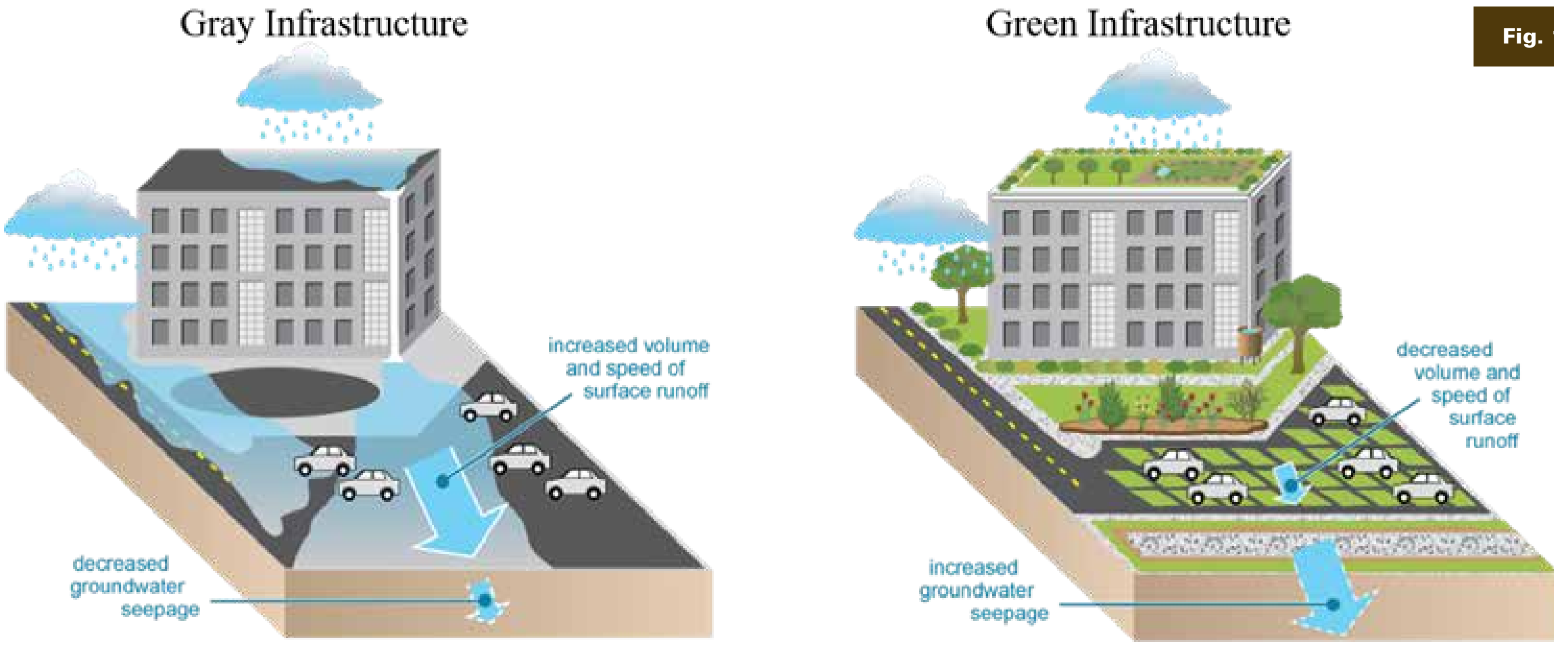
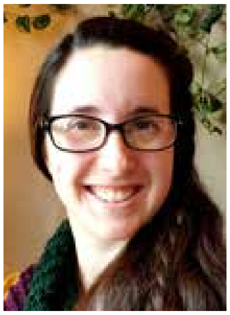


Image Source: Jane Hawkey, Integration and Application Network, University of Maryland Center for Environmental Science (ian.umces.edu/imagelibrary/).

When Stormwater Goes Green

By Breanna Marmur
Ph.D. Candidate, Department of Natural Resource Ecology and Management, Iowa State University



Breanna Marmur

Although Iowa is typically seen as a rural state due to its predominantly agricultural landscape, 64% of Iowa's population actually lives in cities (Iowa Community Indicators Program, 2020). Iowa's many cities and towns play an important role in our state's economy and the lives of nearly all Iowans. However, just as the fields and pastures that spread across our landscape present unique challenges for water quality and aquatic ecosystems, so do urban areas.

Cities and towns, covering a relatively small amount of Iowa's total land area, nonetheless generate large amounts of stormwater runoff during rain events. Impervious surfaces such as roads, parking lots, roofs, and driveways do not allow runoff to soak into the soil, disrupting the natural water cycle. Excess runoff can cause dangerous flash flooding during and immediately after storm events and can lead to damaging large-scale flooding during rainy seasons.

Urban activities also result in pollutants accumulating on impervious surfaces from fuel leaks, motor oil spills, road salt use, domesticated animals, fertilizers and pesticides, and general wear and tear on our vehicles and buildings (Müller et al., 2020). These pollutants are picked up by stormwater when it rains or when snow melts. In most towns in Iowa, the stormwater is not treated before it is discharged, resulting in polluted stormwater being discharged into local rivers and lakes. This leads to contamination, reduced water quality, and can cause harmful algal blooms.

Fortunately, there is a lot we can do to mitigate the negative effects cities have on our water resources. Cities are adopting green infrastructure approaches to stormwater management - approaches that focus on restoring and protecting the natural water cycle in cities (U.S. EPA, 2020). Unlike traditional gray infrastructure such as storm drains and concrete channels, green infrastructure uses vegetation and natural landscape features to reduce and treat stormwater (Figure 1). Green infrastructure helps to reconnect precipitation to the soil by directing runoff away from impervious surfaces and onto vegetated areas. This allows water to infiltrate and pollutants to be captured and filtered in the soil, resulting in less stormwater runoff and improved surface water quality.

Stormwater best management practices (BMPs) are a type of green infrastructure that can range from large detention basins storing great volumes of stormwater during rain events to small rain gardens designed to capture runoff from a single building or parking lot. Other BMP examples include permeable pavements, bioretention cells, rain barrels, soil quality restoration, native landscaping, as well as non-structural practices such as street sweeping or changing lawn care practices to reduce fertilizer use. The wide range of types, sizes, and appearances of BMPs make them well suited for adoption throughout the urban landscape, including their potential for use in industrial, commercial, and residential

Fig. 2

areas. This is crucial because many recent studies have shown that these practices work best when they are widely distributed throughout the landscape (Loperfido et al., 2014). As an example, the watershed surrounding Easter Lake in Des Moines, Iowa was the focus of a recent multimillion-dollar lake and watershed restoration to improve water quality and reduce stormwater runoff into the lake (Easter Lake Watershed Project, 2020). Over the past five years, hundreds of stormwater BMPs have been installed throughout the Easter Lake watershed on city land, around local businesses, and on private residential properties. These practices together can reduce stormwater volumes and limit the quantity of transported pollutants, protecting the valuable recreational, aesthetic, and ecological benefits Easter Lake provides to Iowans and the environment.

Green infrastructure can provide benefits beyond stormwater management alone, since green space can help reduce air pollution and the urban heat island effect, and several of the practices can also provide habitat for pollinators, birds, and other species. In many cases, BMPs are aesthetically pleasing in the form of beautiful gardens or healthy turfgrass lawns (Figure 2).

As an urban water scientist, my work involves monitoring and modeling urban stormwater BMPs, as well as working with homeowners and watershed restoration project coordinators to encourage the adoption of BMPs throughout urban areas (Figure 3). Issues related to urban stormwater are complex and involve hydrology and urban ecology in addition to economics, sociology, water policy, and regulatory dimensions. Stormwater management involves numerous stakeholders and partners, such as city officials, engineers, watershed coordinators, local residents, and commercial business owners. Everyone has a role to play, and their efforts can help protect water quality and local aquatic ecosystems through stormwater management.

Fig. 3

Fig. 1. Gray infrastructure (left) relies on impervious surfaces such as concrete channels and storm drains to quickly direct stormwater off of surfaces and into rivers and lakes. Green infrastructure (right) uses vegetation to reconnect precipitation with the soil, slowing the flow and reducing the volume of runoff.

Fig. 2. Stormwater Best Management Practices (BMPs) can have benefits beyond stormwater management, including providing aesthetic interest in the landscape. (a) Rain gardens with flowering vegetation add beauty to the landscape while also providing habitat for pollinators; (b) soil quality restorations can promote healthier looking turf and more drought resistant lawns.

Fig. 3. Marmur processes a stormwater sample for later lab analysis. Automated samplers installed in storm drains allow continuous monitoring of stormwater flow and sample collection during storm events. Monitoring in watersheds with BMPs allows a better understanding of their effects on stormwater runoff volume and pollutant levels.

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Fig. 1

Understanding Iowa Farmers' Perceptions of the Iowa Nutrient Reduction Strategy

By Laurie Nowatzke
Measurement Coordinator for the Iowa Nutrient Reduction Strategy

Laurie Nowatzke

Row crop farmers in Iowa are working with public agencies, university extension, agribusiness organizations, and on-farm research organizations to address the excess levels of nitrogen and phosphorus that are being lost from farm fields. These nutrients drive local water quality degradation and contribute to hypoxic conditions downstream in the Gulf of Mexico. In 2013, Iowa established the Iowa Nutrient Reduction Strategy (INRS), a framework that, in part, supports farmers in voluntarily adopting conservation practices to mitigate nutrient loss (Iowa Department of Agriculture and Land Stewardship et al., 2017).

Past research in rural sociology and natural resource management has focused on understanding the factors that contribute to conservation behavior in agriculture. Several studies provide evidence that awareness of environmental issues and positive attitudes toward conservation are necessary—but not always sufficient—for conservation action (Prokopy et al., 2019). The INRS Farmer Survey was conducted from 2015 to 2019 with 6,006 landowners who each farmed at least 150 acres of row crops. This survey aimed to understand farmers' attitudes, knowledge, and perceptions toward water quality and nutrient reduction in Iowa.

Understanding patterns in farmers' attitudes toward nutrient reduction is a key component of this survey. The survey asks farmers to indicate their level of agreement with statements ranging from awareness of nutrient issues and concern about impacts to support for conservation action on farms. The percentages of farmers who agree with these statements vary somewhat depending on the region within Iowa (figure 1). Of the respondents in the Missouri-Little Sioux (MLS) watershed, located in the northwest region of the state, 44 percent agreed or strongly agreed that "nutrients from Iowa farms contribute to water quality problems in the Gulf of Mexico" (figure 2). Forty-one percent were uncertain, and 15 percent disagreed or strongly disagreed. At 84 percent, a large percentage of farmers in this northwest region of Iowa agreed that they were "concerned about agriculture's impacts on Iowa's water quality." They reported moderate levels of support for action. Seventy-seven percent agree that they would "like to improve conservation practices on the land I farm to help meet the Nutrient Reduction Strategy's goals," and 45 percent agreed that they would "be willing to have someone help me evaluate how my farm operation is doing in terms of keeping nutrients out of waterways."

In the Des Moines (DM) watershed, primarily located across central and north-central regions of the state, 49 percent of farmers indicated awareness about the impacts of farms on the Gulf's water quality, and 82 percent agreed that they were concerned about impacts on Iowa's water quality. Their support for action was similar to that of farmers in northwest Iowa. Seventy-four percent agreed that they would like to improve their conservation practices, and 44 percent were willing to receive help evaluating their nutrient reduction efforts (figure 2).

Farmers in the Upper Mississippi-Maquoketa-Plum (UMMP) watershed in northeast Iowa reported higher levels of awareness of agriculture's impacts on the Gulf of Mexico, with 54 percent agreeing that nutrients from Iowa farms contribute to water quality problems downstream (figure 2).

Farmers' attitudes toward nutrient reduction have implications for conservation efforts in Iowa. Using data from the INRS Farmer Survey, researchers at Iowa State University (ISU) found that farmers who reported more positive attitudes toward nutrient reduction action were 28 percent more likely to have adopted cover crops (Lee et al., 2018). ISU researchers also aim to examine how these attitudes change over time; preliminary results of a subsample of repeat respondents suggest that attitudes change gradually over the course of three or more years.

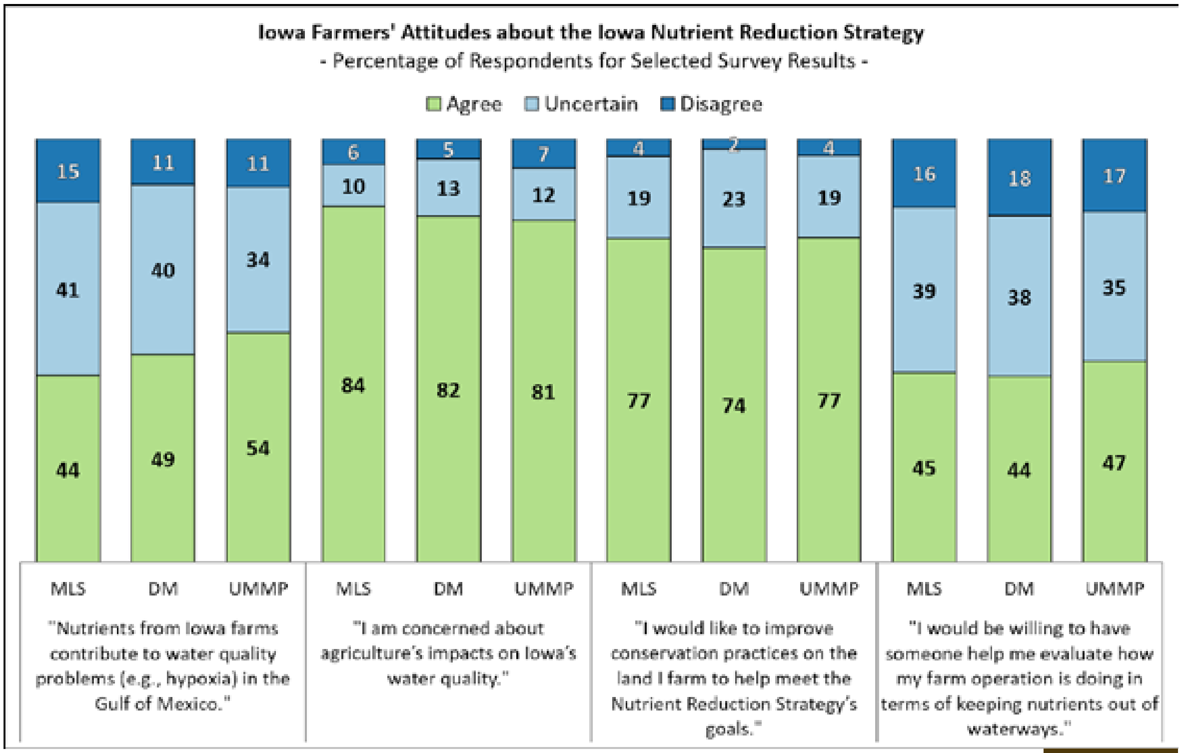

Fig. 2

These findings contribute to our understanding of how individuals' attitudes and perceptions toward soil and water resources management might affect conservation efforts in Iowa. To learn more about findings from this survey for each watershed, visit www.nutrientstrategy.iastate.edu/documents.

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Fig. 1. Iowa map displaying the locations of the Missouri-Little Sioux, Des Moines, and Upper Mississippi-Maquoketa-Plum watersheds. Survey respondents for these selected survey results were located in these three watersheds.

Fig. 2. Percentage of farmers who agreed with, were uncertain about, or disagreed with statements related to the Iowa Nutrient Reduction Strategy. The respondents for this selection of results were located in the Missouri-Little Sioux (MLS) watershed, the Des Moines (DM) watershed, and the Upper Mississippi-Maquoketa-Plum (UMMP) watershed.

Water and Drainage Laws in Iowa and How They Affect Farmers and Homeowners

By Evelyn Platner
Iowa State University Agronomy Student

Homeowners and farmers alike are aware of the problems that arise when Iowa's spring and summer months bring an excess of rain. Water goes where it pleases and is rarely redirected unless it falls in a developed urban setting. It is considered a valued resource with both cities and agricultural projects vying for control. This raises the question: "Who is to blame when water goes awry, and who has the right to water during droughts?" Iowa's complex yet concise Water and Drainage Laws help landowners determine who is responsible for rerouting water as well as who is given priority during times of water scarcity. .

According to Neil Hamilton, Emeritus Professor of Law at Drake University, Iowa's modern water drainage laws have been around since the mid-1950s. Iowa established these laws to combat disputes between landowners and neighbors regarding water drainage routes and volumes. Hamilton mentions that there are a few principles to recognize when studying Iowa's drainage laws. The first principle resolves downhill drainage disputes. Iowa Law states that an estate located uphill, or dominant estate, cannot be penalized if natural water runoff enters their downhill neighbor's property. The dominant estate has a right to allow water to naturally drain into a neighbor's property, even at the downhill neighbor's expense. The second principle states that the estate located downhill, or servient estate, "has a duty or obligation to accept the water" under reasonable circumstances (Hamilton). If the water flows naturally in that direction, the servient estate cannot force the dominant estate to reroute the water flow. Iowa Law also states that the servient estate cannot build barriers to force the water back onto the dominant estate's property. However, if the dominant estate takes unreasonable measures to redirect water and increase the volume flow onto the servient neighbor's property, it may become illegal. Although there is not much the servient estate can legally do to prevent natural water from entering their property, they can enter agreements with the dominant estate regarding water

Evelyn Platner

control. These can be legally binding contracts that affect future owners. Iowa's drainage laws also contain many other different principles regarding unique and specific circumstances surrounding drainage disputes.


Neil D. Hamilton

Over a century ago, the Iowa legislature created an operating branch of government referred to as Drainage Districts. This is a collection of legally overseen projects designed to assist drainage on farmland across Iowa. They were originally created to maintain the state's flatter regions where there are no natural drainage paths formed. This sector of Iowa's government is legally allowed to enter farm property to assess drainage situations and construct, if needed, drainage systems and watersheds. The Drainage District maintains the artificial systems and has the "authority to levy assessments against the properties benefitted by the drainage in proportion to the benefits the landowner receives" (Hamilton). With this system in place, Iowa's farm productivity was able to increase in places where drainage was a key issue.

Neil Hamilton also touched on the importance of Water Rights. These laws determine who is allowed to draw water from public or private bodies. Iowa Law does "require permits to use water, but the permit requirement only applies to those using more than 25,000 gallons a day" or users with unique circumstances. Those who own a body of water on private property are allowed to draw water without requiring a permit from the DNR. This exception allows farmers to tile and drain their fields and allows landowners with streams or ponds to use the water flowing through. There is also a special section in Iowa's Water Laws that determines who has the priority to water if there is a drought. Section §455B.266, also known as the priority allocation, dictates that the "highest priorities are given to human consumption and to maintaining livestock" while the lowest priorities go to irrigation and recreational purposes. However, during a drought, the Iowa DNR is able to restrict water permits to help preserve the resource.

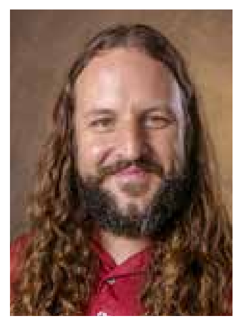
Iowa's lawmakers have set up a comprehensive and concise set of laws to help guide Iowans through water disputes. Trying to contain one of Iowa's major natural forces is a feat in and of itself, but with help from the DNR and Drainage Districts, the state has been helping farmers and landowners for decades.

Disclaimer: All information gathered and represented in this article reflects the original works of professor Neil D. Hamilton, who teaches and specializes in agricultural law at Drake University in Des Moines, Iowa.

Fig. 1

A Precision Method for Meeting Natural Resource Goals

By Chris Morris
Graduate Research Assistant in Rural Sociology and Sustainable Agriculture, Iowa State University



Chris Morris

The state of Iowa is a national leader in the production of a handful of important agriculture products including corn, soybeans, eggs, and hogs. Our state primarily owes this agronomic and economic success to its inherent wealth of natural resources. Iowa is home to some of the most naturally fertile soil in the entire world, as well as a favorable climate with abundant water resources, which makes it an ideal location for growing agricultural commodities. Ironically, this incredibly high level of agricultural production has come at the unfortunately high cost of the state's natural resources becoming impaired. Half the topsoil in Iowa has been lost to erosion from agricultural tillage in just 150 years—soil that took thousands of years to form under the prairie grasslands that once dominated the state's landscape. Thousands of private wells and over half of Iowa's streams, rivers, and lakes have been designated as impaired due to the presence of agricultural chemicals and bacteria in water running off from the state's vast amounts of farmland and concentrated animal feeding operations. Additionally, fertilizer runoff from Iowa is a leading contributor to the Gulf of Mexico's hypoxic zone, an area the size of New Jersey at the mouth of the Mississippi River that has become so impaired from the Midwest's upstream runoff that aquatic animals cannot survive within it.

Fortunately, research conducted over the past century has identified conservation practices—such as no-till farming, terraces, constructed wetlands, grassed waterways, riparian buffers, and prairie strips—that farmers can adopt on their agricultural lands to help protect natural resources such as soil and water from being degraded. While such practices can be incredibly effective if incorporated properly, they can also be difficult and expensive for farmers to install. For that reason, federal and state governmental agencies have developed programs that provide financial and technical assistance to farmers to help them install conservation practices. While such programs have been effective at making some progress in getting conservation practices on the ground, Iowa is still far short of meeting its conservation goals, such as those recommended by the Iowa Nutrient Reduction Strategy. One reason is that, because these programs are strictly voluntary, not all farmers approach conservation agencies to participate in such programs. Relying on farmers to voluntarily ask for assistance has been termed the

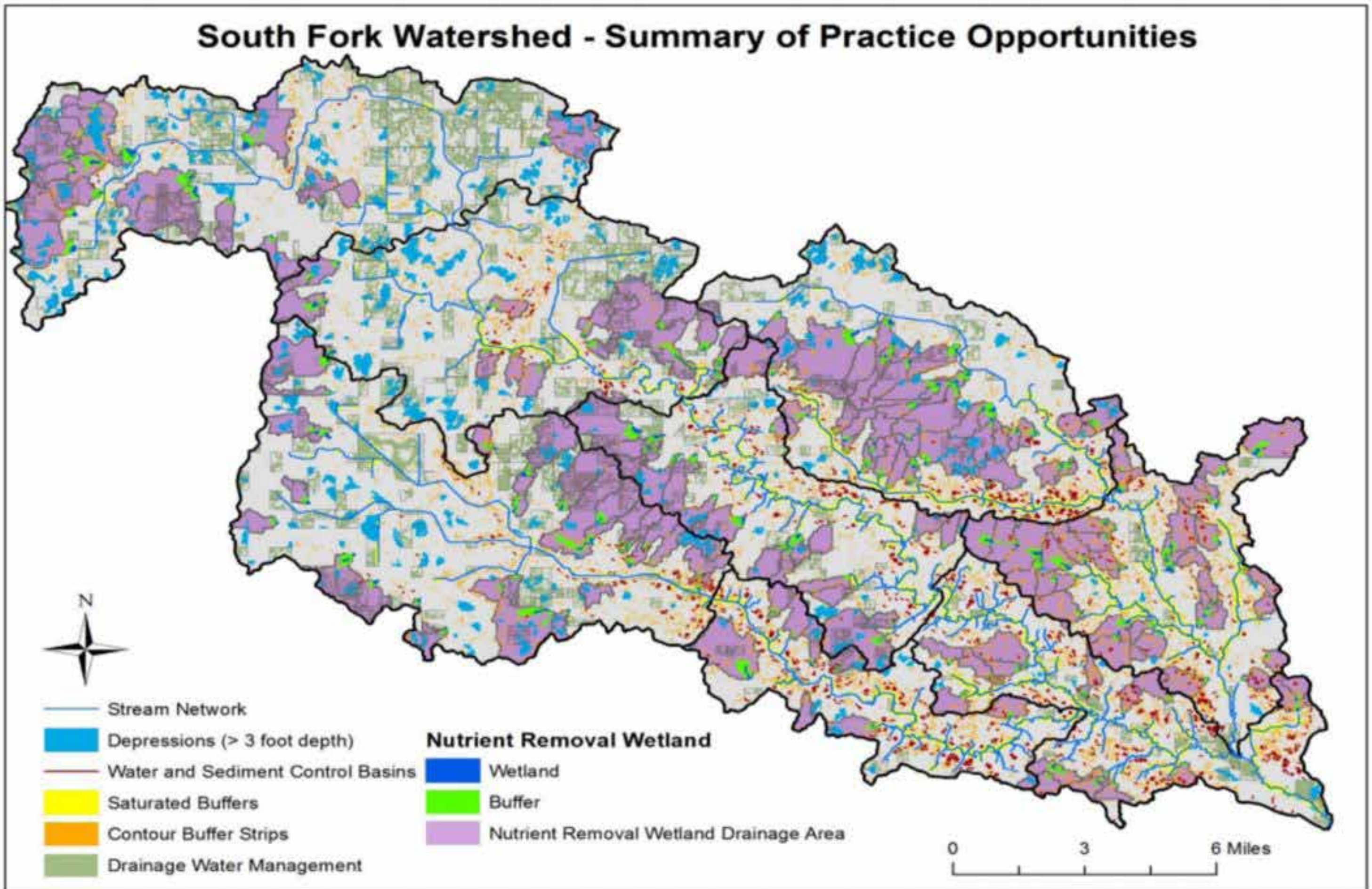


Fig. 2

"shotgun approach" to conservation, which means that areas on the landscape that have the greatest need for conservation practices may not necessarily get treated.

One solution that has been proposed for this dilemma is known as "precision conservation" or "targeted conservation." This approach uses GIS mapping software (like the Agricultural Conservation Planning Framework, or ACPF) to analyze soils, topography, and hydrologic data to identify Critical Source Areas (CSAs)—impaired locations within a watershed that would potentially have the greatest positive impact on overall water quality if recommended conservation practices were installed there. Farmers and/or landowners who manage the land where these CSAs are located are then contacted by conservation agency personnel and are asked for the opportunity to meet to discuss the issue. The location of the CSA and the need for conservation work is then verified in the field, and the conservation professional makes an offer to provide technical assistance to the farmer as part of a conservation plan to install conservation practices to address the need, like planting a riparian buffer to limit streambank erosion.

If this process is successful, targeted conservation results in conservation practices applied to areas that might not have otherwise been treated. Even more importantly, these practices are applied in areas within a watershed that need it the most, meaning that limited conservation agency resources of time, labor, and money are spent addressing CSAs that have the highest potential to make the largest impact on improving natural resources on the landscape. Of course, the success of such an approach depends on how willing farmers are to participate after being contacted. Recent research I conducted with colleagues at Iowa State University has found that the majority of farmers surveyed in Iowa generally support the idea of targeted conservation. Our findings also suggest that this approach would have the greatest chances of success if conservation professionals 1) addressed farmer concerns about the use of data gathered on their land, 2) adhered to a non-regulatory approach, 3) maintained farmer autonomy through a collaborative decision-making process, 4) discussed the planning process face-to-face with farmers in the field, and 5) offered financial incentives to help pay for the suggested practices.

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Fig. 1. Untreated gully erosion in a Critical Source Area (left) versus erosion treated with a grassed waterway (right). Photos courtesy of USDA Natural Resources Conservation Service.

Fig. 2. Example of targeted conservation output map from the Agricultural Conservation Planning Framework with identified Critical Source Areas and suggested conservation practices. Photo courtesy of Iowa Water Center.

Fig. 1

Using Creek Signs to Build Awareness of Creeks, Lakes, and Watersheds in Iowa

By Steve Hopkins
Nonpoint Source Coordinator, Iowa Department of Natural Resources

Iowa's Nonpoint Source Management Plan calls for developing and implementing a statewide campaign to inform people about water quality issues. However, social science survey data show that many Iowans are not even aware of the name of their local creek, much less be familiar with the water quality issues of their creeks, streams, and lakes. Until citizens become aware of and take ownership of their local waters, little progress can be made to improve them..

To build awareness of creeks and watersheds in Iowa, the Iowa Department of Natural Resources (DNR) Watershed Improvement program—which administers Clean Water Act Section 319 grant funding from the U.S. Environmental Protection Agency--has partnered with the Iowa Department of Transportation (DOT) to install new creek signs at federal and state highway creek bridges within priority watershed projects areas. (DOT's normal policy is to install river signs, but not creek signs, as part of its signage at highway bridges.)

Through the DNR's "Stream Sign Initiative", which began in 2014, DNR provides funding to the DOT to install creek signs at highway creek bridges in priority watersheds across Iowa. To date, seven phases of DNR/DOT creek sign projects have been completed, with 533 signs installed. An additional phase will be completed in 2021, when 100 more new creek signs will be installed. When combined with creek sign initiatives led by other groups, there have been more than 1,200 new creek signs installed across Iowa over the past 7 years.

Steve Hopkins

DNR Section 319-funded watershed

"...the ultimate intent of new creek, lake, and watershed signs is not only to build awareness but to motivate citizens to adopt water quality actions on their own."

projects have also worked with cities and counties to install creek signs at bridges on city and county roads in their watersheds to raise awareness of the creek or lake the project is striving to restore. Through these watershed projects, new creek signs have been installed on county roads in Black Hawk, Henry, Lucas, Polk, and Winneshiek Counties, and on city roads in the Cities of Des Moines and Clive. Watershed project coordinators report that feedback from citizens who see the new creek signs in their watersheds have been very positive.

DNR has also begun to work with local road authorities to install additional signs identifying creeks that are the source of a lake--especially in cases where the lake has a different name than the creek that flows into it--to make people aware that the water quality of the creek affects the water quality of the lake downstream.

The first known example of a combined creek/lake sign was installed by Henry County in 2018, paid for by the 319-funded Lake Geode Watershed Project, when two signs were installed—one sign saying "Cedar Creek" and below it a separate sign saying "Source of Lake Geode". Similar combined creek/lake signs have been installed through other 319 watershed projects, including: "Yeader Creek: Source of Easter Lake", funded by the Easter Lake Watershed Project and installed by the City of Des Moines, and "Chariton River: Source of Rathbun Lake", funded by the Rathbun Lake Watershed Project and installed by the Lucas County Engineer's Office.

DNR Section 319-funded watershed projects have also worked with local officials to install watershed signs, to raise awareness of their watershed. For example, in the fall of 2020, a new sign saying "Entering Dry Run Creek Watershed" was installed by the Black Hawk County Engineer's Office and funded by the Dry Run Creek Watershed Project, and two news signs saying "Entering Yellow River Watershed" were installed by the Winneshiek County Engineer's Office and funded by the Yellow River Headwaters Watershed Project.

DNR is planning to study the effectiveness of the new signs. Beginning in 2021, DNR will fund a new Iowa State University social science research project to assess the impact of creek, lake, and watershed signs on citizen awareness of their local waters and watersheds, as well as the impact of signs on citizens' willingness to take actions on their own land to improve water quality.

Since Iowa spends tens of millions of dollars annually to restore impaired streams, rivers, and lakes, the ultimate intent of new creek, lake, and watershed signs is not only to build awareness but to motivate citizens to adopt water quality actions on their own.

Soil and Water Conservation Communication in the Age of COVID-19

Madison McDermott
Undergraduate in Agricultural Engineering Land and Water, Iowa State University

Madison McDermott

Soil, water, COVID-19, and hardworking people. What do these have in common? Primarily, these are reasons why agricultural workplaces across the Midwest can adapt to the new normal we face today. Throughout the past year, COVID-19 and the need for agricultural practices have forced workplaces to innovate and adapt. One aspect of agricultural workplaces that have specifically been put to the test during the pandemic is communication..

Julie Reberg, a District Conservationist with the National Resource Conservation Service (NRCS) located in Wright County, Minnesota, said, "Covid has forced everybody to think outside of the box in order to keep moving forward." Some examples of changes that have been put into effect at local NRCS offices include scheduled appointments for customers and using Microsoft Teams as a communication tool. While the NRCS has had to modify how work gets done and how their employees communicate, Reberg assures that "Nothing has changed regarding the mission." Reberg describes her peers as "dedicated." Despite the face-to-face communication challenges COVID-19 has created, the NRCS is still dedicated to assisting farmers and landowners in their conservation practices.

Maggie Norton, the Farmer Outreach Coordinator with Practical Farmers of Iowa (PFI), stated while discussing communication, "If there is an online form of communication, we are using it right now in some way, shape, or form." PFI is making every attempt to reach its audiences, and it has been paying off. Norton said, "We have reached new audiences being online," which is impressive considering the communication challenges COVID-19 brings. Converting in-person events to virtual events and continuing to connect farmers with opportunities to tell their stories have been some of Norton's main tasks. The platforms PFI utilizes to communicate and maintain a connection with their members, staff, and the wider community include Zoom meetings, Google Meets, hosting virtual field days on Facebook, producing informational movies, online webinars, and many more.

Elizabeth Ripley, the Conservation and Cover Crop Outreach Specialist with Water Rocks! and Iowa Learning Farms (ILF) through Iowa State University, works to implement conservation practices for all ages across Iowa. "Trying to instill a sense of conservation and an appreciation for natural resources can go a long way in the future," said Ripley about the importance of outreach on the future of conservation. Through ILF's COVID-19 journey, they have learned the most efficient outreach tools for their desired audience. This includes using Zoom for virtual field days and weekly webinars, YouTube Live for Water Rocks! streaming, email, and Slack for internal communication. They have also started archiving their videos, which has resulted in an increased number of views.

Courtney Allen, the Event and Professional Development Director/ Executive Assistant to the CEO with the Soil and Water Conservation Society (SWCS) out of Iowa commented, "Our attendance doubled this year" when referring to SWCS's Annual Conference, which was hosted virtually for the first time this past year. Another positive Allen

Julie Reberg

Maggie Norton

Elizabeth Ripley

Courtney Allen

Susan Kozak

mentioned was the experience of their 2020 summer intern. Since the position was completely virtual, Allen was the intern's main contact and developmental mentor. Although SWCS was uncertain about how the intern's experience would land due to COVID-19's challenges, they have been reassured by his positive feedback of their efforts to continue the program in 2021. Innovatively, SWCS is still prioritizing serving and providing professional development for its members.

Susan Kozak, the Soil Conservation and Water Quality Division Director with the Iowa Department of Agriculture and Land Stewardship (IDALS) reported, "We have seen record numbers for conservation practices" when asked about IDALS comparison to previous years. IDALS has found teleworking to be successful and believes they were able to reach more landowners because of it. Another improvement IDALS has made due to COVID-19 that Kozak finds "just as good in certain instances" is electronic signatures. This saves time and ultimately creates more opportunities for her employees to be more productive stewards of the land. The strength of communication and community IDALS has built over many years is prospering now more than ever before, which is a rare occurrence in 2020.

COVID-19 has brought hardship globally, but for local conservation associated workplaces, it has created growth. COVID-19 creates limitations to informal interactions in the workplace, affecting in-person events, networking, and work/life balance for employees. However, it does not reduce the creativity of conservationists and their communication skills. Knowingly, these conservationists have accepted the new normal and embraced its challenges for the greater good of the environment we share.

"Knowingly, these conservationists have accepted the new normal and embraced its challenges for the greater good of the environment we share."

So Flows Knowledge From Water and Dreams From Streams

By Missy Rose
2020 Iowa Water Center Spirit of Water Essay Contest Winner

This creative writing essay was the winner of the Iowa Water Center 2020 Spirit of the Water Essay Contest.

Although Iowa is typically seen as a rural state due to its predominantly agricultural landscape, 64% of Iowa's population actually lives in cities (Iowa Community Indicators Program, 2020). Iowa's many cities and towns play an important role in our state's economy and the lives of nearly all Iowans. However, just as the fields and pastures that spread across our landscape present unique challenges for water quality and aquatic ecosystems, so do urban areas.

Churning, gurgling, racing water dances at my side. Foam bursts in a frothy ballroom dance across endless deep blue water, pounding back and forth, in swirls and lines, jumping around the river. Here I witness the return of a stream from a winter's frozen fingered sleep. The water awakens with a surge, melting rapidly to become rapids. Rushing across Iowa, freezing cold water breathes new life into a quivering ecosystem. As spring encompasses the land, so return the animals from their slumber. Sluggish trout and walleye warm up to pace; squirrels emerge from hidey holes in trees; robins line the skies in their flights home. With the warmth, with the water, I watch the world awaken.

I adore this river. I've watched it grow, adapt, and change in my years, cutting through hills and valleys, eroding the land to form a new picture. Racing waters of this river in the past have seen me learn to play, dare to dream, and grow into myself. Like Tom Sawyer and Huck Finn, I built stick shelters and big dreams. My mind swirled with the waters, and I danced with the stream. With friends I raced flowers, any dandelion or violet we could find, down the river. We met deer and befriended squirrels. These waters have taught me a great deal about life--and not just childhood wonder or wisened thoughts. These waters have taught me about them, about their power, water's power.

Water is an essential building block of life; science tells me this. I remember; I learned. With water, life follows, until it saturates fields and towns. Science states: water is an essential building block of life; but it forgets to mention that water can also destroy life.

In 2008, Cedar Rapids, Iowa faced devastating flooding. Muddied brown water surged through the city--my city--carrying with it waste, parts of buildings and houses, garbage, and sickness. And when those waters left, when the tides fell, destruction was all that was left for us--destruction and respect. Water, we had learned, is unpredictable, a force of its own, and it

takes in everything in its path. We gained an awed sort of respect following the disaster, but we did not fully respect water until we realized, while it holds great power, we can hurt it too. Pollution has run through this stream before. Runoff from fields and hills, chemicals and human waste have littered its waters. I try not to remember such times, not with a future so bright. We have laws now, and rules. Our practices have improved. Farmers plant cover crops in an effort to reduce runoff, and they use sustainable farming practices to retain the beauty of our river. Strict fines accompany polluters. We want the magic of our water, of our river, to last.

Missy Rose

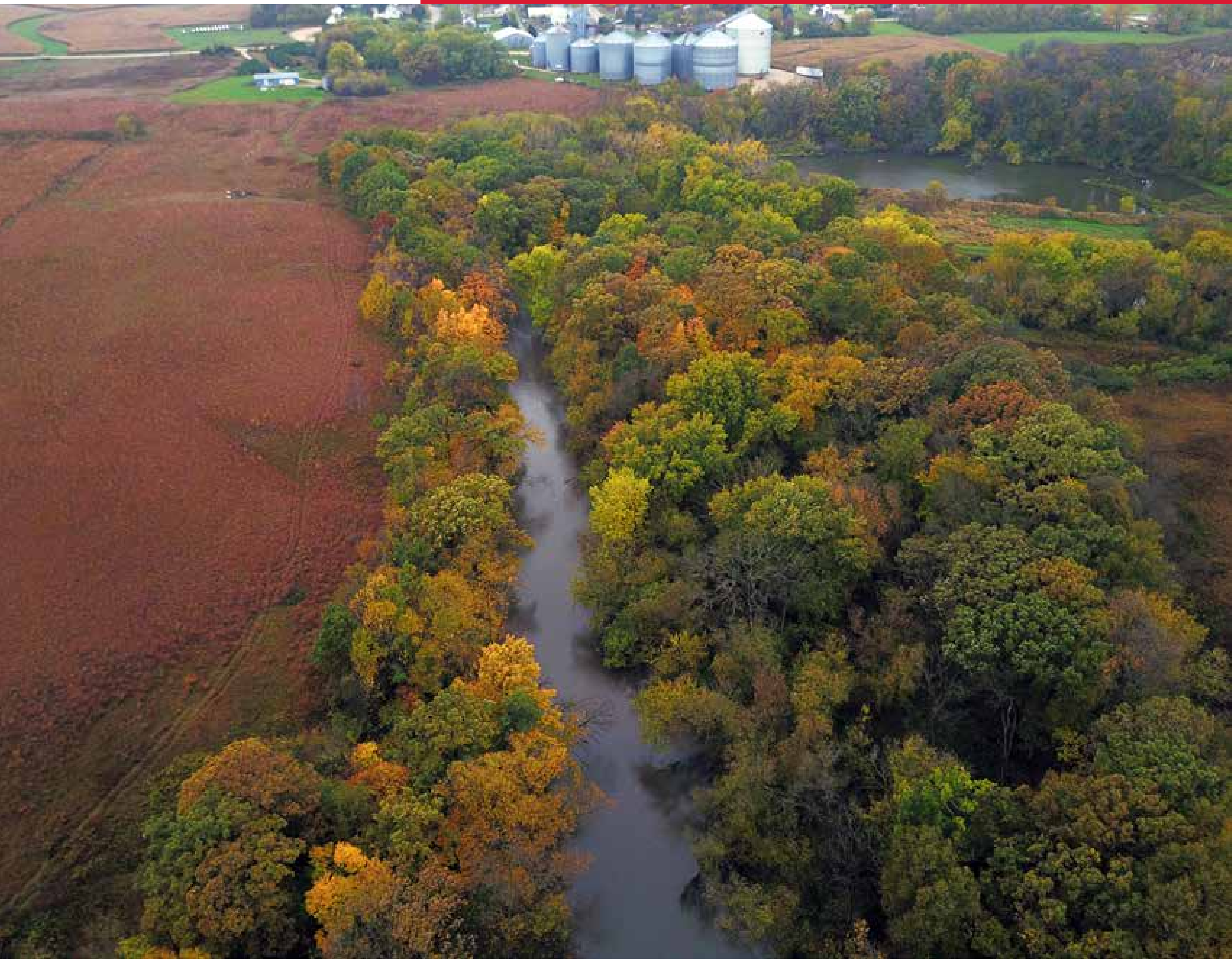
I could write stories about the millions of ways we use this river. Downstream a few miles is a dam we use to power our town and control the raging waters. Beneath my feet groundwater streams are fed by the revived river. Upstream is a spot the fishermen share with the canoers. Downstream farmers use this river to irrigate their fields. And all along this river animals drink, live, and swim. All along this river animals thrive, kids play, and people work. It's a stream out of time, ever and endlessly loved.

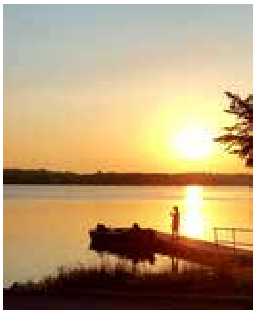
Churning, gurgling, rushing water--what a sight. I hope to see the world awaken in a dance of crashing waves and breaking ice, again and again, for the rest of my life, each time with mind and eyes anew.

"Water is an essential building block of life; science tells me this. I remember; I learned. With water, life follows, until it saturates fields and towns."

The photos at right are the winning entries from the Iowa Water Center 2020 Spirit of Water Photo Essay Contest.

CAN YOU PROVIDE THE WINNER NAMES SO WE CAN REGISNIZE THEM ALL HERE?





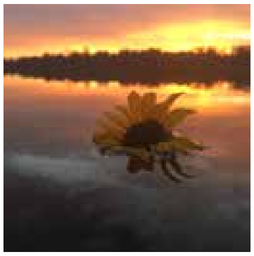


Fig. 1

The Impact of Levees After the Spring of 2019 Flooding in Southwest Iowa

By Rebekah Muench
TITLE

Rebekah Muench

Imagine you are a small farmer working hard to make sure you get a good crop. Now imagine extensive rain and snow-melt forcing levees in your area to falter and flood your farmland. Devastating, right? This may be one of the many feelings farmers, homeowners, and small businesses felt during March of 2019 in Southwest Iowa. The spring of 2019 was a spring to never be forgotten as over 280 miles of Southwest Iowa and Nebraska faced flooding due to levees becoming breached and broken. In an interview with Heidi Ackerman, current academic advisor of agronomy and previous Soil Conservationist for the NRCS, explained how levees, although man-made, are similar to natural floodwalls, in that they are used to help contain floods to a specific area. Levees are a vital part of flood control in the state of Iowa, and as the construction of them spreads, towns are experiencing a decline in flood-related disasters..

The spring of 2019 was detrimental to farmers because of flooding, but the breeches in the southern Iowa levee systems contributed to the damage rather than deterring it. As we saw along the Iowa-Nebraska border, levees cannot reroute all of the water during large rain events,

Fig. 2

which increases flooding and decreases activity in the natural flood plain. Levees contribute to the bulk of the water flow during heavy rainfall and reroute it quickly, although this process can reduce natural floodplain activity. Natural floodplains and the surrounding ecosystem are meant to hold water during floods without the help of other structures. When levees are constructed near a natural flood plain, they can starve the area of water and reduce its water holding capacity, as well as some of its biological activity. Levees may have their advantages in controlling where floodwaters go, but taking a more in-depth look into these systems shows that they can also have some drawbacks.

So, what was the impact of the levee breaches in 2019? The agricultural community suffered under these circumstances. Heidi Ackerman mentioned that not only did farmers in Southwest Iowa lose their crops from flooding, but large deposits of sand were left in the wake of the flood's path. After such extreme flood events, farmers may have to spend extra time tilling in the sand for a more balanced soil texture or may even have to scrape off the sand at their own expense.

Now you may be asking, who is responsible for fixing these levees? The U.S. Army Corps of Engineers has taken on these problems as their own in order to repair and provide support for these communities. According to Lowell Blankers, a project engineer working on the levees, the U.S. Army Corps of Engineers maintains control of levees put in place by the federal government as authorized by the Flood Control Act of 1944. Historically, the Act authorizes construction on public works of land to control floods, such as dams and levees.

Lowell Blankers stated that repairs to all the levee systems across the Iowa-Nebraska border are projected to be finished during the summer of 2021. With over 1200 members, including civilians, in the Omaha District of the U.S. Army Corps of Engineers, the future of Iowa's levee systems looks bright in the wake of last year's disaster.

Fig. 1. Flooded cropland in southwest Iowa after heavy rains. Photo courtesy of USDA Natural Resources Conservation Service.

Fig. 2. Sediment from a field fills a road ditch after intense flooding. Photo courtesy of USDA Natural Resources Conservation Service.

Fig. 1

Next-Generation Stream Monitoring with Smart Cameras

By Yusuf Sermet, Postdoctoral Researcher, IIHR – Hydroscience & Engineering, University of Iowa; and Ibrahim Demir, Assistant Professor, Civil and Environmental Engineering, University of Iowa

Water-related natural hazards, including flooding and droughts, caused over $350 billion in damage and killed over 3,500 people in the U.S. in the last 40 years (Smith, 2019). Water resources support hundreds of billions of dollars in commerce and provide safe drinking water, recreation, irrigation, power generation, and manufacturing. Reliable and real-time monitoring of water resources is critical for minimizing the loss of life and property from water-related hazards and effective management of water resources. There are 30 million stream reaches in the U.S. with an insufficient monitoring network of just 8,300 sensors (Marcarelli, 2019). Currently, in the United States, federal and state agencies are using stage sensors that cost from $3,000 to $15,000, with annual maintenance costs ranging from $1,000 to $15,000 (Hennigan, 2011). These expensive sensor prices cause a lack of critical data coverage, which is crucial to tackling vital issues like natural disaster mitigation, water resources management, and climate change. Furthermore, a report sponsored by the Federal Emergency Management Agency (FEMA) shows that for every $1 spent on

Yusuf Sermet

Ibrahim Demir

disaster mitigation efforts from federal grants, $6 are saved from disaster damages on average (Multihazard Mitigation

Council, 2018). Thus, the current state of water monitoring requires an immediate solution for low-cost and accurate water level measurement sensors.

At the University of Iowa Hydroinformatics Lab, we conduct cutting edge research on exploring novel computational techniques and approaches for environmental engineering applications. To address the scarcity of stream stage measurement points in the United States, we proposed a novel methodology for water level measurement in collaboration with the Iowa Flood Center. We introduced several mathematical approaches that utilize prevalent smartphone sensors (Demir and Sermet, 2020). The presented methodology creates a distinct opportunity for two innovative approaches for stage measurement: (1) a mobile application for smartphones and (2) a camera-equipped embedded system. As a citizen science practice, the public can use the mobile application to perform and share surveys (i.e. taking pictures of a river) to support environmental research and decision-making (Sermet et al., 2020). For continuous and reliable monitoring of selected sites, stand-alone water level measurement sensors comprised of low-cost camera-based single-board computers are utilized as a significantly low-cost alternative to existing systems.

To realize stand-alone camera-based stage sensors, we established designs using Raspberry Pi enhanced with different combinations of auxiliary hardware (e.g., camera, servomotor, inertial measurement unit, GPS receiver, battery, cell modem, solar panel) suitable for various use cases. The sensor is designed for installation on a structure with a direct view to a water body (e.g., river) whilst getting internet access via Wi-Fi or GSM modem and solar panel or electrical outlet to power the sensor (Figure 1). While our proposed methodology shows promising results in the simulated scenarios (Figure 2), on-site experimentation is needed to assess the error margins brought by the environmental conditions and visibility. In support of this cause, we received a grant from the Iowa Water Center to prototype several configurations and perform a case study. Though this is an ongoing experiment, the preliminary results suggest that the proposed low-cost camera-based sensor provides consistent measurements for points of interest (POI) that are at most 120 meters away from the sensor.

On-site availability of internet-enabled and camera-equipped devices with high computational power opens up a plethora of opportunities for future enhancements and alternative applications. In addition to the water level measurement, the presence of the camera enables further monitoring scenarios such as recognizing objects (e.g., debris, trees, humans, boats) on the water surface using deep learning and supplying annotated data for use in hydrological processes, including surface water modeling, streamflow estimation, and flood prediction (Sit et al., 2020).

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Though this is an ongoing experiment, the preliminary results suggest that the proposed low-cost camera-based sensor provides consistent measurements for points of interest (POI) that are at most 120 meters away from the sensor.

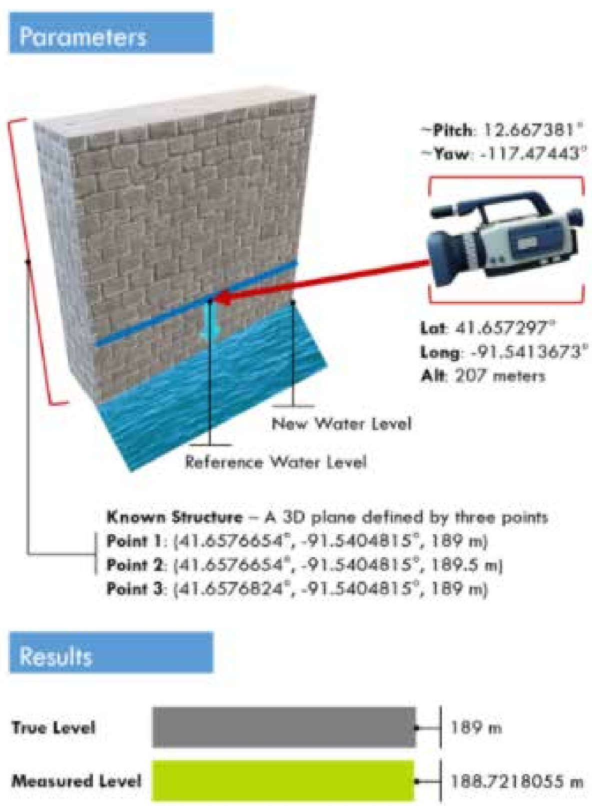

Fig. 2

Fig. 1. The simulation setup for camera-based measurements showing the sensor location and the point of interest.

Fig. 2. Preliminary results based on computer simulation.

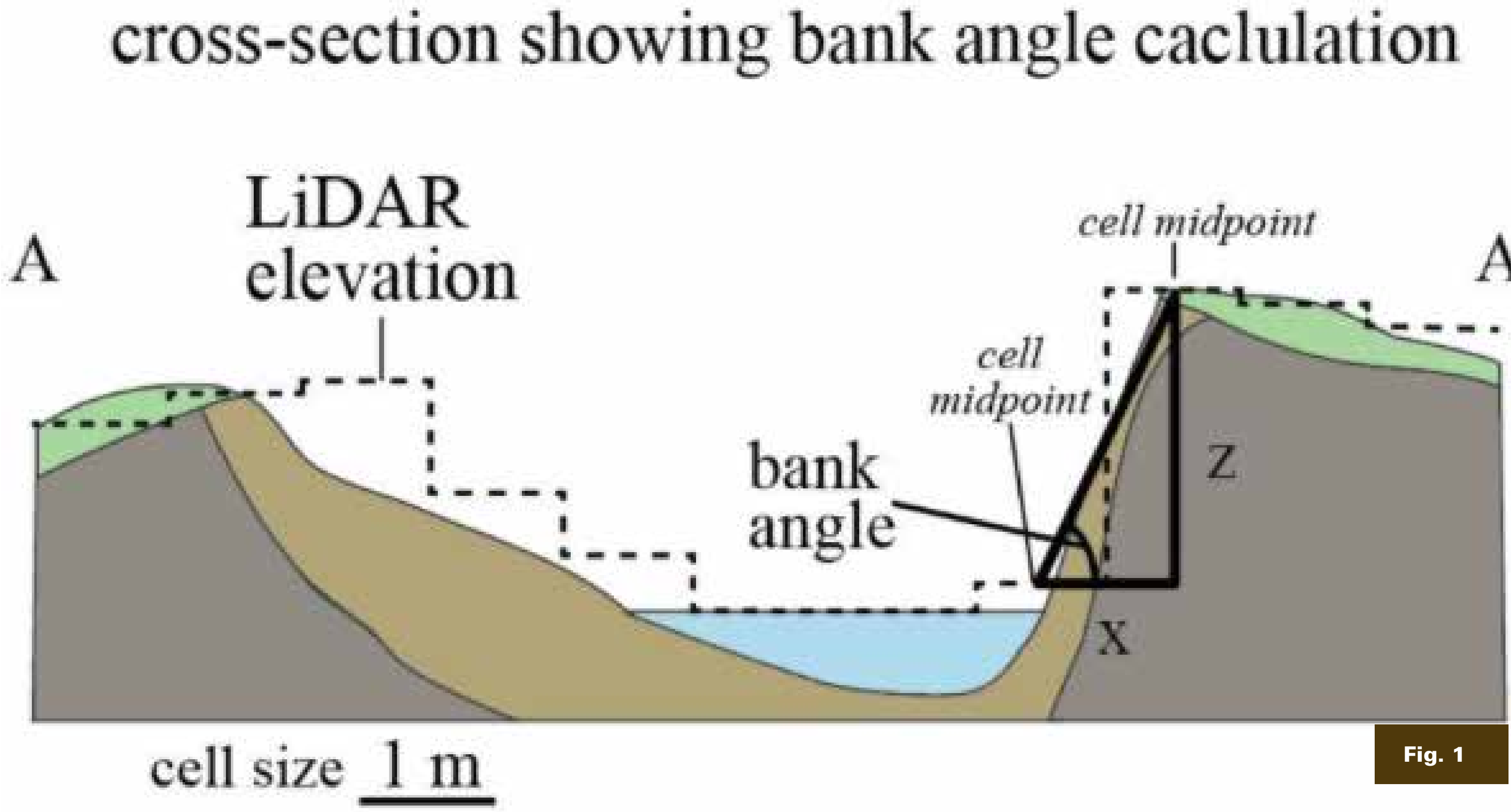

Fig. 1

Contribution of Eroding Streambanks to Phosphorus Export from Iowa

Keith Schilling, Ph.D.
State Geologist

Keith Schilling, Ph.D.

Streambank erosion is a natural geomorphic process, but it is being increasingly recognized that excessive streambank erosion can be a large contributor to sediment and phosphorus (P) loads in agricultural watersheds. However, quantifying the scope and impact of streambank erosion across a region has been a challenge for scientists for many decades. The Iowa Nutrient Reduction Strategy specifically stated that the P evaluation did not include stream bank sources due to the lack of relevant spatial and temporal data. Through projects funded by the Iowa Department of Transportation and the Iowa Nutrient Research Center, Iowa Geological Survey (IGS) geologists--along with researchers from the Iowa Department of Natural Resources (DNR), Iowa State University, the U.S. Department of Agriculture, University of Tennessee, Iowa Soybean Association, and students from the University of Iowa--have sought to answer the question, "What is the contribution of streambank sources to Total Phosphorus (TP) export from the state of Iowa?"

Mapping Streambank Erosion

Identifying locations where severely eroding streambanks are occurring in watersheds is a crucial first step in assessing their potential impact. Field mapping in small watersheds can be done to map eroding streambank lengths, but it is exhaustive and time-consuming.

To estimate streambank erosion at a larger scale, a new geographic information system (GIS) routine was developed to estimate severe streambank erosion based on Light Detection and Ranging (LiDAR) data available for the state. Led by DNR GIS specialist Calvin Wolter, a GIS model based on bank heights and the streambank slope (in a nutshell: greater bank angles indicate more vertical banks) was used to quantify the extent of severely eroding streambanks in Iowa's 3rd to 6th order streams (Fig.1).

Using model criteria, we estimated that 35,200 km (21,870 miles) of streambanks along 3rd to 6th order rivers are severely eroding in Iowa. Compared to 85,970 km (53,420 miles) of available streambanks, our data suggests that approximately 41% of the streambanks in Iowa are severely eroding. It was clearly evident that more streambank erosion appears to be occurring in southwest and southern Iowa than other portions of the state (Fig. 2). We found that larger rivers have more eroding banks since they receive discharge from larger watershed areas. This increase in discharge increases stream power and contributes to greater bank erosion. The average streambank height along 3rd to 6th order rivers was 3.2 m.

Contribution of Bank Erosion to P Loads in Iowa Rivers

With the new mapping data available, the mass of P eroded from streambanks can be estimated in an equation that multiplies eroding bank lengths by bank recession rates, bank heights, bulk density, and soil P content:

*Eroding bank length (m) * Bank height (m) * Recession rate (m/ yr-1) * Bulk density (kg/m-*^{3}*) * P content in streambank soils (mg/kg) = Annual mass of P in eroded streambank soils (kg/ yr-1)*

We designed a data compilation and collection strategy to estimate these terms and provide a first-order approximation of the P loads produced by streambank erosion. For more than two decades, researchers at Iowa State University have pinned several hundred streambanks across Iowa to measure bank recession in wadable 3rd to 4th order channels. We compiled the annual streambank erosion estimates for 385 streambank-years from five different long-term monitoring sites in the state. Although recession rates were found to vary during wet and dry years, we estimated that severely eroding banks are receding about 12 cm per year. To account for the soil properties of eroding banks, IGS geologists traveled across Iowa to sample exposed banks (Fig. 3). With help from the USDA National Laboratory for Agriculture and Environment and utilizing the IGS sediment lab, we found that bank soils have an average P content of about 470 mg/kg and a bulk density of approximately 1.17 g/cm3.

What is the Contribution of Streambanks to TP Export?

Assuming that 35,200 m of 3.2 m high streambanks are actively eroding in Iowa rivers at an annual rate of 12.4 cm yr-1, and the streambank soil TP concentration and bulk density are 470 mg kg-1 1.17 g/cm3, respectively, we estimate that approximately 7,681 Mg of TP is eroded from streambanks and delivered to Iowa rivers every year.

To estimate the contribution of streambank sources to P export from the state of Iowa, we needed to estimate the annual TP export from Iowa rivers. Recent work by Schilling et al. (2020) utilized ambient water quality and discharge data and load estimation models to report that TP export ranged from 5,377 to 72,182 Mg and averaged 24,842 Mg per year. Hence, we estimate that on a long-term annual basis, streambanks contribute approximately 31% of the riverine TP export from Iowa (7,681 Mg of streambank TP / 24,842 Mg of TP export). It is important to note that this estimated fraction represents a long-term average because riverine TP export from Iowa varies considerably year after year.

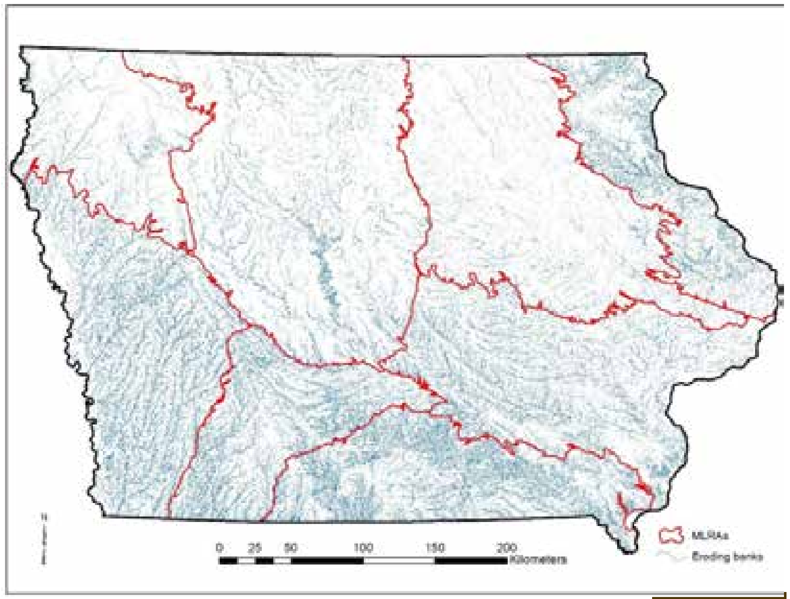

Fig. 2

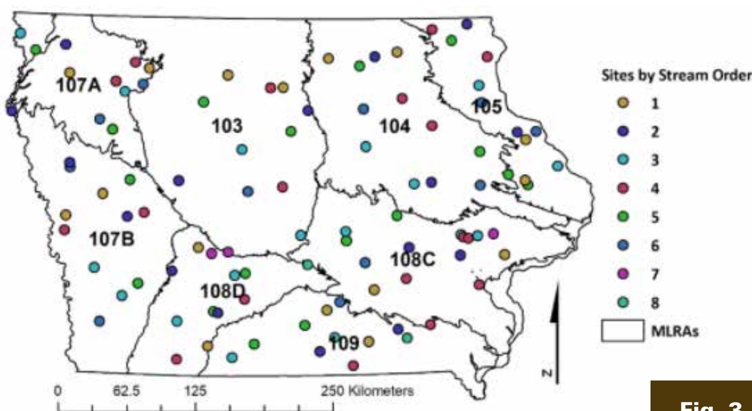

Fig. 3

So what does all this mean? Knowing that streambanks could account for about one-third of the P export confirms what many of us have suspected: streambank sources are a major source of P export from Iowa. However, turning this recognition into action will be a tremendous challenge. Nearly all conservation practices identified within the INRS are designed to reduce in-field sources of P by reducing soil erosion. Our results point out the critical need to develop and implement conservation practices that address both upland erosion (and P loss) and in-stream sources to help mitigate the downstream impacts on water quality.

Overall, our efforts to quantify streambank erosion and P export in Iowa have benefited greatly from collaborations with many different scientists from different institutions and agencies. The new information we have gathered from these projects is advancing the science of river geomorphology and nutrient loading in new and exciting directions.

Fig. 1. Using streambank slopes to identify potential bank erosion.

Fig. 2. Extent of eroding streambanks in Iowa.

Fig. 3. Location of streambank soil samples collected from stream order sites located in a range of landscape regions in Iowa

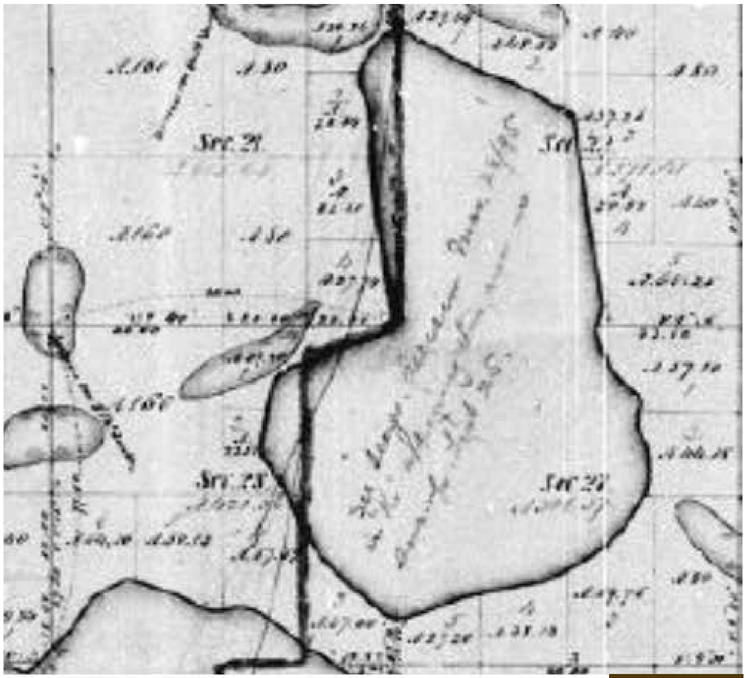

Fig. 1

Fig. 2

Lake Drainage in Iowa

By Joseph W. Otto
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This article explores a historical moment in Iowa's agricultural past that is as forgotten as it is brief – the drainage of natural lakes between 1880 and 1920.

Iowans first sought more control over excess water by simply avoiding it – buying lands distant from lakeshores, leaving swampy river bottoms in timber, and pasturing livestock around troublesome sloughs. But not all water is distinguishable from the surrounding lands. What happens when a wetland is too deep to be a wetland, too shallow to be a lake, and capable of being tilled in some years but not others? Between 1880 and 1920, Iowans struggled with these questions by redefining the physical and legal barriers of the state's numerous, depressional lakes in order to drain them. Some lakes were unceremoniously drained, while others were partially or unsuccessfully drained, and some were sites of conflict over the benefits of drainage and the ethical stewardship of private lands and public waters.

.Federal surveys taken before the Civil War marked lakes by "meander lines" overtop the survey grids that denoted a legal boundary between land and water. Lands outside meander lines could be bought and sold, while within the lines was a public water body. To gain ownership of a lake meant redrawing the meander lines or removing them altogether, which, in turn, required the re-classification of a lake as swamplands. This practice first appeared in Iowa in the 1880s with the drainage of small riverine lakes in counties bordering the Missouri River. By the 1890s, lake drainage appeared atop watersheds in central and western Iowa. Owl Lake in Humboldt County, for instance, was drained by a local railroad investor who received much praise for his efforts. On the other hand, Cairo Lake in Hamilton County was bitterly fought over for over a decade before it was drained. Not all lakes were successfully drained, however. Rice Lake in Winnebago and Worth Counties underwent multiple attempts that were contested by a burgeoning group of tourism promoters who relied on the lake's non-agricultural aesthetics for survival – similar to the efforts of lake-adjacent communities in the Iowa Great Lakes region that emerged around the same time. [1]

Joseph W. Otto

In 1895 the legality of lake drainage was called into question by Iowa Governor Frank Jackson. On the advice of his attorney general, Jackson concluded that "the policy of the state should be to maintain all the lakes of Iowa in their original extent and beauty," and that the practice of draining lakes "appears to me to be utilitarianism run mad."[2] Governor Jackson's 1895 prohibition of lake drainage suggests an emergent awareness that

[1] Joseph W. Otto, "The History of Drainage in Iowa," PhD Dissertation (University of Oklahoma, forthcoming, 2021); Kristen A. Greteman, "Lost Lake: A deep map of a farm field," Master's Thesis (Iowa State University, 2020).

[2] "Opinion of Attorney-General," *Report of the Secretary of State to the Governor of Iowa, of the Transactions of the Land Department*, (Des Moines, 1895), 39-42.

agricultural expansion into wetlands could at times injure the public welfare. Jackson's decision did not halt lake drainage as intended but rather touched off a contentious and politicized discussion over the state's responsibility to manage and protect public lands and waters. Following the declaration, Jackson ordered an inventory of public waters that identified approximately one hundred lakes, covering over 60,000 acres and 500 miles of shoreline. [3] In 1904 the legislature created procedures for the governor's office to review, approve, and reject lake drainage applications. By 1906 thirty-six lakes had been approved for drainage using this procedure. Yet despite--and arguably in response to--ongoing efforts to drain lakes, an alternative approach emerged in the 1910s that resulted in a policy change in favor of conserving Iowa's dwindling supply of water resources. In 1915 the legislature ordered a re-inventory of the sixty-nine remaining lakes and made recommendations for their preservation. [4] This action foreshadowed the creation of the State Board of Conservation (the predecessor to the Iowa Department of Natural Resources) in 1918 and the formal protection of lakes via the creation of public parks in the 1920s. [5]

Iowa's agricultural history is often understood as an ongoing struggle to manage the land, but just as important as it is overlooked is Iowans' struggle to manage water. In both instances, people choose which of nature's boundaries are most readily and beneficially pushed back, and at what point to abandon the struggle or pause it momentarily for reevaluation.

Fig. 3

Fig. 4

Fig. 5

Fig. 6

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Fig. 1. Owl Lake as mapped in 1852 by federal surveyors. Source: Lake Township, Humboldt County (1852). Survey Plats and Field Notes, General Land Office (GLO) Records, Bureau of Land Management (BLM), U.S. Department of the Interior. https://glorecords.blm.gov/.

Fig. 2. Current satellite imagery of Owl Lake. Source: Lake Township, Humboldt County, Iowa (2015), Google Earth.

Fig. 3. Cairo Lake as mapped in 1850 by federal surveyors. Source: Hamilton and Lyon Townships, Hamilton County, Iowa (1850). Survey Plats and Field Notes, General Land Office (GLO) Records, Bureau of Land Management (BLM), U.S. Department of the Interior. https://glorecords.blm.gov/.

Fig. 4. Current satellite imagery of Cairo Lake. Source: Hamilton and Lyon Townships, Hamilton County, Iowa (2015), Google Earth.

Fig. 5. Rice Lake as mapped in 1855 by federal surveyors. Source: Center Township, Winnebago County, Iowa, and Bristol Township, Worth County, Iowa (1855). Survey Plats and Field Notes, General Land Office (GLO) Records, Bureau of Land Management (BLM), U.S. Department of the Interior. https://glorecords.blm.gov/.

Fig. 6. Current satellite imagery of Rice Lake. Center Township, Winnebago County, Iowa, and Bristol Township, Worth County, Iowa (2015), Google Earth.

[3] "Meandered Lakes," *Report of the Secretary of State to the Governor of Iowa, of the Transactions of the Land Department*, (Des Moines, 1895), 45-47..

[4] "Lakes Reported Upon Under the Present Law," *Report of State Highway Commission on the Iowa Lakes and Lake Beds* (Iowa State Highway Commission: Des Moines, 1916), 22-23.

[5] "Iowa Lakes and Lake Areas," *Iowa Parks: Conservation of Iowa Historic, Scenic, and Scientific Areas* (Iowa State Board of Conservation: Des Moines, 1919), 175-187.

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