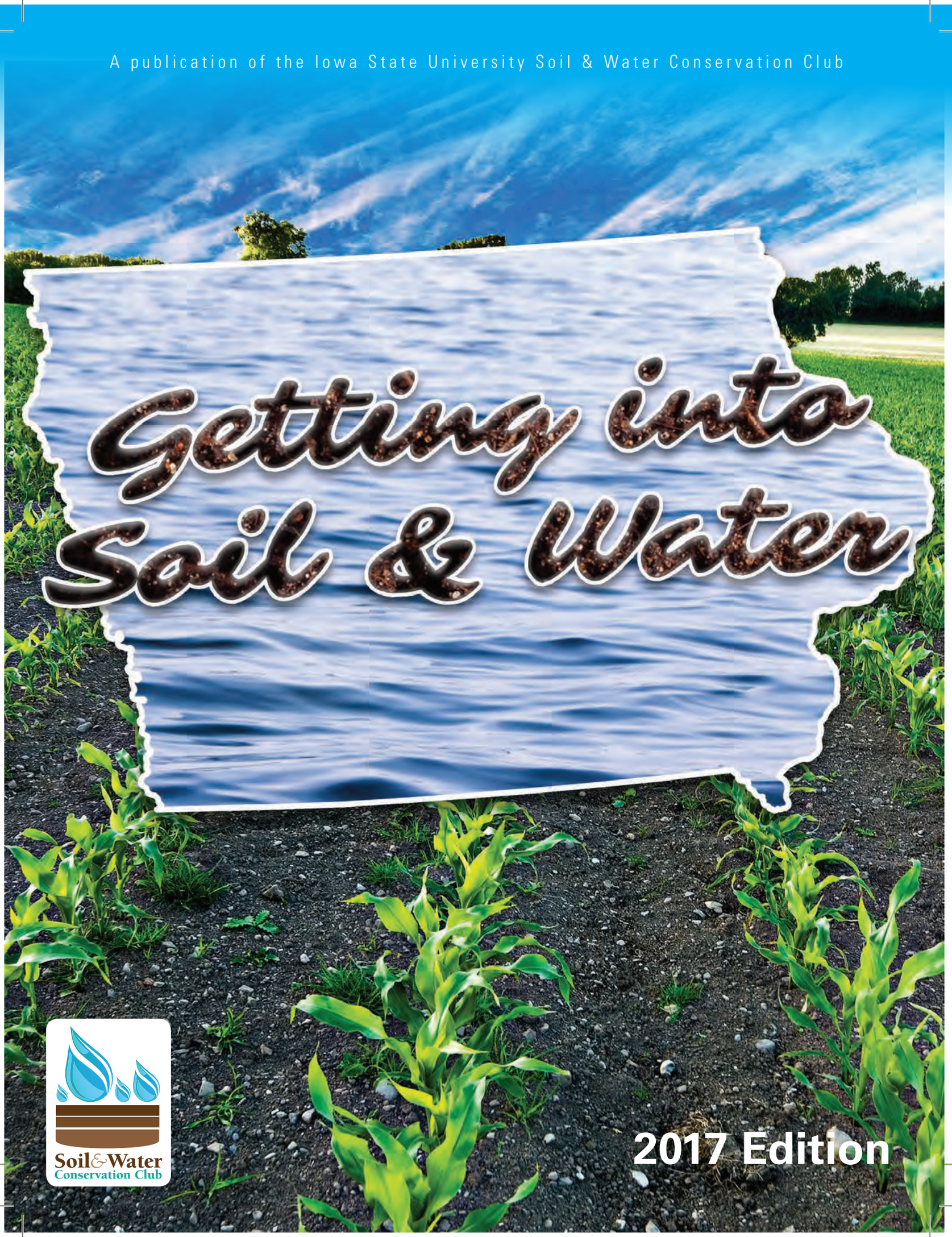
A publication of the Iowa State University Soil & Water Conservation Club




Soil & Water Conservation Club

2017 Edition

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FROM THE EDITORS

# We Are Proud to Present Our 2017 Publication

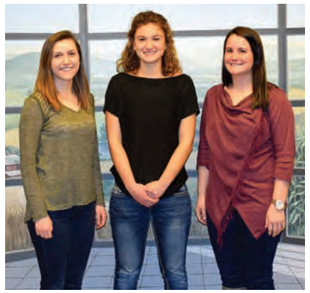
By Hannah Corey, Lindsay Brown and Leah Ellensohn, 2017 Editors

In its eighth year, Getting into Soil and Water is packed full of great articles and information that we are excited to share with you. The goal of this year's publication is to show our readers that everyone has a place and connection with soil and water. Our team of three co-editors is made up of Hannah Corey, Lindsay Brown and Leah Ellensohn. 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, and have been a member of the Soil and Water Conservation Club since the spring of 2016. Growing up on a farm in Northwest Iowa, water quality issues in my home county 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 high-quality information across Iowa and beyond. Whether you are a farmer or a politician, a student or a professional, it is my hope that Getting into Soil and Water 2017 will give you a new perspective on soil and water conservation.

Lindsay Brown: I am a junior 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.

Leah Ellensohn: I am a senior in agronomy and seed science. I joined the Soil and Water Conservation Club in the fall of 2016 because I have always been interested in conservation and the outdoors. Now, with my current area of study, I am very interested in soil and soil water because they are important aspects when it comes to a seed's success in the ground. I was able to combine my interests of conservation, soil and seeds by joining the SWCC. Serving as co-editor of this publication has been a great learning experience in so many ways. I hope that the articles we have prepared for you are able to expand your knowledge of soil and water just as much as they have mine.



Left to right: Lindsay Brown, Hannah Corey and Leah Ellensohn

We want to send out a big thanks to all of our committee members. This publication could not have happened without the help of their creative thinking and scientific knowledge. We would like to especially thank our club advisors, Dr. Rick Cruse and Dr. Bradley Miller. They are an essential part of this publication, and we cannot thank them enough.

Lastly, we want to thank our readers. Your continued support is why this publication is on its eighth successful year. We strongly believe that the articles included will deepen your knowledge of soil and water. We hope you enjoy (and learn from) Getting into Soil and Water 2017!


IMPACTING THE ENVIRONMENT AND THE ECOSYSTEM

# Making a Difference with the Skunk River Navy

By James T. Colbert, Department of Ecology, Evolution, and Organismal Biology, Undergraduate Biology Program Director, Commanding "Admiral", Skunk River Navy

A first-year student learning community was in need of a project to connect them to their new local environment and a river was in need of some love – as clearly evidenced by a discarded cast iron clawfoot bathtub half-buried in a sand bar. Standing thigh-deep in the cool water of the South Skunk River, fishing pole in hand on that hot day in September 1997, looking at the bathtub with disgust, an idea crystallized in my mind's eye.

Our biology learning community ("BEST") students could dig out and remove that bathtub – and at the same time connect to their local environment, while also learning something about the local biodiversity. Wow. I went home and tried to explain my vision to my thoughtful (and long-suffering) wife. She told me it would never work – why would college students get up early on a Saturday morning to get wet and muddy with me? An excellent question, but one that would take a year to answer because most of the BEST activities were already over for the fall of 1997.

James T. Colbert

By the fall of 1998 we had incorporated the newly named "Skunk River Navy" activity into the BEST curriculum. As my wife watched the 12 first-ever SRN volunteers load into a 15-passenger ISU van, she (having been on hikes with me before) whispered, "like lambs to the slaughter". We went to the stretch of river with the aforementioned bathtub, investigated some of the local biodiversity, and then headed downstream pulling the canoes through water and over rocky shallows and filling them with trash. When we reached the sandbar with the bathtub, the students made quick work of digging it out and, to their surprise, it went in a canoe without causing it to sink! We continued wading a couple of miles downstream, hauled the tub (and the rest of the trash) up a steep muddy bank and ended the day with a pizza dinner.

## A Lasting Tradition

Since that day in 1998, 18 more SRN seasons have come and gone. Depending on the weather and water levels some years we were able to do multiple "trash patrols", other years only one. We were very fortunate to get substantial and ongoing contributions from Jim Holtz in our Biology Advising group beginning in 2000. Our overall approach has remained pretty much the same, although we now serve food in the middle of the day to preserve morale, and my wife, who came fully "on board" along the way, now bakes home-made cookies for the après SRN survival celebration. As of fall 2016 we have completed 50 SRN trash patrols, with the contributions, according to our records, of 2,270 volunteers, most of whom were first-year ISU biology majors. We have also been fortunate to have as volunteers BEST peer mentors, biology majors further along in their programs, students in other majors, graduate students, faculty, local citizens and even alumni who have returned to campus specifically to participate in a SRN trash patrol. These hard-working volunteers have removed 157,600 pounds (~79) tons of trash from the river, most of which was transported and recycled by the City of Ames Arnold O. Chantland Resource Recovery Plant. The volunteers have also collected numerous sets of stream biodiversity data that were submitted to the IOWATER database.

## Addressing Major Issues

I am often asked, "has it made any difference?" The answer is "yes, no and I hope so". "Yes" in the sense that we have removed a lot of "legacy trash" – everything from barbed wire, couches, refrigerators and port-a-potties to a wooden-spoke wagon wheel. People using the river for recreational purposes, e.g., a canoe trip, are now likely to have a more aesthetically pleasing experience. "No" because none of what the SRN has done addresses the truly major issues that this river (and virtually all Iowa rivers) faces: high sediment loads, high nutrient levels and dramatic variations in water flow. Addressing such issues will require a much broader watershed approach. The "I hope so" part is the thought that every SRN "veteran" is now much more aware of the challenges our rivers face, as well as the great potential they have – and that no SRN volunteer would EVER throw trash in a river.

It has been a long, winding (and muddy) road with many stories, but let me give one of our 2016 participants "the last word":

"[The] SRN demonstrates how people impact their environment and ecosystem. It's not uncommon for society to take nature for granted, and by the time we do realize our actions have consequences we throw our hands in the air and say it's too late to do anything. SRN is proof it's not too late to take action to preserve our one planet."

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Fig. 1 James T. Colbert, Commanding "Admiral", Skunk River Navy removes a tire from the river.

Fig. 1 Contaminated floodwaters reach North Carolina's Atlantic coast. Photo by Jeff Schmaltz and Adam Voiland, NASA MODIS, Oct 9th, 2016.

HURRICANE MATTHEW FLOODS HUNDREDS OF CONFINED ANIMAL FEEDING OPERATIONS IN NORTH CAROLINA

# Making the Same Mistake Twice

By Wicitra Mahotama, Agriculture Conservation and Environmental Analyst, EWG

Earlier this year, Hurricane Matthew stormed through North Carolina's coastal plain inundating 14 manure lagoons – open air basins filled with animal waste – and 141 swine and poultry barns. Eighteen inches of rain fell from October 7th through the 9th, triggering flooding of the Neuse, Black and Cape Fear rivers. Flood levels rivaled those seen during Hurricane Floyd in 1999.

When floodwaters submerge livestock barns and manure lagoons, animal urine and feces are carried away with the current. Contaminated floodwaters transport pollutants harmful to human health and the environment such as fecal coliform bacteria; the most common being E. Coli. Higher levels of fecal coliform suggest the presence of disease-causing bacteria, posing a serious risk to drinking water, ecosystems and recreation areas. Past experiences from Hurricane Floyd suggests dangerous levels of E.Coli and another bacteria, Clostridium perfringens, will persist even after the floods recede.

## A Detailed View

The Environmental Working Group (EWG) and Waterkeeper Alliance produced a detailed map highlighting the flood's impact on factory farms along the numerous rivers of the Atlantic coastal plain of North Carolina. Aerial images taken during the floods are featured in this interactive map and are available at the EWG's website, http://www.ewg.org/research/exposing-fields-filth-hurricane-matthew.

Wicitra Mahotama

The EWG-Waterkeeper Alliance analysis of the flood's impact on the eight counties most heavily inundated found:

In Craven, Duplin, Green, Jones, Lenoir, Pitt, Sampson and Wayne counties, the flood partially submerged 10 industrial pig farms with 39 barns, 26 large chicken-raising operations with 102 barns and 14 open-air pits holding millions of gallons of liquid hog manure.

Fig. 3 Aerial images, like the one above, show the risk of building confined animal feeding operations in a floodplain. Animal urine and feces flow away from submerged barn. Source: Waterkeeper Alliance.

In the 47 counties in the larger coastal plain, Confined Animal Feeding Operations (CAFOs) generate more than nine billion gallons (96% of North Carolina's output) of liquid animal waste and over 193 million pounds (47% of the total) of dry animal waste each year. Wet animal waste is produced in swine operations and stored in open-pit manure lagoons, then sprayed onto fields as fertilizer. Dry animal waste is produced in poultry operations and is also used as a fertilizer.

Within the 100-year floodplain of the coastal counties, 92 CAFOs house approximately 235,000 hogs and 1.8 million chickens. There are 166 open-air manure lagoons directly within the 100 year floodplain, and another 366 within 100 feet of the floodplain.

> A mistake made twice is no longer a mistake, it is a choice and a bad decision.

## Mitigating Issues

Attempts were made 17 years ago to correct the issues caused by Hurricane Floyd, yet the problems persist. In 1999, after Hurricane Floyd, the state of North Carolina and Smithfield Foods, Inc. enacted a moratorium on swine operations and implemented other measures to prevent pollution from facilities in the 100-year floodplain. According to the North Carolina Department of Agriculture, the state spent $18.6 million of taxpayers' money to close 42 facilities with 103 waste pits. The state also prohibited the construction of any new swine operations that used manure lagoons or sprayed manure onto fields, although many established operations remain.

However, these measures did not address poultry CAFOs in 100-year floodplains. North Carolina currently does not issue permits for the storage and land application of poultry waste. The absence of oversight leaves waterways vulnerable to the mishandling of an estimated two million tons of poultry waste a year. Waterkeeper Alliance has documented numerous instances in which enormous, open piles of poultry waste have been stored directly next to waterways.

A mistake made twice is no longer a mistake, it is a choice and a bad decision. EWG-Waterkeeper Alliance's aerial surveys and landscape analysis document a persistent and unresolved problem putting North Carolina's public health, environment and recreational areas at risk. Policymakers must be bold to protect human health and the environment from a recurring, unnecessary and above all, preventable issue.

CROP DIVERSITY AND SOIL HEALTH:

# What is Underlying the 'Rotation Effect'?

By Marshall McDaniel, Assistant Professor, Department of Agronomy, Iowa State University

Healthy soils are key to solving some of the major environmental challenges of this era. For example, global issues like climate change and food security are both intimately linked to the health of our soils. The recent use of the phrase 'soil health' which emerged from the earlier terms of 'soil quality' and 'soil tilth', is in large part a realization of the importance of soil biology. After all, only something living can have good or bad health, right?

Many management practices have been shown to increase soil health; here I will focus on one – increasing crop diversity through sequential rotations. Crop rotations have been around for millennia due mostly to the fact that they were observed to increase crop yields. This is now often referred to as the "rotation effect". While rotating crops does, under many conditions, lead to better yields, those pioneering farmers were also unknowingly improving soil health. This increase in soil health could arguably be the primary reason for, or the underlying cause of, the observed rotation effect.

Presently, modern large-scale agriculture has very limited use of crop rotations, with the most common rotation in the Midwest being a corn-soybean rotation. This two-year rotation ranges from 18-84% of total cultivated land, by state, in the Midwest. In many states, there is still a dominance of monoculture cropping of either corn or soybeans only. Since cultivation of Midwestern soils in the 1800s, it is estimated that our soils have lost nearly 50% of their soil carbon. There are many cultivation-related reasons for this loss (i.e. tillage and tile-drainage), but one of the most salient differences between cropland and the extensive prairies which dominated the landscape before them is the large difference in plant diversity. Perhaps increasing crop diversity through rotations could restore some of this lost soil carbon and have other benefits, like increasing yields and reducing nutrient loss.

A quantitative review of 112 crop rotation studies from around the world found that having any type of crop rotation increased soil carbon by an average of approximately 4%, and total N by 5% (Fig. 1). Soil organic matter (SOM), or soil carbon content (~58% of SOM), is key to soil health. Increasing soil carbon also tends to improve other physical and chemical indicators of soil health: it increases cation exchange capacity, decreases bulk density, improves soil structure and increases plant-available nutrients. The increased soil nitrogen found from the 112 studies was likely due to including a legume, or N-fixing crop, like soybeans or leguminous cover crops like red clover. Together these benefits of rotations could lead to increased soil carbon and long-term fertility of our soils.

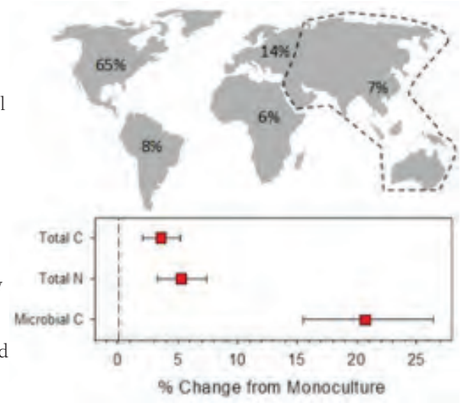


Fig. 1 Distribution of the 112 studies on crop rotations (above) and overall soil results from these studies (below). Most of the studies came from North and Central America (65%). The square represents the mean relative difference (% change) between a crop rotation and monoculture cropping system soil. The error bars are 95% confidence intervals.

Soil microbial biomass, a pillar of soil health, was increased by nearly 21% for extended rotations on average across all of the 112 studies! This large effect of extended crop rotations on soil microbial biomass may be linked to the "rotation effect", since soil microbes are key to making nutrients stored in SOM available to crops. Microbial activity, measured through respiration and extracellular enzyme activity (used to mineralize SOM) was also shown to increase with extended crop rotations. Thus a larger, more active, soil microbial community will be able to mineralize more of the nutrients stored in SOM like nitrogen, phosphorus and sulfur, making them more available to crops. Some recent studies suggest that increases in crop diversity also increase the diversity of soil fauna and flora. What this belowground diversity means for soil ecosystem services like soil carbon or increased nutrient availability is still largely unknown.

Other important ways crop rotations may increase yields is by decreasing the abundance of pests, weeds and crop diseases. By skipping years of a certain crop you can disrupt pests' life cycles that depend on that crop, thereby decreasing incidence of pest damage. Furthermore, crop rotations may also increase the physical aspects of soil health like increasing soil structure and pore space, while decreasing soil bulk density. These physical benefits might be due to a variety of root forms from different crops.

The bottom line is that the benefits of extended crop rotations to soil health and crop yields are good enough reason to reevaluate the lack of crop diversity in the Midwest. There are other ways to inject crop diversity on the farm that I have not discussed, such as cover crop mixtures and inter-cropping. Increasing crop diversity through any means possible, even sequentially through time as in a rotation, appears to have many benefits to soil health and may improve the sustainability of modern agriculture in the Midwest.

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EXPLORING MISCANTHUS AS A PERENNIAL BIOMASS CROP

# What is Happening with Perennial Biomass Crops in Iowa?

By Mauricio Tejera and Emily Heaton, Department of Agronomy, Iowa State University

Among renewable energy options, only bioenergy can protect soil and water while reducing fossil fuel use. Iowa is a leader in ethanol and biodiesel production, producing nearly twice as much energy in biofuels as it used across the whole transportation section last year. However, the expansion of acres growing corn and soy in the last decade has proved problematic for regional water quality. Perennial biomass crops could help address this problem by providing a source of clean, renewable energy while simultaneously protecting soil and water.

Soil is more vulnerable to erosion under annual cropping systems because the roots of annual crops are not present throughout the entire year like perennial roots (Cosentino et al., 2015). Further, annual crops have a shorter active growing season compared to perennials and thus take up less water and nutrients, allowing more pollutants to 'leak' from the system (Zhou et al., 2014, Daigh et al., 2015). This is not good for water quality. As pointed out by Keith Schilling in his 2016 GISW article, the amount of nitrate in Iowa waterways is directly correlated to the amount of annual crops in the watershed. The Iowa State University Daily Erosion Project shows similarly concerning impacts on soil loss in areas dominated by annual crops, indicating that more than 20 tons of soil were lost per acre in many Iowa watersheds in 2016.

Mauricio Tejera

Emily Heaton

## How can perennials help?

Perennials can help in many ways because perennials provide a plethora of ecosystem services including: soil and water quality improvement, carbon sequestration and habitat for wildlife and pollinators. Unfortunately, while the environmental benefits of perennial crops are rarely disputed, their economic viability in Iowa is tenuous. There are few well-developed markets for perennial crops beyond hay and livestock bedding. However, perennials can complement row crops. For example, our work indicates that around 500,000 acres of Iowa row cropland lose more than $100 per acre nearly every year (Brandes et al., 2016). Typically, these acres are surrounded by more productive land within a field. If we grew perennial crops in these unprofitable sub-field areas, the perennials would not actually have to make money. Instead, they would only have to lose less money than the row crop they displaced. It does not sound like a big deal, but 'precision conservation' with perennials could help boost overall farm profitability while improving ecosystem function.



Fig. 2 LAMPS experimental sites across Iowa. Each site has 4.5 acres of miscanthus with corn controls.

## How are we using perennials in Iowa today?

The prairie STRIPS team has pioneered precision conservation in Iowa by incorporating strips of prairie into cropland for improved system performance. Farms across the Midwest are now adopting prairie strips. The University of Iowa Biomass Fuel Project is planting the perennial biomass crop miscanthus (Miscanthus × giganteus) around the Iowa City area to supply 10% of the University's energy needs while reducing its carbon footprint. The miscanthus biomass is chopped, mixed with coal and burnt to generate steam that heats and powers the university.

Currently ~300 acres of miscanthus have been planted in a corridor ranging from Cedar Rapids to Muscatine. The University of Iowa has paid farmers on a long-term contract basis to grow miscanthus on their land. This contract is similar to a CRP contract in many ways and is structured to reduce risk for farmers growing this new crop. Miscanthus is harvested in the winter (Fig. 1), when other Iowa cropping activities are over. This harvest timing is not only helpful for farmer schedules, but also allows the plant to recycle most of its nutrients found in the aboveground stems to belowground storage organs known as rhizomes prior to harvest. Recycling nutrients means the crop requires less fertilizer. Even better, while the crop stands in the field throughout the winter months it blocks wind (and snow!) and provides wildlife habitat.

Iowa State University supports the Biomass Fuel Project by conducting agronomic research on biomass crops like prairie and miscanthus. Miscanthus has only been studied as a crop in Iowa since 2009, and the best management practices are still tentative. To learn more about the potential for growing miscanthus in Iowa, we started the Long-term Assessment of Miscanthus Productivity and Sustainability (LAMPS) experiment in 2015 at three locations across the state (Fig. 2). At these sites, we are addressing questions such as:

How do productivity, nutrient demands and biomass quality change as miscanthus ages?

What is the optimal nitrogen fertilization rate for miscanthus?

How does miscanthus impact soil and water quality?

As we learn more from LAMPS, we will use results to deploy biomass crops in ways that allow Iowa to produce even more renewable energy, while protecting and improving our natural resources.



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Fig. 1 Nick Longbucco from TNC shares how their team used the touchscreen tool to design different BMP implementation scenarios.

TOUCHSCREENS AND STREAMS:

# Targeted Implementation of BMPs Provide Cost Effective Benefits Downstream

By Nicholas Longbucco, Ceder Basin Freshwater Manager, The Nature Conservancy

In Iowa nearly 70% of all assessed lakes, rivers and streams are designated as "impaired" . These 765 waterbodies are considered "impaired" because the water quality does not fully support designated uses for human contact, aquatic life or drinking water. Many of these impairments are caused by non-point sources of nutrient runoff. To improve water quality and address the nutrient issue the Iowa Nutrient Reduction Strategy (INRS) calls for a 41% reduction of nitrate□N and a 29% reduction of phosphorus-P from non-point sources. An assortment of best management practices (BMPs) implemented at large watershed scales is needed to reach these reduction goals. To achieve reduction goals, implementation and operational costs of different BMP scenarios are estimated at $77 million to $1.2 billion a year. Strategic targeting of resources and BMPs are critical to ensure this investment in Iowa's water resources is effective.

The Nature Conservancy (TNC) and the World Wildlife Fund (WWF) are leading a cutting-edge scientific analysis to better target implementation of BMPs to ensure the best nutrient reduction bang for the conservation buck. Using a new optimization tool developed with the University of Minnesota, this scientific analysis links nutrient reduction and other environmental benefits with data about their implementation costs and identifies which practices should go where in a watershed to achieve the most cost-effective nutrient reduction.

A practical demonstration of this tool is being conducted in the Middle Cedar Watershed. A group of 16 private and public partners led by the City of Cedar Rapids secured more than $4 million through the U.S. Department of Agriculture's Regional Conservation Partnership Program grants, forming the "Middle Cedar Partnership Project" (MCPP). The MCPP has catalyzed action around water quality issues in the Middle Cedar and is focused on implementing agricultural BMPs to reduce erosion, keep nutrients in farm fields and improve water quality for downstream users.

The optimization tool can better help prioritize and target conservation efforts in the five MCPP priority watersheds. For example, in the Wolf Creek Watershed the tool determined the most cost-effective combinations of BMPs on the landscape to achieve a particular set of nutrient reduction goals (Fig. 1). Scenario-A illustrates a landscape with a moderate 20% nitrate-N reduction with an average annual costs of $9 per cropland acre (Fig.1). Scenario-B illustrates a landscape with a 40% reduction (nearly matching the INRS's 41% reduction goal) at an annual cost of $25 per cropland acre (Fig.1). Costs are based on the estimated impact to agricultural returns taking into account impacts to yield, commodity prices and practice implementation costs. The INRS's reduction goal of 41% has an Estimated Equal Annualized Cost of $11-$67 per acre. By targeting and considering the variable cost-effectiveness of BMPs in a landscape the optimization tool can help deliver nutrient reduction benefits at the low end of the INRS's cost range.

Nicholas Longbucco

When analyzing a complex watershed system even the best models will fail to fully represent reality, as a host of factors influence the decisions of landowners and producers. However, by incorporating feedback from local experts, stakeholders and landowners, the model can better represent real-life conditions. Additionally, the process of sharing information and facilitating engaging conversations can help to strengthen partner relationships. To encourage the sharing process, the watershed models were loaded on 55" touchscreen monitors and featured in a "collaborative design" workshop in Cedar Rapids, putting this valuable information at the fingertips of local watershed decision makers (Fig. 2). In this unique meeting farmers, watershed coordinators, and partners from producer organizations and state and federal agencies worked together using the interactive touchscreens to "custom design" a watershed that could support profitable farming and provide clean water (Fig. 3).

During the workshop, the City of Cedar Rapids gained valuable insights about how to make smart investments to achieve the most improvements to water quality possible with limited MCPP funding. Farmers and producers explored opportunities to implement practices that can improve water quality downstream while minimizing impacts to farm profitability (Fig. 3). Most importantly, partners from upstream and downstream communities did not get mired in assigning blame but rather had open, collaborative dialog about how to design shared solutions.

Solving the nutrient and water quality challenges of the Cedar River Watershed will not be easy or cheap. However, by incorporating rigorous science, inclusive partnerships and strategic targeting we can design more optimal watersheds that support agriculture production while providing clean water and other environmental benefits.

Fig. 2 Len Kne from the University of Minnesota explains how the web application and touchscreen TV can be used to custom design watershed scenarios.

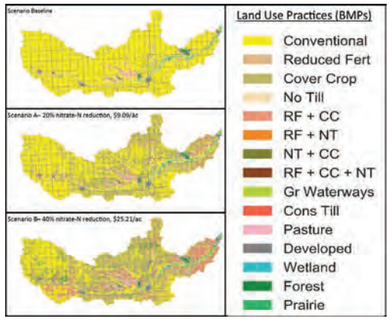
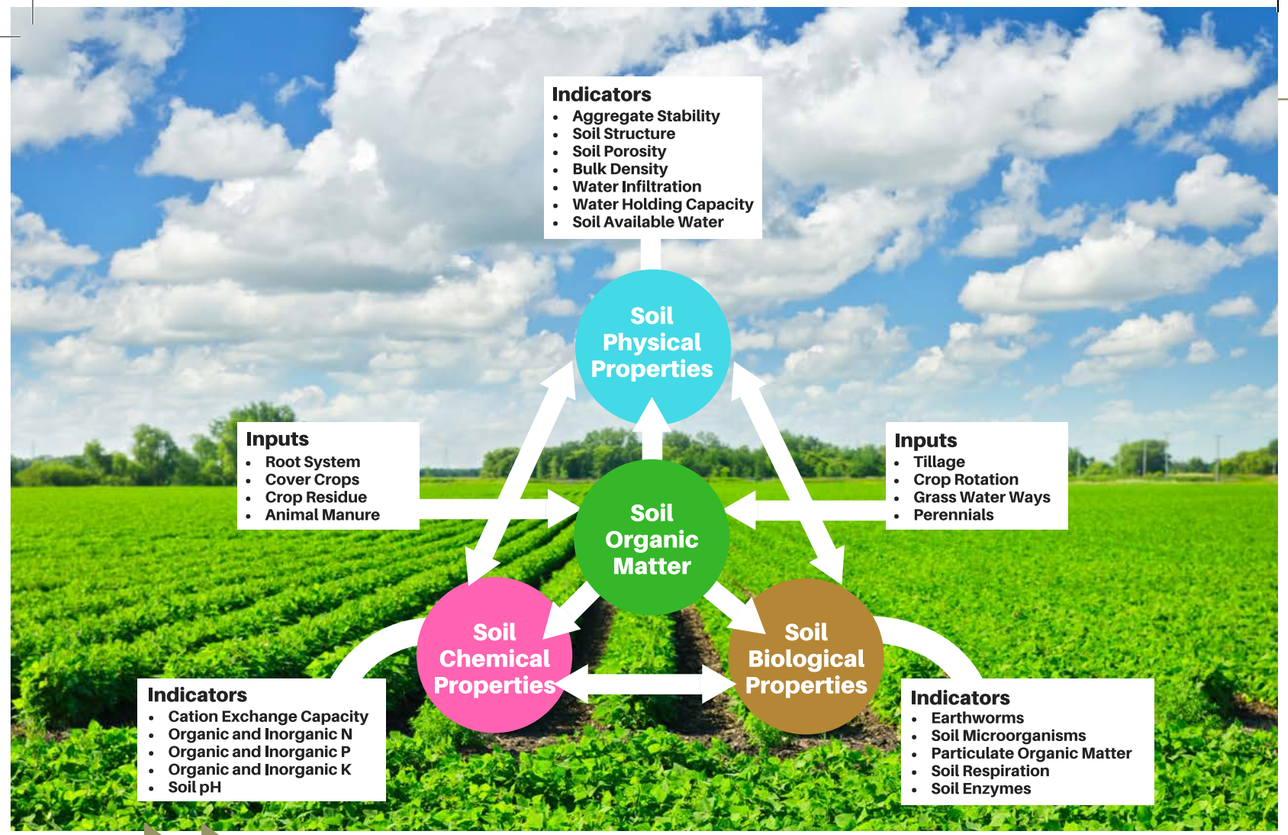



Fig. 3 The Optimization tool selects and locates practices that achieve the most cost-effective nutrient reduction possible.




SUPPORTING HUMAN HEALTH & WILDLIFE HABITAT

# What is Soil Health and Why do We Care?

By Mahdi Al-Kaisi, Professor of Soil Management/Environment, Agronomy Department, Iowa State University

Soil health is defined as the continued capacity of the soil to function within natural or managed ecosystem boundaries to sustain plant, animal and human lives. The complex biological, physical and chemical interactions of a healthy soil can influence plant water availability (especially under dry conditions), the availability of nutrients through nutrient cycling for food and fiber production and off-field nutrient losses to nearby streams during rain events.

Mahdi Al-Kaisi

A healthy soil maintains or enhances water and air quality by increasing water infiltration and storage. It also supports human health and wildlife habitat. The benefits of a healthy soil in sustaining food and crop production are most evident when growing conditions are less than ideal.

Healthy soils increase the capacity of crops to withstand weather variability, including short-term extreme precipitation events and drought. Highly variable weather conditions present increased risks to crops, and require careful attention to conservation planning to support soil health and crop productivity.

## What affects soil health?

Soil management practices, cropping systems and weather conditions influence soil health. A healthy soil that is well managed can increase soil water infiltration, nutrient supply, microbial diversity and storage of water, nutrients and soil carbon. Soil organic matter (SOM) is a central soil property that is heavily affected by management practices. SOM in turn influences soil physical, biological and chemical functions.

Fig. 1 Soil health indicators and systems inputs.

The relationships between SOM and management practices such as tillage and cropping systems can be documented through the evaluation of soil health indicators (Figure 1). Those indicators reflect the level of response of the soil system to different management inputs. Field and laboratory evaluation of these different indicators can aid in fine-tuning management practices to optimize soil biological, physical and chemical functions.

Within the soil system, the organic matter component is only a small fraction of the topsoil (ranging from 1% to 5% or greater by dry weight, depending on soil type and other formation factors). The point is, organic matter is essential for the soil's function and general ecosystem services.

The key services of a healthy soil for production agriculture are nutrient provision and cycling, pest and pathogen protection, production of growth factors, water availability and formation of stable soil structure (aggregates) to reduce the risk of soil erosion. However, these functions are sequentially influenced by each other starting with organic matter as the building block for the well-linked functions.

Healthy soils increase the capacity of crops to withstand weather variability, including short-term extreme precipitation events and drought.

## Tillage Effects on Soil Services

Many factors contribute to degradation of soil health, but tillage is the prime contributing factor. Soils under modern production agriculture have lost a significant amount of their carbon pool because of erosion, organic matter decomposition and leaching. There is an estimated loss of 30-60% soil organic carbon (SOC) from cultivated soils in the Midwest region of the United States since the late 1800s. This can be attributed to the conversion of prairie systems to cultivated land. This loss in SOC by cultivation is in part caused by the oxidation of organic matter and CO2 release in addition to losses through surface runoff and soil erosion.

The increased use of intensive tillage and other management practices in row crop production can increase soil erosion, reduce soil health and water quality and reduce the capacity to achieve sustainable agricultural production systems. In row cropping systems, soil erosion is always associated with tillage intensity, especially during springtime when soils are most vulnerable to water erosion due to lack of vegetation or residue cover that protects the soil surface from high rain intensity.

Soil management practices that protect soil health are not only economically and environmentally necessary, but the right approach to sustain and increase soil resiliency. An increase in soil health can be achieved by adopting conservation practices that are practical, site specific and designed to be an integral component of the overall agricultural production system. These conservation practices could include no-till and reduced tillage (i.e., strip-tillage), which leave post-harvest crop residue to cover the soil surface, cover crops and construction of grass waterways, terraces, buffer strips and pasture erosion control systems with manure application and soil testing.



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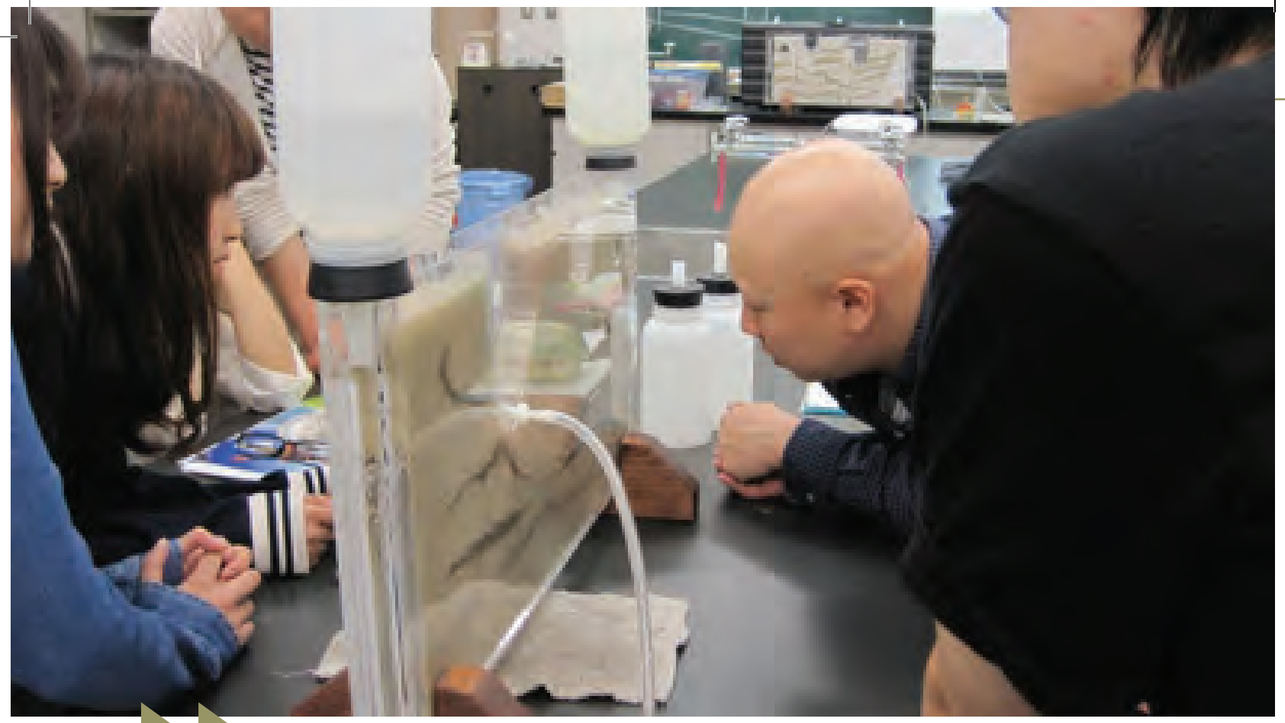


VISUALIZATION OF GROUNDWATER AND MATERIAL FLOW SYSTEMS

# Creating the Right Image for Environmental Water Education

By Seongwon Lee, Department of Environment Systems, Faculty of Geo-Environmental Science, RISSHO University in Japan

Seongwon Lee

It is essential to understand groundwater flow and the material cycle accompanying it to fully understand hydrological cycles on the earth. Unfortunately, directly educating students about the flow of groundwater is difficult because groundwater flows where we cannot observe it. As a result, incorrect interpretations of groundwater movement frequently occurs. Too often, tap water from a faucet is recognized as a domestic and commercial water source. In fact, there are many students who have not explored water beyond their kitchen or bathroom sink and have never considered a well as a daily water source.

Engaging students in understanding groundwater flow is an important issue. If they do not understand groundwater flow, it is impossible for them to understand the material cycle accompanying it and the potential contamination process. Helping students understand the concept of water as a carrier of various materials is an important issue for future environmental water education and conservation.

To solve this issue, an educational tool called a Groundwater Flow Model (GFM) is used in the classroom to show the flow of groundwater. The results of conducting classes to educate students about groundwater flow and the material cycle accompanying it are reported here.

## Educational Material

The educational materials installed were requested of and created by Dr. Richard M. Cruse of Iowa State University and the Iowa State Soil and Water Conservation Club. Prior to the AP Program (*1), when the GFM was introduced in April 2013, it was a demonstrational tool used by teachers only, and there was only one available model. In March 2015, two more models were acquired which enabled the GFM to be an active experiment that students could interact with along with the teachers (Figs. 1&2).

## Implementation of water environmental education

By installing the GFM (Fig. 2) as an educational tool that visualizes the invisible flow of groundwater and material cycle associated with it, I work to improve the image of the natural phenomenon related to groundwater flow in the curriculum that I teach. Other curriculum materials associated with GFM include using ICT educational materials demonstrating proper use of the tool (subtitled in Japanese) which are available on YouTube (Figs. 3&4).

Content of classes: groundwater flow, groundwater and surface water interaction, diffusion of contaminant and soil contamination

Targeted class: Experiment of Hydrological Environment

Number of participants: 29

Class dates: April 2015 to August 2015 (15 classes)

## Responses and Impressions of Students

After the classes, questionnaires were distributed to students. I asked them to write their opinions regarding the classes where GFM was used. Included below are some of their opinions:

As we imitated groundwater movement ourselves, we deepened our understanding of it.

By imitating the flow of contaminated water that has been invisible to us so far, we could recognize the way it flows.

By coloring groundwater, we could visualize the flow location and speed of the groundwater.

Even for people who did not have much interest in groundwater, it seemed to be something that took their breath away.

By being able to change the flow of rainwater or groundwater and adding contaminants into the flow ourselves, we could confirm invisible groundwater movement.

Survey results showed that all students deepened their understanding of groundwater flow and the material cycle associated with it. The responses indicate that this tool may serve as an effective education tool for a range of students from elementary to high school. Furthermore, by creating educational materials for the explanation of experiments where the GFM is used, I would like to address the importance of environmental water education and conservation to a wider audience.

## To All Members of the Iowa Water Center

GFM has been utilized by university students in Japan, approximately 10,000 km away from Iowa. I sincerely appreciate your valuable work. We are looking forward to further developing our educational materials for use in the United States, and we strongly wish to work with you in the future.

## Acknowledgment

This paper is a part of the results of the AP Program. Upon promoting this program, having received a lot of assistance and advice from Dr. Richard M. Cruse of Iowa State University and all members of the Iowa Water Center, I would like to express my gratitude here.

*1: Acceleration Program for University Education Rebuilding: AP Program

The AP Program intends to assist universities that carry out advanced efforts that are consistent with the new direction indicated by the Education Rebuilding Council to further promote the reform of university education that the Japanese Government leads. The AP Program that we promote comprises four pillars: a bi-directional educational system using tablet PCs, creation and publication of movies for the preparation of classes, field work mainly managed by students, and the collection and utilization of real materials for classes. Our efforts were conducted as a part of the collection and utilization of real materials for classes.

Fig. 2 The actual condition of the experiment.

Fig. 1 The actual condition of the experiment.

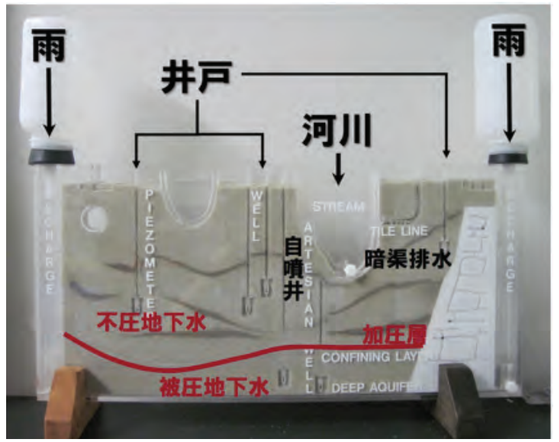



Fig. 3 Structure of Groundwater Flow Model in Japanese.

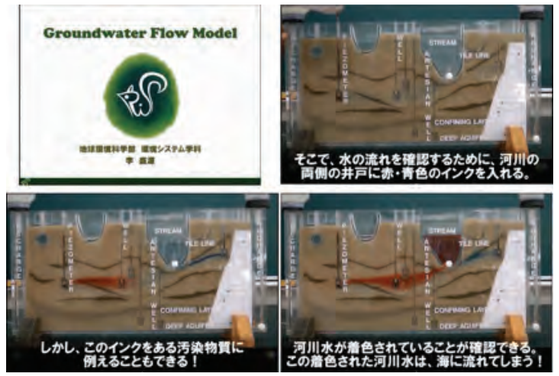



Fig. 4 ICT educational material capture using Groundwater Flow Model (Subtitled in Japanese) (quad-speed).

Fig. 1 Cows in the pasture at John Gilbert's farm.

SUPPORTING HUMAN HEALTH & WILDLIFE HABITAT

# A Farmer's Perspective on Improving Water Quality

By John Gilbert, Gibralter Farms

As a conservation-minded farmer, I keep thinking it should not be that difficult to understand Iowa's water quality issues, but I am not sure. I would like to think I am using the best practices for water quality, but honestly, I cannot guarantee I am not part of the problem.

From my many farming experiences, working with soil conservation, participating in our local watershed group and listening to scientists, I have reached four conclusions, plus a fifth I fear is true.

(1) This is not a simple issue. There are no easy answers, quick fixes or magic solutions. Searching for silver bullets and holy grails just distracts from the work that needs doing. For more than a hundred years, thousands of people have made millions of decisions leading to the current conditions.

(2) We can always do more. "We" being the people on our farm in particular, farmers and landowners in general and anyone else in Iowa using water. Those of us working on Iowa's land know the recommendations: eliminate full-width tillage, use cover crops, utilize diverse rotations, manage nutrients more efficiently, employ basic conservation practices such as waterways, terraces and buffers and remove nutrients on field edges with wetlands.

John Gilbert

## Remember Three Things

For those not involved in land management, remember three things: (a) if you are not part of the solution, you are part of the problem; (b) the Golden Rule of watersheds borrowed from Wendell Berry, "do unto those downstream as you would have those upstream do unto you"; and (c) water quality must be a determining factor in who we elect to all public positions.

(3)This is not an issue that can be put off. It is tempting to be defensive. We all take pride in our farming, so it is hard not to be insulted when non-farmers put the blame on us. We all hear the frequent commercials showing farmers being good stewards, but do we all live up to the stewardship being shown? It is not fair for only farmers to take the blame, and we must all contribute to the solution.

> If you are not part of the solution, you are part of the problem.

## A Team Approach

A solution will not come from farmers alone. Government and commodity leaders need to know their dithering, denying and obfuscating are sending a dangerous message. We are saying to the rest of the world we do not have the resolve, the ability or the desire to solve complex problems. We are admitting we lack the pride and self-respect to protect our basic resources. That message is not inviting to the kind of people and businesses we would like as new Iowans.



Former Iowa governor and former US Secretary of Agriculture Tom Vilsack is the first official to publicly recognize this problem in a recent speech when he warned Iowa that there would be "hell to pay" if water quality issues were not addressed soon.

(4) We are dealing with a problem that is bigger than nitrates in drinking water (although it gets most of the press). Our problem is bigger than the other nutrients blamed for the dead zone in the Gulf of Mexico. Our water also has pathogens (often enough to limit recreation), silt and even pharmaceuticals. The problem is bigger... even bigger than the insufficient way we look after our precious soils. Our water quality issues are the tip of the proverbial iceberg. Our real problem is that we have not learned how to look after our resources and assets.

This is a holdover from the time when there was always "more" over the next ridge, in the next hole, in the next frontier. We have run out of unexplored areas and undiscovered resources, but our attitudes have not caught up. Many resources can no longer be for the "owner" to exploit and plunder. They are needed for the common good. That is certainly the case with water. The first step towards change is recognizing there is a problem. The second step is understanding that it is much easier to change rules than attitudes.

(5) Finally, the conclusion I fear is true: We are not going to make progress on water quality or soil conservation as long as we insist on full-throttle agriculture production. We are being told we have to feed a gazillion more people by 2000 something. It is a noble idea, but a mirage. If we bankrupt our soil and water feeding more mouths now, that just means more will suffer when we do exceed our ability to produce more. Mass disruptions when population exceeds the land's capacity to produce have been the history of civilizations for more than 10,000 years.

## Changing the Mentality

Adopting a production-is-all-that-matters mentality means things like soil erosion and water pollution become acceptable. This is not a viable mentality. We have built a farming system that demands maximized production, and that is the real problem. We have created structural impediments that guarantee trouble: From the farm bill to the tax code, from the reliance on two crops to the way our farms are set up, our agriculture demands all-out production. How do we change a structural problem? Not easily. The first step is to acknowledge that the problem is man-made and can be corrected. The problem with structural aspects of any business is they are well-structured; poured in concrete, set in stone. Changing them is expensive, takes time and is generally quite painful.

Much vexation is being made about the government dictating how we farm. We still have time to head off regulations, but not enough for more delays. We need to acknowledge we have problems with our current farming methods, and we are the only ones who can fix them. We can only make a difference together.

***John Gilbert farms and dairies with other family members in Hardin County along Southfork, a tributary of the Iowa River.***

Fig. 1 Jamie Benning, Water Quality Program Manager at Iowa State University Extension & Outreach, demonstrating how to use the 360 Soil Scan at a field day in July 2016. Photo from Prairie Rivers of Iowa Resource Conservation & Development.

"A JACK OF ALL TRADES IS A MASTER OF NONE, BUT OFTENTIMES BETTER THAN A MASTER OF ONE."

# Boots on the Ground in Conservation

By Hanna Bates, Program Assistant at the Iowa Water Center

Over the past year, I worked as the watershed coordinator for the Squaw Creek Watershed in central Iowa. This position is supported by the Iowa Department of Agriculture and Land Stewardship Water Quality Initiative, and housed at Prairie Rivers of Iowa Resource Conservation and Development in Ames, Iowa. This position has allowed me to work with area farmers to implement conservation practices as well as lead the planning for field days and workshops to show conservation practices at work. Watershed coordinators have a diverse skillset in which they provide technical information, financial assistance and education for conservation practices. With no two days being identical, I think the best way to describe the work is through the following observations and experiences.

Pictured, left to right: Hanna Bates, Program Assistant at the Iowa Water Center; Al Lingren, Farmer in Boone County; and Iowa Secretary of Agriculture Bill Northey at a field day in July 2016. Photo from Prairie Rivers of Iowa Resource

## It involves thinking like a farmer…

To run a successful farming operation, farmers must be agronomists, economists, marketers, veterinarians, mechanics and conservationists. To demonstrate how conservation practices can fit into a specific farm operation, one must think about how it can balance with the other goals a farmer wants to achieve and the challenges they face from day-to-day. Conservation practices can often support these goals - it is a matter of getting to know what a farmer wants to achieve and how to identify the conservation efforts that can fit within the farm operation.

## It involves having a sense of humor…

I will never forget my first farm visit as a watershed coordinator. The farmer took one look at me and asked if I was comfortable taking a walk out in his field. I shared my experiences with him as a farm kid where I spent plenty of time out in a tractor cab and was chased by cattle more times than I would care to admit. Naturally, after I attempted to prove that I was a tough farm kid, the first step I took out in the field was directly into a fox hole and I got a face full of soil. My second farm visit at a neighboring farm involved getting a sunburn from head-to-toe. Through these experiences, I got to know those two farmers well and they agreed to work with me on conservation initiatives. Of course, I will always be known as that clumsy kid on their farms.

## It involves a little creativity and resourcefulness…

Every Thursday during the winter months, I set my alarm for 5 am so that I could eat a stack of pancakes out in a farm shop long before the sunrise. Why in the world would I do that, you ask? I got word from an individual in the area about an unofficial breakfast club among a group of farmers who met and talked shop. Listening to this group of farmers allowed me to get insight into what they cared about when it came to managing their farm and their thoughts on conservation. I was fortunate enough to befriend a few of these farmers. Unfortunately, I never got the top-secret pancake recipe.

## Sometimes things work out, sometimes they don't…

It would be easy to focus on the successes and not the challenges that watershed coordinators face in their job positions. Sometimes unforeseen circumstances happen- like having a rainstorm or dangerously hot temperatures during a summer field day (in my case, both!). The important thing is that the job allows an individual to come in with a plan, learn and adjust for the next time.

## Finally, it involves establishing strong relationships and partnerships…

When starting new outreach initiatives, I was reminded of the following African proverb, "If you want to go fast, go alone. If you want to go far, go together." When it comes to providing the best service to farmers, I learned that it is important to reach out to a variety of individuals and organizations. You never know who could be helpful when you need something, or even to get the name of the best barbecue place for a field day lunch.

In the end, water quality efforts in Iowa should not only be about supporting wider environmental goals, but also about supporting an individual farmer's goals for their farm operation. More often than you would think, these goals are one and the same. Watershed coordinators have the unique opportunity to coordinate and collaborate with many people so that we may all have a resilient future for Iowa agriculture.

THE IOWA WATERSHED APPROACH

# Reducing Flooding and Advancing Water Quality

By Tom Oswald, Deputy Operations Officer, Homeland Security and Emergency Management, Recovery Division

Water runs downhill. It is a magically simple concept that starts when rain falls on the fields, pastures, timber areas, cities and towns within Iowa's many watersheds and then moves through the dendritic patterns of the Iowa landscape, eventually into the Gulf of Mexico. As the journey of water interacts with the land, water can have positive and negative impacts. Too much water can overload our rivers and saturate watersheds resulting in flooding. Flooding in Iowa in August and September of 2016 resulted in two Presidential Disaster declarations totaling more than $25 million in assistance to public infrastructure and leaving a soggy trail of damaged homes, businesses and lives.

Iowa's rural and urban landscapes hold the key to reducing future flood damage in Iowa. We can do something to reduce flooding by working within Iowa's primarily agricultural watersheds to reduce peak hydrologic flows. We can keep the water where it lands by utilizing our rich, fertile soils. With high water holding capacity and good soil health, we can increase the sustainability of our soil systems. As we work to reduce sheet and rill erosion, ephemeral erosion, soil deposition and nutrient loss we can also reduce the often tragic impacts of flooding. This is a simple idea that is now being brought to light.

Earlier last year the State of Iowa competed in a national grant competition and secured a $97 million award from Housing and Urban Development (HUD) to implement a strategy to reduce peak flows by 25-30% in targeted areas of Iowa. This competition, called the National Disaster Resilience Competition (NDRC), was based in part on significant Iowa flood disaster history from 2011 to 2013. This time frame is when Iowa received eight Presidential Disaster declarations substantiating the likelihood of future increased precipitation and heavy rainfall events.

To convince HUD that their investment in Iowa was a good decision, Iowa had to sell the concept that there is an unmistakable and undeniable link between flooding in our urban environments and future investments in Iowa's watersheds as well as private lands. Further, these investments will provide many benefits to rural and urban areas. This one-water concept was a heavy lift conceptually, but with the partnership of universities, state agencies, commodity, agricultural groups and natural resource groups as well as many others, it was accomplished. Through this effort emerged the Iowa Watershed Approach (IWA), which can be accessed through this link: http://www.iihr.uiowa.edu/iwa/?doing_wp_cron=1479738242.7071579700775146484375.

This project, while addressing flooding as a priority, is also intended to prove that strategic planning and implementation can also improve water quality, wildlife habitat and increase resilience to disaster.

The HUD criteria utilized in the grant competition led to the establishment of nine priority watersheds around the state. The grant funding supports the planning and implementation of practices to reduce flooding on a watershed basis. Each selected watershed will establish, or has established, a Watershed Management Authority (WMA) and will have a watershed coordinator. The WMA (http://www.iowadnr.gov/Environmental-Protection/Water-Quality/Watershed-Management-Authorities) can be comprised of all of the cities, counties and Soil and Water Conservation Districts within the 8-digit HUC watershed. The WMA will undertake activities including assessing and reducing flood risk, assessing and improving water quality and other watershed issues on a voluntary participation basis.

Although WMA's are the key to the planning and implementation of best practices within Iowa's watersheds, state agencies also have committed substantial resources to assist the WMAs with their plan. WMA planning activities will prioritize small sub-watershed areas (12-digit HUC) based on desired positive impacts to selected communities and the likelihood of reducing peak runoff to prevent future damages. The comprehensive watershed-based plan is comprised of three parts: a watershed plan, a hydrologic plan and a resilience plan.

The cornerstone principle of working with private landowners and producers relies on voluntary participation. Under the IWA, program delivery through the WMAs will focus on providing information and educating citizens on how to reduce flood risk, the benefits of participation to landowners and the benefit to the entire watershed. The grant provides a 75% cost-share program to work with stakeholders to locate potential projects based on hydrologic assessment, the watershed plan and stakeholder input.


Fig. 1 Map of the nine Iowa watersheds.

Projects may include: wetlands, pond terraces, buffer strips, streambank stabilization and many others. Projects will follow developed standards and specifications described by the Natural Resources Conservation Service.

Many state and government agencies will be involved with the project including: the Iowa Flood Center (IFC) at the University of Iowa, Iowa State University, the University of Northern Iowa, Iowa Department of Natural Resources, Iowa Department of Agriculture and Land Stewardship, Iowa Economic Development Authority and Iowa Homeland Security and Emergency Management. Bringing science into planning and implementation, while not new, allows for a different approach in this ambitious project.

This project is the "first-of-its-kind" in the nation and links urban flooding with the implementation of practices on agricultural lands. It works cooperatively with many groups to reduce flooding while simultaneously improving water quality and increasing overall resilience to future disasters.


A MULTIFACETED APPROACH

# Topeka Shiner Research in Iowa

By Nick Simpson, Alex Bybel and Courtney Zambory. Graduate Students,
Department of Natural Resource Ecology and Management, Iowa State University

Iowa's landscape, once dominated by meandering streams, wild prairies and marshes, underwent dramatic changes with the arrival of European settlers. Wetlands were drained, and prairies were converted into rich and productive farmland. While those alterations to the landscape allowed Iowa to become a top producer of corn and soybeans in the United States, these changes to the natural landscape presented a problem for a small minnow swimming largely unnoticed in Iowa streams. The Topeka Shiner (Notropis topeka; Fig. 1) once ranged across six Midwestern States: Iowa, Minnesota, Nebraska, Missouri, South Dakota and Kansas. Once widespread in Iowa, Topeka Shiner populations are now restricted to only three watersheds in the state, and the species was listed as federally endangered in 1998.

Topeka Shiners had been thought to prefer cool, clear, slow-moving stream pools, but that habitat has largely been eliminated from Iowa's landscape due to channelization of many streams. However, these fish were recently discovered to be present in oxbows, lakes and cattle ponds-typically called "off-channel habitats". Oxbow lakes are naturally formed when a stream meanders and curves. Over time the meandering sections are cut off from the main stream channel and form an oxbow (Fig 2). When natural meandering is prevented from occurring, oxbows are no longer created, and former oxbows eventually fill in with sediment to become "scars". During much of the year, off-channel habitats remain disconnected from the stream. However, wet periods and flooding events may facilitate movement of fish between off-channel habitats and the stream. Conversely, drought years isolate off-channel habitats and cause them to overheat, become oxygen depleted, or dry up. Luckily, the Topeka Shiner is a hardy species and can tolerate harsh conditions whereas other fishes cannot, though they too will perish if the oxbow dries up. Therefore, off-channel habitats are thought to provide these hardy minnows with additional refuge and spawning areas apart from the stream. The US Fish and Wildlife Service began working with private landowners in 2002 to restore oxbows by digging out oxbows that had silted in over time, and today, over 60 restorations have been completed (Fig. 3).


Left to right: Nick Simpson, Alex Bybel and Courtney Zambory

## Improving Understanding

Three graduate students at Iowa State University are working to improve our understanding of the lives of Topeka Shiners and what we can do to facilitate their recovery. Alex Bybel and Nick Simpson spent all of the 2016 summer field season using backpack and barge electrofishing as well as seine netting to sample streams and oxbows – both natural and restored – in the North Raccoon, Boone and Rock River watersheds for Topeka Shiners (Fig. 4).

Alex Bybel is using fin clips taken from live Topeka Shiners to investigate genetic variation of Topeka Shiners among these watersheds. Alex will also estimate genetic population structure and migration to determine how Topeka Shiners disperse in streams, which will provide information on the connectivity of populations. In addition, he will be analyzing migration rates and other measures of genetic health of restored oxbows to determine how connected these populations are to the streams. This analysis will serve as an evaluation of restored oxbows and increase the effectiveness of future restorations.

## Organizing Characteristics

Nick Simpson is compiling and organizing dozens of habitat characteristics measured during sampling, such as riparian vegetation, flow velocity, depth, substrate, bank angles and changes caused by human influence to evaluate relationships between habitat and Topeka Shiner presence. Nick is also investigating the chronology of fish assemblages in oxbows following restoration. This information will be important because it could lead to modifications in restored oxbow design or location to improve the likelihood that Topeka Shiners will inhabit these areas.

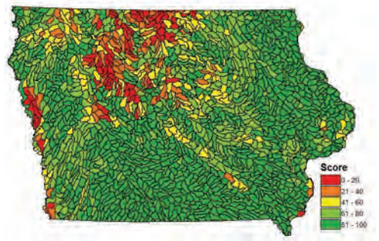



Fig. 5

Lastly, Courtney Zambory is approaching Topeka Shiner conservation from an aerial view. Using satellite imagery and fine-scale digital elevation models, she is developing a process to use Geographic Information Systems (GIS) to search the landscape to find and prioritize potential restoration sites. Additionally, Courtney is developing a watershed health assessment index for all watersheds in Iowa using Minnesota's Watershed Health Assessment Framework (WHAF) as a guide (Fig. 5). Using health scores generated for watersheds at multiple scales she will look at what stressors are most affecting areas that Topeka Shiners are located. A watershed health index for Iowa will also provide additional information to managers to help align their conservation efforts.

Together, Iowa State's Topeka Shiner team will provide much needed information about the status of Topeka Shiners in Iowa, which will be vital for biologists to ensure this remarkable little fish stays alive and well in our streams.

Fig. 2

Fig. 3

Fig. 4


Fig. 1 Members of Barb's class at Resurrection Elementary play Wetland BINGO.

WATER ROCKS!

# Teacher Summits Making a Splash

By Jacqueline Comito, PhD, Director of Water Rocks!, Iowa State University

Today's students are tomorrow's leaders. Who is talking to them about soil and water issues in Iowa? Water Rocks! is.


Jacqueline Comito, PhD

Founded in 2012, Water Rocks!, Iowa's statewide youth water awareness program educates, challenges and inspires 20,000+ students each year towards a greater appreciation of the environment around them. Unfortunately, that is only a small portion of Iowa's youth.

Our solution? We developed Water Rocks! Teacher Summits, two-day professional development workshops for Iowa's K-12 classroom teachers and non-traditional environmental educators.

Each workshop offers timely, pertinent and hands-on training on environmental and agricultural related topics. Each Summit is centered around building teachers' knowledge of water, wetlands, soil, biodiversity, climate change and more. We offer hands-on, interactive games and activities to help teach these topics in the classroom and communities year after year – the multiplier effect!

## In the Classroom

One of those classroom teachers is Barb Davis, a fourth grade teacher at Resurrection Elementary School in Dubuque, Iowa. Barb is wild about Water Rocks! after attending the June 2016 Teacher Summit. During breaks, Barb approached different Water Rocks! team members to share ideas and thoughts about using the materials with her students. Her ideas were creative and inspiring.

Once she returned home, Barb shared with the team her reflection on the Summit experience:

"From the moment I arrived to the end of the course on the second day, it was a fast-paced, informative and active meeting. The materials that were provided and given to each team were well-designed and practical for educating students on the variety of issues that were presented."

Barb took her enthusiasm back to her classroom, where she has been diligently working to incorporate Water Rocks! games, videos and activities into her lesson plans.

"I have really enjoyed digging into all the materials on the website. It was a bit overwhelming at first! No one can complain that you don't have enough resources. I spent an afternoon watching all the music videos. What a hoot! …There were so many activities and videos that work with my fourth grade curriculum that I wanted to include them all!," Barb told us.

> "So many teachers are apprehensive about teaching science. With these well-designed and age-appropriate tools, how can they not help but be excited and confident about the concepts that they are presenting!"

## Exploring Biodiversity

Her favorite Water Rocks! material is the Wonderful World of Wetlands module. Barb's fourth grade students recently finished several lessons using Water Rocks! resources to explore the biodiversity in wetland ecosystems, and the important jobs wetlands do for the natural world.

Barb's love for educating others about preserving natural resources stretches beyond the classroom. She and her husband volunteer as organizers of summer hiking and backpacking trips for Sierra Club members to mountain ranges in the Western U.S. Barb also leads her school's environmental club that involves 40 fourth and fifth graders at Resurrection Elementary.

Barb has been teaching for 23 years, and has taught students from kindergarten through seventh grade. She's been teaching fourth graders for four years, and loves how enthusiastic they are about learning! She finds that Water Rocks! activities are perfect for the age and grade level of her students.

"So many teachers are apprehensive about teaching science. With these well-designed and age-appropriate tools, how can they not help but be excited and confident about the concepts that they are presenting!"

We are ecstatic about how educator Barb Davis has worked Water Rocks! resources into her classroom curriculum. Barb and other teachers like her are helping to raise awareness with future generations on environmental issues affecting our state. We want to give Barb a great big shout out for all her hard work, and say THANK YOU for utilizing Water Rocks! to get the word out about conserving Iowa's natural resources!


## Spanning the Midwest

Since 2014, Water Rocks! Summits have educated 144 classroom teachers, 11 high school peer mentors, and 61 extension/environmental educators. The classroom teachers were primarily from Iowa, with seven from Kansas and Missouri. The non-traditional environmental educators have come from Iowa, Missouri, Kansas, Nebraska and South Dakota.

Water Rocks!, with the help of teachers like Barb, is shaping the way Iowa's next generation thinks about and cares about our natural resources. In 2016, the Water Rocks! team was recognized for their efforts as a recipient of the Iowa Governor's Environmental Excellence Award in Environmental Education.

Visit the Water Rocks! website to learn more about Teacher Summits, donating to the program or general information: www.waterrocks.org. Follow Water Rocks! on Facebook and Twitter.

Partners of Water Rocks! are Iowa State University Extension and Outreach, Iowa Department of Natural Resources (USEPA Section 319), Leopold Center for Sustainable Agriculture, Iowa Water Center, and Iowa Learning Farms.


TOPSOIL MAPPER:

# A Novel Device for Soil Mapping and Implement Control

By Michael Pregesbauer and Immo Trinks of Geoprospectors, Gewerbepark Traiskirchen, Wienersdorferstrasse 20-24, 2514 Traiskirchen, Austria

The most valuable resource to agriculturalists is typically not machinery or farm buildings, but the land that is being farmed. Typically traditional family farms have decades of experience working the land and observing crop growth and yield result in personal expertise and knowledge of the variability and capacity of the soils being farmed, while modern industrial farm businesses often lack information on soil heterogeneity. Industrialized precision farming is in dire need of detailed information about soil properties in order to permit cost- and resource-efficient site specific management.

The capability of soils to retain water and soil moisture is of vital importance for their agricultural potential. Detailed knowledge of soil physical properties including their texture, water content and depth of the agriculturally relevant horizon are of considerable importance for resource-efficient tillage and targeted intelligent application of fertilizers or irrigation.

Near-surface geophysical sensors that measure soil physical parameters permit the generation of soil maps that provide detailed information for site-specific cultivation.

Traditional near-surface geophysical prospection systems for agricultural soil mapping have either been based on earth resistance measurements that use electrode-disks, which require soil contact and have inherent issues, or electromagnetic induction (EMI) measurements conducted by devices mounted in non-metallic sledges towed several meters behind survey vehicles across the fields.

Michael Pregesbauer

Immo Trinks

## The Topsoil Mapper

Based on the fact that every farmer across the world passes over their fields several times during each growing season, working the soil and treating the crops, a novel simple-to-use soil mapping system has been developed. This system enables the farmer to simultaneously acquire soil conductivity information and derived soil parameters while passing over their fields using different agricultural implements. The measurement principle of the 'so called' Topsoil Mapper (TSM) is electromagnetic induction using a multi-coil array to acquire conductivity information along a vertical profile down to a depth of approximately 1.1 meters.

Instead of being towed several meters behind the tractor, as common with traditional EMI systems used in precision farming, the TSM is conveniently mounted on the front hitch of a tractor and operated from a terminal in the tractor cab. A major improvement compared with existing EMI devices is the system's capability to cope with the induced noise from the tractor. This is possible through integration of a mechanical shielding mechanism into the sensor housing. Any remaining vehicle induced high-frequency electromagnetic noise is filtered out 'on-the-fly' by the data acquisition software, logging the data and positioning information on a sturdy small computer. The main purpose of this system is to efficiently provide landowners or farmers with accurate maps of the soil's electrical conductivity across their fields on the acreage scale. The main objective of the measurements is to obtain detailed information on the long wavelength variability of soil structure, while eliminating short wavelength variations.

The calculation of the depth of the agriculturally important topsoil has been implemented by inverting the three measured soil conductivities and delivering the vertical distribution of agriculturally relevant soil parameters, such as relative water content and soil texture. The assumption of a layered earth, sufficient contrast in soil conductivities between the layers and sufficient thickness of the layers are prerequisites for this approach. The soil can be classified using libraries linking the apparent conductivity measurements with soil texture, as well as local calibration measurements.

Fig. 2 Real-time depth-control of agricultural implements for sub-are specific soil cultivation.

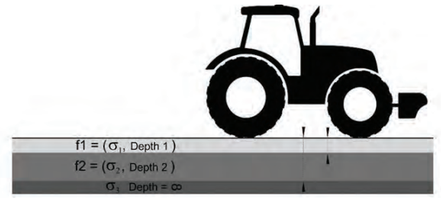



Fig. 1 2D inversion of the measured apparent soil conductivity to derive distributions maps of soil texture and relative soil water content.

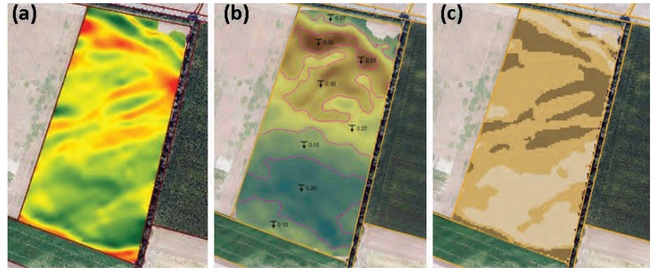



Fig. 3 Map of lateral conductivity variation. (b) Depth of the compacted zone in centimeters. (c) Soil texture zoning. The example illustrated in Figure 3 presents an EMI survey with the TSM of circa 9.6 ha (23.7 acres) of area with 6 m (20 ft) profile spacing. The map of the lateral conductivity variation shows the soil variation caused by a former channel of a meandering river. The depth of the compacted zone as well as the soil texture were derived and mapped. These results were validated using test excavations at selected locations (Fig. 4) as well as the measurement of a number of 2D ground-penetrating radar (GPR) profiles. The excavated soil profiles confirmed the depth of the A-horizon determined by EMI survey within ±4 cm accuracy.

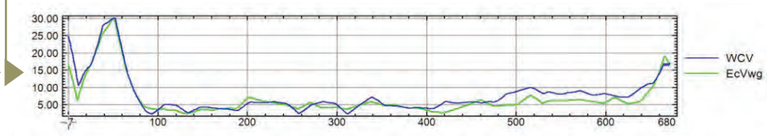

Fig. 4 The comparison between the profile section and the TSM measurements show an accuracy of ± 4 cm.

Fig. 5 Comparison of water content variation (WCV) derived from TSM survey and measurement with GS3 probe (EcVwg).

The depth of the A-horizon determined by GPR measurements using a 500 MHz Sensors & Software pulseEkko Pro antenna system and a constant GPR signal velocity of 10 cm/ns agreed on average with ±4.5 cm with the depth derived from the EMI survey.

Additionally, along test profiles the variation of water content derived from the TSM was compared against water content measurements conducted with a Decagon GS3 probe, with good agreement observed.

By providing depth-to-interface, soil texture and water content information in real-time, the farmer can utilize site-specific tillage depth or control agricultural implements such as cultivator or subsoiler, based on the derived information. This can render soil cultivation both ecologically and economically more efficient, considerably enhancing work performance and drastically reducing fuel consumption.




WCV (Water Content Variation pursuant TSM calculation);
EcVwg (water content pursuant GS3 Probe)

Fig. 1

FROM STREAM TO SCREEN

# Iowa Water Quality Information System

By Chris Jones, IIHR Research Engineer, IIHR-Hydroscience and Engineering, The University of Iowa

Chris Jones

University of Iowa IIHR Hydroscience and Engineering is bringing water quality out of the shadows and onto your computer screen. Iowans can now access real-time water quality data using IIHR's new suite of online tools, the Iowa Water Quality Information System (IWQIS). A network of in-stream water quality sensors across Iowa gathers the data and relays it back to IIHR where the information is presented in a user-friendly online interface. Landowners and other stakeholders can see the real-time data and trends over time, compare different sensors, overlay the water quality information with precipitation and streamflow data and more. A tutorial is available on the IWQIS launch page: http://iwqis.iowawis.org.

## Real-time Nitrate-nitrogen Measurements for the State

The IWQIS monitoring network includes about 60 sites. This includes 41 IIHR sensors, 14 United States Geological Survey devices and five sites sponsored by the USDA's Agricultural Research Service. Coverage includes all the state's major rivers. For the first time, researchers at IIHR and elsewhere can quantify the total amount of nitrate leaving Iowa in the state's rivers on a daily basis. This will be critical information as scientists and policy-makers move toward meeting Iowa's water quality goals.

## Monitoring Iowa Nutrient Reduction Strategy Effectiveness

The monitoring network and associated data make it possible for Iowans to use a science-based approach when making decisions that affect water quality. Scientists and stakeholders are tracking stream data with IWQIS to assess the effectiveness of Iowa Nutrient Reduction Strategy conservation practices and progress toward water quality objectives. IIHR is assessing nitrate-reduction strategies such as cover crops and constructed wetlands. Tracking both water quality improvements and progress toward practice implementation is critical as we refine our production systems for environmental performance.

## Available Data

IWQIS users will find an abundance of tools that assist in data interpretation. Nitrate data can be displayed in several different ways:

Concentration: This is reported as milligrams per liter (mg/L). Concentration is the amount or mass of a substance per unit volume.

Load: The total mass of a pollutant carried by a stream over a defined period of time is the load. This is reported in pounds per day. The accumulated load for the year to the present date is also shown. Both load and concentration are good for comparing different years in one watershed. Some data dates back as far as 2012.

Yield: This is the load per watershed area, reported in pounds per acre. The yield function in IWQIS is a good tool for comparing multiple watersheds.

## Other Parameters

Other information is available beyond nitrate data. At about half the sites, data is available for dissolved oxygen, turbidity (cloudiness), specific conductance (a measure of how salty the water is), pH, water temperature and discharge (volume). A guide to the different parameters and their importance to overall water quality is available on the site.

The site also includes a watershed mapping tool that delineates the land area draining to the sensor. Land cover, such as the area in corn or forest, can also be displayed for the watershed area.

## How are Monitoring Sites Selected?

Sites are selected based on several factors:

Sensing equipment is partially funded specifically for a research proposal or project in a selected watershed.

Major interior river sites are selected based on their importance for nitrate load estimations.

Stream's significance for recreation, municipal water supply or other uses.

Site suitability for sensor equipment, i.e. security and water depth.

Requests from outside stakeholders.

The number and location of IIHR monitoring sites varies from week to week depending upon research needs, equipment maintenance and other factors.

## The Power of Water Monitoring

As we move forward with the Iowa Nutrient Reduction Strategy, IIHR researchers believe science-based water quality monitoring is needed because it integrates landscape practices, weather and policy changes to provide an unbiased measure of success. We at IIHR believe that true progress for meeting our water quality goals can only be credible if it includes robust water monitoring. The IWQIS system provides the latest in measurement and data reporting technology to make monitoring available to scientists, policy makers and the public at large.

## About IIHR

Situated on the Iowa River at the University of Iowa campus in Iowa City, Iowa, IIHR Hydroscience and Engineering seeks to be a research leader in hydraulics, hydrology, water quantity and water quality and to educate students to be future leaders in these areas. The education IIHR provides, combined with hands-on engineering practice, attracts a vibrant international mix of students and faculty with a rich variety of interests.

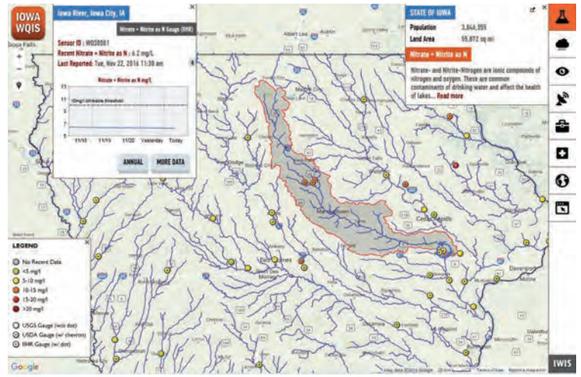



Fig. 2 An example of the IWQIS tool highlighting a watershed


Fig. 3 Tom standing near a research site

Fig. 1 Downtown Des Moines

A Q & A WITH BILL STOWE AND FARMERS FROM CALHOUN, SAC, AND BUENA VISTA COUNTIES

# An Inside Perspective on the Des Moines Water Works Lawsuit

Questions by Hannah Corey, Getting into Soil and Water Co-Editor

In March of 2015, Des Moines Water Works (DMWW), the utility which provides water to the Des Moines area, filed a lawsuit against the drainage districts in three counties in the Raccoon River Watershed--Calhoun, Sac, and Buena Vista. DMWW alleges that the agricultural runoff from these three counties is violating the Safe Drinking Water Act because their agricultural runoff and tile drainage contributes to the abnormally high nitrate concentration in the Raccoon River, one of the sources of water for DMWW.

Bill Stowe

The "Getting into Soil and Water" editing team wanted to give our readers an inside perspective on the lawsuit based in science, not politics or emotions. We asked Bill Stowe, CEO and General Manager of DMWW, as well as four farmers from Calhoun, Sac and Buena Vista counties to independently answer the same set of questions regarding nitrates and the lawsuit. Here is what they had to say:

### What practices do you employ to reduce nitrate levels in the water?

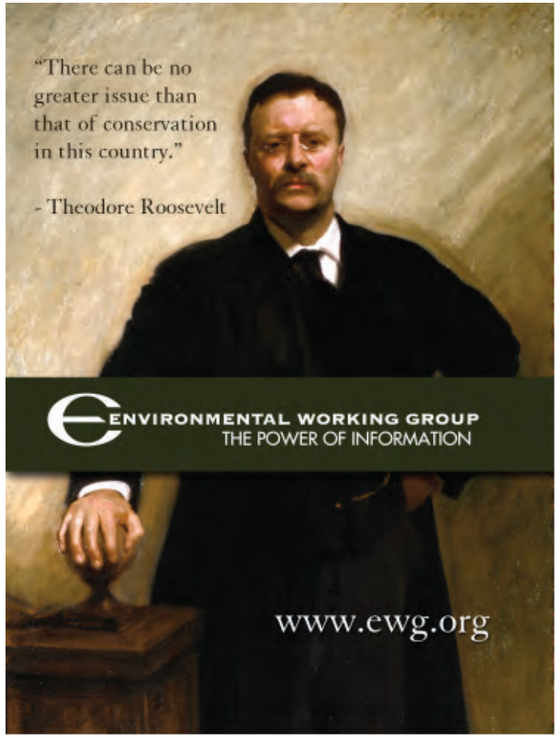
Bill: Under the Safe Drinking Water Act, the United States Environmental Protection Agency (EPA) sets standards for maximum contaminant levels for various contaminants in finished drinking water. DMWW is required to produce drinking water that contains 10 mg/L or less of nitrate. On occasion, nitrate levels spike so high in the source water coming from the northern parts of our watershed that we must divert some of the water to a nitrate removal facility. The facility ran continuously for a record number of days in 2015 – 177 days, at a cost of $1.5 million, which was paid by DMWW ratepayers. DMWW also relies on natural methods of denitrification, including wetlands and off-river storage in ponds and quarries.

Farmers: Over the years we have cut nitrogen fertilizer application rates from previous levels. We have also experimented using total sidedress with lower rates and split shot applications. We use N-serve, a nitrogen stabilizer that slows the conversion process of ammonia to nitrate, to keep nitrogen in the soil longer,make it more available to the plant when it needs it most and prevent leaching. We have also used cover crops and experimented with alternative crops that require less nitrogen.

Additionally, other farmers mentioned using conservation tillage, strip tillage, buffer strips and testing young corn plants to decide on nitrogen rates to apply.

### What barriers or limitations do you have to work around in trying to reduce nitrate levels in the water/increase your conservation practices?

Bill: The watersheds from which DMWW draws its source water are some of the most heavily tile-drained acres in the nation; nearly 78% of the land in the North Raccoon Watershed is artificially drained. Sixty-one percent of Iowa's drainage districts dump into DMWW's source water. DMWW has a long history of collaboration in the Raccoon River Watershed with no measurable improvement in water quality to show for it--hence the lawsuit.




Farmers: Split shot or total sidedress applications can be difficult to perform in timely manners if the weather does not cooperate, and timing can severely affect the crop's efficient use of nitrogen, causing yield limitations. Proper drainage has also been targeted as a cause for high nitrate levels in rivers and streams. Without tile drainage in this area most of the land would not support crops.

The two biggest barriers are our soil types and Mother Nature. We have many different soil types in our area that take different farming methods to manage.

Our northern latitude makes it difficult to get cover crops established well before winter sets in. Nobody around here grows small grains which allow for early crop planting. We farm poorly drained soils that run the risk of staying saturated in spring if they are not tilled and cover crop residue is present.

### What economic challenges have motivated your decisions concerning nitrate removal and conservation practices?

Bill: DMWW operated its nitrate removal facility for a record number of days in 2015 at a cost to our customers of $1.5 million. Data and studies call for construction of additional nitrate removal treatment (expansion of existing nitrate removal facilities and constructed wetlands), at a cost of $80 million. Meanwhile, agriculture commodity groups continue to ask for "more time". DMWW will continue to invest in infrastructure, work for source water restoration and protection and pursue a course of litigation until large-scale change occurs in our watershed.

Farmers: Economic factors have been the biggest challenge. Nitrogen application is one of the most important factors for growing a good corn crop. Many times a small increase in nitrogen can increase yield to allow our operations to profit.

Farming has to work economically as well as environmentally or I will not be in business long.

I see it as just the opposite, it is an economic benefit. The practices we use are beneficial to our bottom line.

### What changes have you seen in nitrate levels/ conservation practices in Iowa over the past 20 years?

Bill: Nitrate concentrations have climbed over the past three decades (See Fig. 3 on Page 34). DMWW is required to produce water that meets and/or exceeds EPA standards every day--regardless of rainfall or land use practices in our watershed. Doing so becomes costlier and more difficult every year.

Farmers: With new technologies and more information becoming available, we are seeing reduced nitrogen application rates compared to 20 years ago. Years ago the attitude was "more is better", but that is slowly fading away as we are seeing more efficient nitrogen use that will provide the crop with the same potentially profitable yields.

I have seen more conservation tillage practices that reduce water erosion and runoff. Cover crops are becoming more widely used as well.

Continued on Page 34

**Have you seen a change in the way conservation practices are perceived in Iowa since the lawsuit was announced? (i.e. are they now seen as more of a necessity?)**

Bill: Our lawsuit has opened the door to unprecedented dialogue about the costs of unregulated industrialized agriculture and its off-site impacts. Students of soil and water restoration are on the cutting edge of solving some of the world's most perplexing challenges using innovative technology, effective public policy and stronger environmental law.

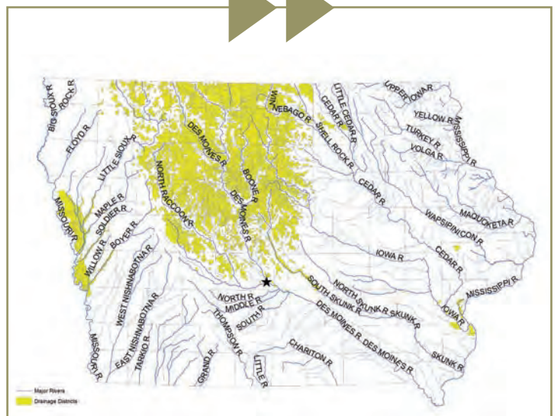


Fig. 3

Farmers: The lawsuit has opened up more of a discussion on the positive impacts of conservation practices and how they can reduce the nitrate levels in the water.

It seems to have generated a lot more conversation. People talk about practices going on and how they are either good or bad for reducing nitrate levels. Over the last two years there has been a large increase in the amount of cover crops planted.

Some farmers are becoming more proactive, but I believe they were more conservation minded from the beginning. Other farmers are thinking more about conservation practices, but out of necessity, because they believe they will be forced to change eventually. There are some who will not change practices until forced to.

**If greater regulation on runoff from agricultural land and tile drainage were to be enforced, what would you see as positive and negative impacts?**

Bill: If DMWW prevails in its lawsuit, drainage districts will be recognized as point source polluters and will be required to obtain permits to discharge into public waterways (including groundwater effluent from tile outlets). Drainage districts and landowners will decide how to meet standards imposed by those permits.

This is a win-win, outcome-based approach tailored to the landscape. As with any new endeavor, changing attitudes and behaviors will be a challenge.

Farmers: Regulations have a way of sounding good, thinking that we will level the playing field for all farmers. Too many times they end up being a burden to those who abide by them, and become a bureaucratic nightmare to try and enforce on those trying to find ways around them.

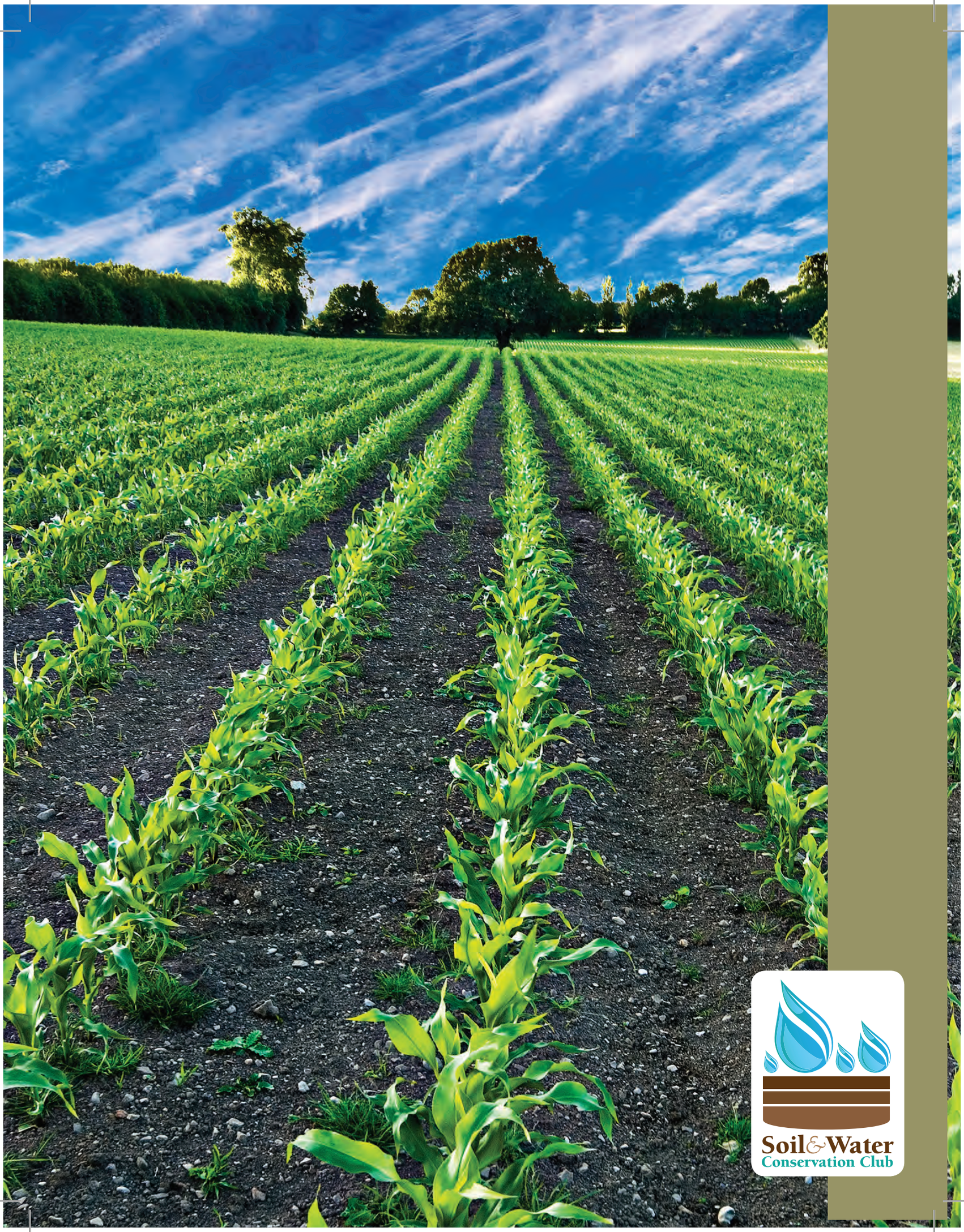
Mandates concern me when producers are losing money and agronomic challenges are different from one area to the next. Not one program will fit all acres. I feel a lot of absentee land owners will not want to spend any money on conservation or water quality practices, and the farmer is not always able to afford said practices.

**What additional comments do you have on the subject?**

Bill: Our mission to provide safe drinking water will require collaboration to restore and protect our source water; regulation to ensure basic health standards are met; and unfortunately, litigation when the largest contributors of nutrient pollution make the choice to continue polluting.

Farmers: In the end, we are trying to find a balance between being good stewards of the land, remaining profitable in order to survive and raising feedstuffs in order to feed a growing population.

Though Bill and the farmers have differing opinions on some aspects of the lawsuit, they do seem to agree on one thing: This lawsuit has gotten people talking about water quality in Iowa. No matter which side of the lawsuit you stand on, water quality impacts your life. So please, keep this conversation going. Intelligent discussions and healthy arguments have a way of creating solutions.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