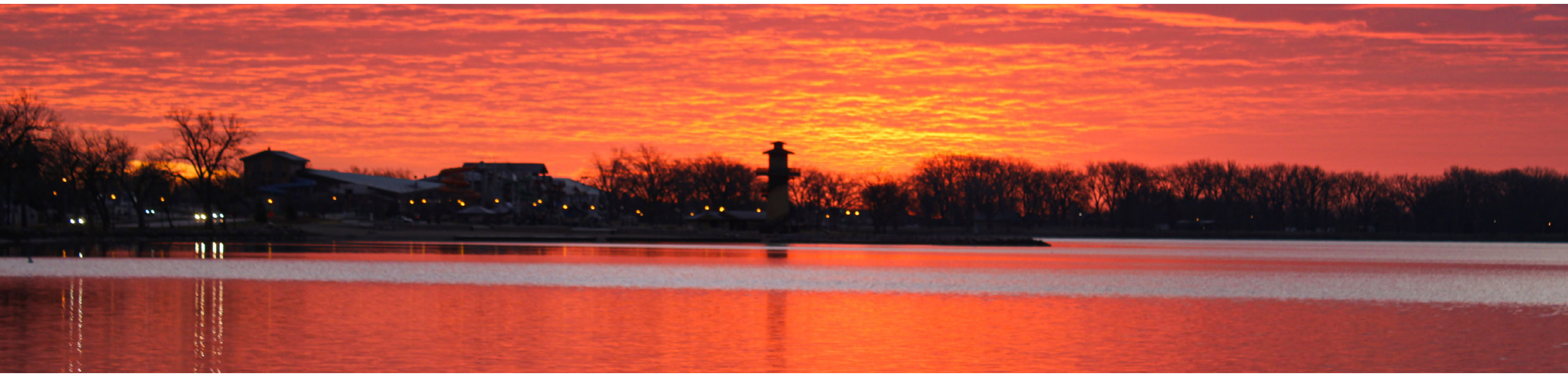
Getting Into Soil and Water

2023

Soil & Water Conservation Club at Iowa State University



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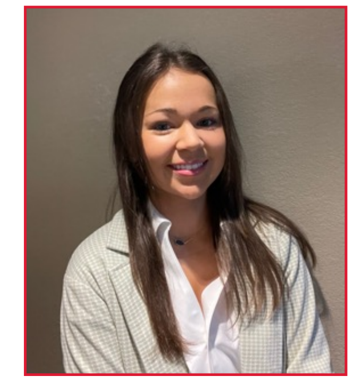
Meet our Editors

Courtney Harle
I am a junior with a double major in Agronomy and International Agriculture, and I joined the Soil and Water Conservation club in the Fall of 2022. I grew up in Kanawha, IA on a row crop operation and have always had a love for the outdoors. It has been an incredible joy to work with the authors and learn about the research and practices being implemented to protect this land's resources.

Emily Kihlstrom
I am a freshman studying Agronomy and I joined Iowa State's Soil and Water Conservation Club in the Fall of 2022. I grew up in Avon, Indiana, and while it's not a farming area I always had a passion for conservation and protecting the environment. When I came across the Soil and Water Conservation Club, I knew that I wanted to join and discover new ways that people are protecting the environment and how we could do better in the future. It was great to work as a co-editor for this issue of Getting into Soil and Water as I got to learn from those making new and thrilling strides in the world of soil and water conservation.



Hailey Sandeen
I am a senior majoring in Agronomy, where I will also attain a Soil Science certificate. I joined Iowa State Soil and Water Conservation Club last year and assumed responsibility for editing this article this past fall. I joined this club to learn more about soil conservation from experts currently practicing and networking with my peers. I plan to attend The University of Kentucky in fall 2023 to attain my master's in integrated plant and soil science. This club has inspired me to follow this path, and hearing from some of the authors in this article has made me even more inspired to do so.

Lydia Brown
I joined the Soil and Water Conservation Club in the fall of 2021 when I transferred to Iowa State University. I am now a senior in Agronomy and hope to return to my family farm in eastern Iowa. I wanted to help edit this issue of "Getting into Soil and Water" because I am always inspired to hear from the many people who are trying to better understand and protect Iowa's natural resources.

Megan Blauwet
I am a senior in Agronomy, and I joined the Soil and Water Conservation club in the Fall of 2019. I have been a part of this publication for multiple years and always enjoy seeing the new topics and articles shared. I plan to attend graduate school this upcoming year in soil microbiology so I especially enjoy reading the articles related to that. I love being able to continue learning about relevant soil and water conservation topics through this publication.

We remain dedicated to soil and water conservation education

The Iowa Nitrogen Initiative:
Advancing nitrogen fertilizer recommendations through a public-private partnership with Iowa's farmers

By Melissa Miller, *Project Director, Iowa Nitrogen Initiative*,
Dr. Sotirios Archontoulis *Associate Professor of Agronomy, Iowa State University*,
and Dr. Michael Castellano *Professor of Agronomy*

"In partnership with farmers and their advisors, researchers at Iowa State University are conducting hundreds of nitrogen rate trials to develop real-time, localized, and customizable information to help farmers understand and apply the right nitrogen rates."

Iowa corn farmers are the best in the world in terms of productivity and environmental performance.

Weather uncertainty and spatial variability around the optimum rate of nitrogen fertilizer application, one of the costliest inputs for corn production, increases risk of profit loss, yield loss, and negative environmental impact. **Research conducted by Iowa State University shows the optimum rate of nitrogen can vary up to 100% (Puntel et. al., 2016; Poffenbarger et. al., 2017), both spatially (across fields) and temporally (within fields, from year to year).** New scientific advances, including research and technology, can solve this problem. Precision agriculture technologies now allow massive experimentation that can measure the actual optimum nitrogen input in hundreds of fields every year, but such data have not yet been collected at scale. At the same time, Iowa State University has become a world leader in the development of mathematical representations of cropping systems performance under specific conditions, a research domain known as cropping systems modeling.

The Iowa Nitrogen Initiative is a new project that aims to leverage precision ag and cropping systems modeling to reduce the uncertainty around nitrogen fertilizer recommendations and to provide Iowans with the best nitrogen science and recommendations for increased productivity, profitability, and environmental performance. In partnership with farmers and their advisors, researchers at Iowa State University are conducting hundreds of nitrogen rate trials to develop real-time, localized, and customizable information to help farmers understand and apply the right nitrogen rates for their operations as it varies with the weather, soil, genetics, and management.

Our first goal is to establish a robust nitrogen rate trial database that ensures farmer anonymity and data protection. This database will be the foundation for researchers to develop:

- A web-based benchmarking system that allows access to anonymized outcomes of on-farm nitrogen fertilizer rate trials every year.
- Real-time, web-based forecasting systems that allow farmers to visualize how current weather and crop conditions compare to past years.
- End-of-season, web-based hindcasting systems that allow farmers to understand how different management choices and weather scenarios would have impacted yields and nitrogen management.

Reflecting on the 2022 crop year

In 2022, Iowa experienced a drought summer for a fourth consecutive year. Despite that, corn yields were only two bushels per acre below last year (which was a record year) and are still close to the historical yield trendline. In 2022, 150 nitrogen rate trials were conducted in Iowa through the Iowa Nitrogen Initiative. The trials captured many different regions in Iowa, and in a subset of trials, we investigated the effect of plant density, genetics, tile drainage, and residue removal on the optimum nitrogen rate.

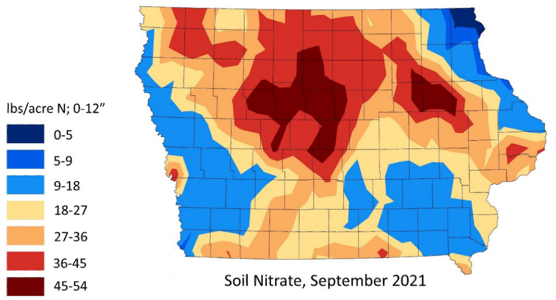
Data analysis is still in progress, but preliminary analysis of the 2022 data indicates:

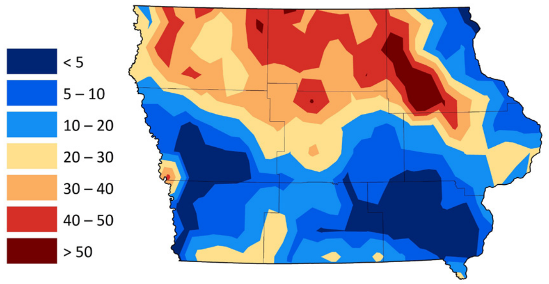
1) highly variable economic optimum nitrogen rate (EONR) across space (120 to 250 lbs N/ac)

2) lower EONR in fields with tile drainage than undrained fields

3) increased nitrogen use efficiency with increased plant density.

Model simulations for all of Iowa (n=2,500 fields) indicate similar residual nitrate (at crop harvest) as in the past five years.





Aerial view of a small plot nitrogen rate trial. Photo furnished by Premier Crop Services.

Looking ahead to 2023

As of December 2022, approximately 75 nitrogen rate trials have been established on Iowa fields. Farmers can still participate in the 2023 trials by incorporating a variable nitrogen rate prescription into their spring or late-season applied nitrogen.

Trials are conducted within a small plot within the field, typically four to seven acres. The size and location of the trial are dependent on factors like the shape of the field, areas of consistent yield (either high or low), the width of the applicator, and the direction the equipment travels in the field. The farmer works collaboratively with their preferred retailer and ISU to determine the rates to be tested. A typical trial will test five nitrogen rates, 30 to 60lbs apart, in five different random replications within the plot area.

Once the trial is established (by applying the nitrogen according to the variable rate prescription), the farmer or their preferred retailer sends ISU the as-applied nitrogen data.

After the field is harvested, the farmer sends yield data to ISU. This data, along with information like hybrid, plant population, soil management, plant and emergence data, and herbicide and fungicide use will be anonymized and compiled to populate the trial database. Farmers will receive an analysis of their trials after harvest.

To learn more about the Iowa Nitrogen Initiative, please visit agron.iastate.edu/ini.

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Building Conservation Partnership in Diverse and Changing Landscapes

By Josh Balk, *Watershed and Source Water Coordinator with the Iowa Department of Natural Resources*

"We all live in a watershed, and we all have a role to play"

There are many buzzwords and catchphrases used in the realm of conservation. Two of my favorites are "Culture of Conservation" and "One Watershed Approach." A commonality between these is the acknowledgment that there is much work to be done and that it takes everyone getting involved. It also identifies that no conservation project is too small, as each step serves to inspire others and culminates in the larger goal.

The Dry Run Creek Watershed Improvement Project (DRCWIP) began in 2005 focusing on two state-designated water quality impairments (stream biology and bacteria) in Cedar Falls, Iowa. With an almost even split of urban and rural land, engaging all stakeholders has served as an essential tenet to our efforts. Over the last 17 years, we have had the opportunity to work with homeowners, businesses, educational institutions, conservation groups, municipalities, farmers, and landowners. These fruitful partnerships have helped DRCWIP to reach targeted milestones along the way and stay on track toward our overall watershed goals. One particular initiative has seen a growing impact.

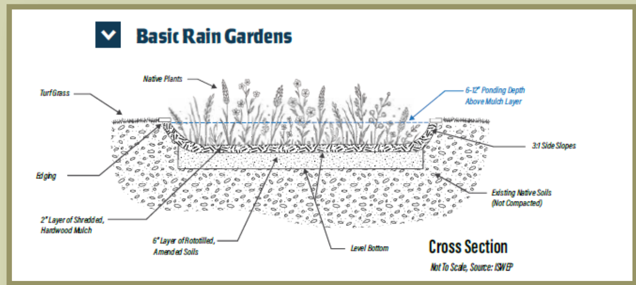
Many buildings have gutters and downspouts to help move the rainwater away from their foundation. This stormwater runoff then traverses the land, picking up pollutants – excess nutrients from lawn fertilizer, bacteria from pet waste, hydrocarbons in gas and oil, and many other water-soluble chemicals. Most of the time, this runoff flows to a municipal storm drain system. This conveyance is largely untreated and outlets directly to a creek, pond, lake, or river, adding those contaminants into the waterbody. Urban conservation practices like rain gardens aim to intercept this system, temporarily ponding the stormwater in a shallow landscaped depression, providing a chance to infiltrate through the soil, and naturally remove pollutants through biological processes. Rain gardens are custom-tailored for each landowner to meet their aesthetic preferences, budget, and landscape.

We have many qualified landscapers in the Cedar Falls area but were only seeing one or two rain garden installations each year. To ramp up implementation, we sought to engage our local partnerships and involve the community. In the last five years, DRCWIP trained over 300 volunteers on the benefits of these very effective conservation practices and used their support to install 34 rain gardens. Landowners get a product at a fraction of the cost compared to a professional landscaper, local citizens take an active role in the improvement of their community's water quality, and our limited grant dollars stretch a bit further. It's really a win-win for all groups involved. While the installations are small, the culmination of these volunteer rain gardens is treating over 275,000 gallons of stormwater in Dry Run Creek every year! Having many installations scattered throughout the watershed also provide higher visibility and increased awareness to inspire further homeowner involvement. Here in 2023, we could have over ten volunteer rain gardens installed alone, a true milestone for our conservation efforts and a testament to the power of small-scale conservation having a significant impact.

The intent of this article is not to brag about how great the Dry Run Creek is or hoist ourselves up on a pedestal. It's to highlight the power of partnership and the replicability of such a program in your community. There are students, volunteers, retirees, conservation groups, and general citizens throughout our great state and beyond who are concerned about their water quality, who recreate in and around our rivers, lakes, and streams, who desire it to be a bit cleaner for their use and generations to come, who are looking for tangible actions they can undertake to have an active role in their watershed, and who want to help out their neighbors. While every community might not have a dedicated watershed improvement project or a local municipal cost share program to provide homeowners with funds, these are low-cost urban conservation projects, and there are technical resources readily available to all (such as the Iowa Rain Garden Design and Installation Guide). With the modest cost and materials involved for rain gardens as well as their wide-scale applicability, they really can be a small first step towards impactful change.

We all live in a watershed, and all have a role to play. While small actions like a rain garden may only be a drop in a bucket, we can be part of a tidal change of water quality improvement regardless of where we live or work. By each doing our part and emphasizing the true value of this resource, we create a culture of conservation and inspire those around us.

Volunteers with the Green Iowa AmeriCorps program celebrating a successfully constructed residential rain garden. This project will help to treat some 23,000 gallons of stormwater each year.



Rain garden cross section (Source: Iowa Stormwater Education Partnership, Iowa Rain Garden Design & Installation Guide)

"Team Dry Run Creek" with representation from the Black Hawk Soil and Water Conservation District, Natural Resource Conservation Service, Iowa Department of Agriculture and Land Stewardship, Iowa Department of Natural Resources, and local advisory board.

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From Rump to Runoff -
Antimicrobial Resistance in Agricultural Ecosystems

By Laura Alt *Postdoctoral Researcher, Agricultural and Biosystems Engineering, Iowa State University*

"The emergence, evolution, and spread of antibiotic resistant pathogens represents one of the world's most urgent public health crises. In agriculture, numerous pathways exist for AMR to develop and spread."

Have you ever gone to work, encountered a coworker who was feeling just a little bit off, and now a couple days later you find that you're sick? Illness is never fun, but when it's caused by a bacterial infection, we often find that a trip to the doctor and a round of antibiotics can have us quickly on the mend.

Now picture the same scenario, only this time your prescribed antibiotics don't work nearly as well, and you remain sick. Your doctor discovers that the bacteria causing your illness are resistant to the previously effective antibiotic, meaning this treatment will no longer clear your illness. While there are other options to use second- or third-line antibiotics, as you move down this chain you find the treatments become more intense, have higher costs, and can take longer to have you feeling better.

Antimicrobial resistance (AMR) describes the ability of a microorganism (bacteria, fungi, virus, or parasite) to survive and grow in the presence of an antibiotic, or other antimicrobial drug, to which it was once sensitive or susceptible. While AMR is not new, it is a growing problem. In 2014 the Review on Antimicrobial Resistance estimated that 700,000 people died annually from infections caused by resistant microorganisms (O'Neill, 2014). More recently, in 2019, a systematic analysis estimated that 1.27 million annual global deaths were directly attributable to bacterial AMR (Murray et al., 2022).

Daunting predictions have indicated that without sufficient action, a post-antibiotic era could occur within the 21st century (WHO, 2014). The emergence, evolution, and spread of antibiotic resistant pathogens represents one of the world's most urgent public health crises.

AMR and Agriculture

In agriculture, numerous pathways exist for AMR to develop and spread. One specific pathway involves the excretion of resistance contaminants in animal manure that is then used as a fertilizer on crop fields (Figure 1). Briefly, antimicrobials, predominantly in the form of antibiotics, are commonly administered to production animals. While often necessary, this use of antibiotics also creates an opportunity for bacterial resistance to develop in the digestive system of these animals. As a result, resistant bacteria and undigested antibiotics can be expelled in the animal's manure. Frequently used as a fertilizer on crop fields, this manure becomes susceptible to downstream transport where reservoirs of resistance can form in recipient soils and waters, and human exposure can occur.

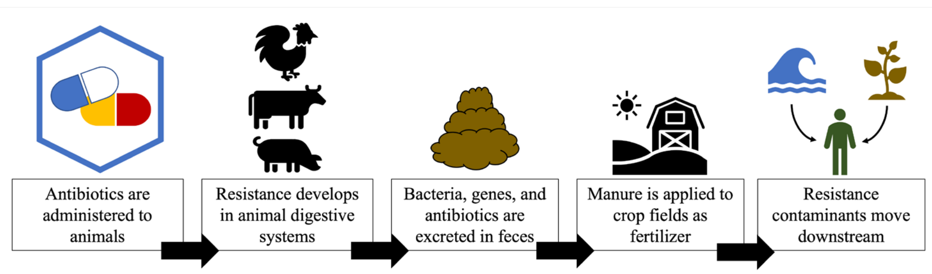

Figure 1. A descriptive illustration of resistance movement to and from agricultural fields.

As a contaminant of emerging environmental concern, the occurrence, transport, and fate of resistance contaminants have been increasingly monitored within agriculturally impacted water systems over the last decade. Through these efforts, researchers and lawmakers have now begun to propose solutions aimed at reducing agriculture's contribution to AMR.

Management Solutions

When considering management solutions to alleviate the input that agriculture has on AMR, sometimes it's easier to look broadly at the system's inputs and outputs. For example, the field application of animal manure represents an environmental input, and the resistance contaminant concentrations at downstream recreational areas are an output. In order to reduce the amount of resistance contaminants at the output, we must target a multitude of spots along the AMR pathway.

Starting upstream, the responsible and monitored distribution of antibiotics to production animals could reduce the initial selection for resistance. For example, regulations like the Veterinary Feed Directive have banned the use of certain antibiotics for production purposes (e.g., growth promotion or increased feed efficiency) in livestock and have brought the use of these antibiotics under the strict supervision of licensed veterinarians (FDA, 2021).

Further along the pathway, the management and conscientious application of manure both represent ways to limit the initial introduction of resistance contaminants into surrounding environments. Strategies including anaerobic digestion, aerobic composting, heat treatment, solid/liquid separation, and liming are all currently being investigated for their abilities to reduce the concentrations of resistance contaminants in livestock manure.

Finally, once introduced into the environment, various best management practices are being considered to limit the transport of resistance contaminants downstream. For example, one strategy has come through a partnership with the STRIPS (Science-based Trials of Rowcrops Integrated with Prairie Strips) team at Iowa State University. Promising research has demonstrated that the use of prairie strips within, and at the edge of, manured fields can help mitigate the movement of resistance contaminants downstream (Figure 2).

AMR is an adaptive challenge and a One Health issue, connecting the health of animals, humans, and the environment. Effectively addressing AMR will require collaborative efforts between researchers, policymakers, and stakeholders and targeted changes to traditional management.

Figure 2. An aerial view of an in-field prairie strip (Photo credit: Omar de Kok-Mercado – Iowa State University).

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What is Green Stormwater Infrastructure, and how can it help?

By Gregory H. LeFevre *Associate Professor of Environmental Engineering*

"Green Stormwater Infrastructure helps more closely emulate the pre-development water characteristics by keeping rain closer to where it falls, and then infiltrating it into the ground or filtering it before releasing to streams."

When it rains it pours!
And, if you are located in a place with a large amount of "hard" landscape or impervious surfaces like roads, roofs, parking lots, etc. much of that rain doesn't actually soak into the ground but rather creates runoff. Unlike natural areas like prairies and forests where much of the rainfall soaks into the ground, urban areas where people often live are full of impervious surfaces—and therefore can generate a significant amount of runoff. Runoff from impervious surfaces in urban areas is called stormwater. Excess stormwater runoff can cause flooding—both localized in people's basements and can contribute to larger regional dangerous floods. In some older cities, when stormwater was collected (either on purpose or accident) it went to the sewage treatment plant—and floods there can cause the treatment plant to overflow and send raw sewage into waterways or back up into homes. Obviously, that's bad!

People have long been concerned about trying to avoid the negative effects of stormwater. Engineers have built stormwater infrastructure that historically has tried to move stormwater away from people as quickly as possible through a network of concrete pipes and collections systems. This 'grey' (the color of concrete) infrastructure does transport water away, but that rapid movement of water can lead to flooding elsewhere and intensify flows that cause stream erosion. Later, stormwater 'ponds' were used to try to hold back water and then slowly release the water to decrease the intensity of peak flows. Ponds also can help remove some particle-associated pollutants by settling. However, removal of dissolved pollutants is limited, and ponds don't decrease the total volume of stormwater generated (they only release it more slowly).

In addition to runoff generating excess water quantity, stormwater also can negatively impact water quality. When stormwater runs off of impervious surfaces, it collects pollutants that have accumulated there along the way. Examples of these stormwater pollutants include excess nutrients from fertilizers, pesticides, vehicle-related compounds, road salts, etc. When stormwater transports these pollutants to local water bodies, it can degrade the water quality by using up oxygen in the water or adding chemicals that can impact ecosystems or local drinking water systems.

What is Green Stormwater Infrastructure (GSI)? GSI is a set of built and management practices that are designed to more closely emulate the natural, pre-development hydrologic system. GSI often emphasizes infiltration (soaking into or through) the ground to help decrease the total volume of runoff exported—keeping rain closer to where it falls. This approach helps recharge groundwater much more like a natural ecosystem and can also help remove many more pollutants while slowing down water flows.

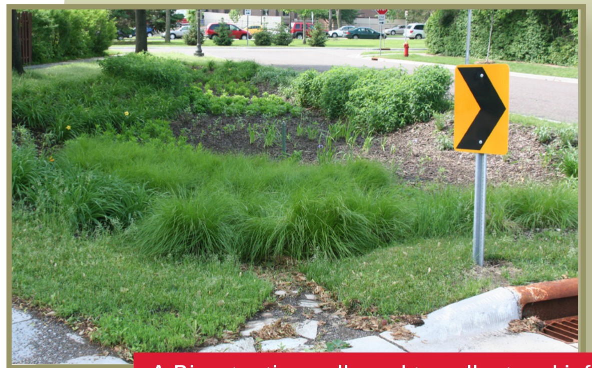
There are many types of GSI—and you may have passed some without even knowing it! Examples might include bioretention cells/raingardens, rain barrels, infiltration trenches, or green roofs. Most of these GSI practices use some sort of 'engineered soil' mixed with sand to make infiltration go faster (many urban soils are compacted). Water needs to infiltrate in about 3 days so that mosquitos cannot breed, and faster infiltration allows more land area to drain to the GSI. The hydraulic loading ratio is the area of land (parking lot, roof) that drains to a given area of GSI practice and is usually about 5:1 to 20:1—thus higher infiltration rates are important to not overflow the system! Some GSI practices infiltrate directly into the ground, while others have man-made structures like underdrains to collect water from the bottom after being filtered or overflows, which act as a bypass to a pipe in case of high flows to keep the GSI from flooding. Engineered soils not only increase infiltration but can also help remove more pollutants. Some particle-associated pollutants get filtered, some will adsorb or chemically "stick" to the soils—but some pollutants, like road salts, cannot be removed and continue to represent a danger to water resources. Many GSI systems are, in fact, little living ecosystems that also help clean up the water. Most bioretention/ raingardens are planted, which makes them beautiful and also creates little homes for tiny living things. The bacteria, plants, and fungi that live in GSI can help break down or degrade some of the contaminants that are captured; for example, pesticides, oils, and some fertilizers. Our research lab, as environmental engineers, works to help understand how these living creatures can be optimized and work with enhancements to the engineered soil media to capture and break down stormwater pollutants in GSI. It involves chemistry, microbiology, plant science, hydrology, design, and creativity—all part of environmental engineering!

One of the best parts of GSI is that people can build them right at home! For example, I have three rain barrels that capture our roof runoff which is later used to water our flower gardens. People can also build raingardens right at home too by diverting runoff from a roof or driveway. It's fun to do, makes your yard beautiful, and improves water quality and local drainage. There are many guides available for Iowa (for example Iowa DNR:
https://www.iowadnr.gov/portals/idnr/uploads/water/watershed/files/raingardens.pdf
and the Iowa Stormwater Education Partnership:
https://iowastormwater.org/)
as well as resources from neighboring Midwestern states (like WI DNR, MN Pollution Control Agency).

These guides can help size a raingarden, create a well-infiltrating soil, choose plants that won't mind being inundated for a few days and quite dry for extended periods, and how to make it visually appealing. Mostly, plants that are native to a region are chosen because they are used to the climate.

Conclusions: Green infrastructure can be a fun event for a family or community—as well as improving water quality, beautifying communities, and creating urban microhabitats for pollinators like bees and butterflies. GSI can help remove many stormwater pollutants and restore hydrologic function to urban areas by slowing down runoff and keeping raindrops closer to where they fall. Finally, GSI is also being used as a tool to help advance environmental justice efforts by creating equitable access to green spaces. GSI can be implemented on a city or regional basis—but every household can take action today by building a raingarden in their yard today!

LeFevre in a large regional GSI infiltration area, demonstrating the overflow structure that water can use to bypass in the event of extreme flows.



A Bioretention cell used to collect and infiltrate stormwater. Note the cut in the curb that collects stormwater and the use of native plants.

LeFevre collects a soil sample from a bioswale in Coralville, Iowa.

Oil from cars is a very visible example of stormwater pollution—but many pollutants cannot be seen.

Small grains pay while providing soil and water benefits!

By Rebecca Clay, *Field Crops Viability coordinator at Practical Farmers of Iowa*

Cresting a hill in Iowa's grey December, you spot a field of narrowly-planted rows of emerald green grass leaves. A cover crop, you think, but as you pass the field the following July, you notice what then had been low grass is now a tan, waist-high field with seedheads- this must be a cash crop!

Cool-season small grain crops such as oats, cereal rye, and wheat begin growth in fall or early spring, unlike corn and soybean which are planted in late spring. During these months, small grains reduce erosion by covering the soil and aiding water infiltration. The roots of the small grain sustain soil microfauna, improving soil structure; and the vegetation provides wildlife habitat wildlife when other fields are barren.

Figure 1: Small grains protect soil from erosion.

Small grains support lower-input, higher-yielding corn and soybeans

Beyond the soil and water services of small grains, agronomic systems also benefit from including a small grain in the cropping rotation. The early spring vegetation competes with weed populations, reducing weed pressure throughout the rotation.

Small grains' mid-summer harvest timing provides opportunity for vigorous growth of a nitrogen-fixing legume such as clover or alfalfa, which can provide a 50 lb N/acre nitrogen credit to meet the following corn crop's N requirements . Some farmers make use of the additional heat and sunlight of a mid-summer harvest to raise a robust grazing crop.

The Marsden Long-Term Rotation Study near Boone, Iowa, which compares a two-year rotation with three-year and four-year rotation, found that the improved soil structure, decreased pest pressure, and increased nitrogen availability associated with longer rotations results in increased corn and soybean yields relative to two-year rotation yields .

Figure 2: Red clover provides nitrogen credit and hosts pollinators.

Practical Farmers for small grains

Practical Farmers of Iowa (PFI) is a non-profit organization for farmers, by farmers, with the mission to equip farmers to build resilient farms and communities. Our members host field days and conduct farmer-led research.

PFI began administering cost-share for Midwest producers raising small grains in 2017, and this past year the cost-share supported 168 Midwest farmers in raising over 12,500 acres of small grains! In Iowa alone, 80 farmers received cost-share on over 5,000 small grain acres in 2022.

Figure 3: PFI members learn from each other at field days; PFI board member Nathan Anderson of Aurelia, Iowa hosted a field day in 2022.

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Small grains have precedence in Iowa

The practice of extended rotation is far from new age. Before tractors were commonplace, small grains such as oats fueled the horses and oxen that pulled farm implements. Oats commonly served as a nurse crop for legumes such as alfalfa or clover, which enabled biological fixation of nitrogen when synthetic nitrogen fertilizer was not commercially available.

Even after the widespread use of synthetic nitrogen fertilizer and specialization of crops, the farmers and researchers who founded Practical Farmers of Iowa in 1985 valued small grains in crop rotation for their input-reduction potential and improvements to soil and water quality.

Figure 4: Oats, once common in Iowa, are making a resurgence.

Further market development for more small grain acres

Currently there is not a huge market signal encouraging farmers to raise small grains. But as cover crop acres increase, enterprising Iowa farmers have started to raise cereal rye and oats for cover crop seed for their own use or to sell. In fact, about 44% of Iowa acres in PFI's small grain cost-share are for cover crop seed! While additional cover crop seed demand could drive more small grain acres, market development beyond cover crop seed will be crucial.

PFI members advocate that additional markets and more competitive prices would incentivize them to raise small grains on more acres. Farmers cite straw markets as lacking; a northeast Iowa farmer shared, "To be competitive with corn or soybeans it is necessary to get income from the straw."

Despite the barriers to raising small grains, cost-share participants report that extended rotations help their bottom line. **When asked how an extended rotation with a small grain impacts their farm financial goals, 88% of PFI's cost-share famers responded positively or very positively!** Additional demand and higher prices for small grains would drive more small grain acres, bolstering farm finances while improving soil and water quality.

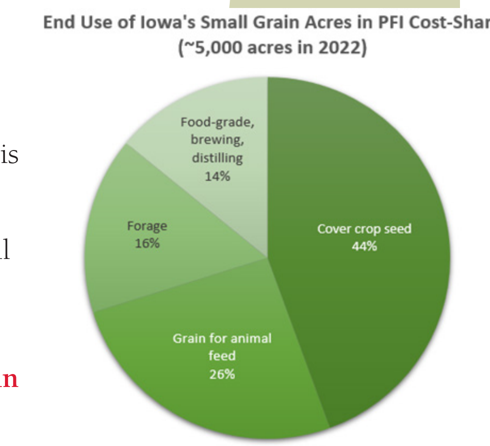

Figure 5: According to PFI's small grain cost-share data, cover crop seed is the leading use of small grains in Iowa, followed by grain for animal feed, forage (hay), and food-grade/brewing/distilling.

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It Keeps Getting Better Every Year

By Steve Berger, *farmer*

Next spring will be forty-four years since we switched our farm to no-till. I planted corn into a cereal rye cover crop for my 4-H project in May 1979 and began using cereal rye as a cover crop starting in 2000. We routinely apply swine and turkey manure to our fields with cover crops. The transition to no-till and cover crops has been a good decision with challenges and mistakes. I recommend farmers consider transitioning to no-till and cover crops. The soil responds to management with improved soil aggregate stability, higher infiltration rates, and reduced erosion.

Managing cover crop termination and nitrogen requirements are my two biggest challenges. These unknowns every spring require the most management. Planter upgrades, herbicides, and pest management are more easily managed. The key to making the system work is eliminating all tillage and growing a cover yearly.

Soil Aggregate Stability

When tillage stops, the soil's physical properties improve, specifically pore size and arrangement. A 60% water and 40% air ratio in the soil's macropores creates optimal conditions for plant roots and microorganisms that help plants thrive. Soil aggregate stability measures the ability of soil particles that bind together to resist breaking apart when exposed to external forces. Soils with good aggregate stability act as a sponge and have a higher water infiltration rate that can dry quickly and offer several advantages to farmers.

Long-term no-till fields will have more days for planting and harvesting because equipment can get on them sooner. Paul Reed, Washington, always tells me, "If you can walk across a field, you can plant it." My experience is the long-term cover crop fields have extremely mellow soils in the spring that are ideal for planting with good seed-to-soil contact. There are many agronomic advantages to minimizing soil disturbance.

Nitrogen Takeaways

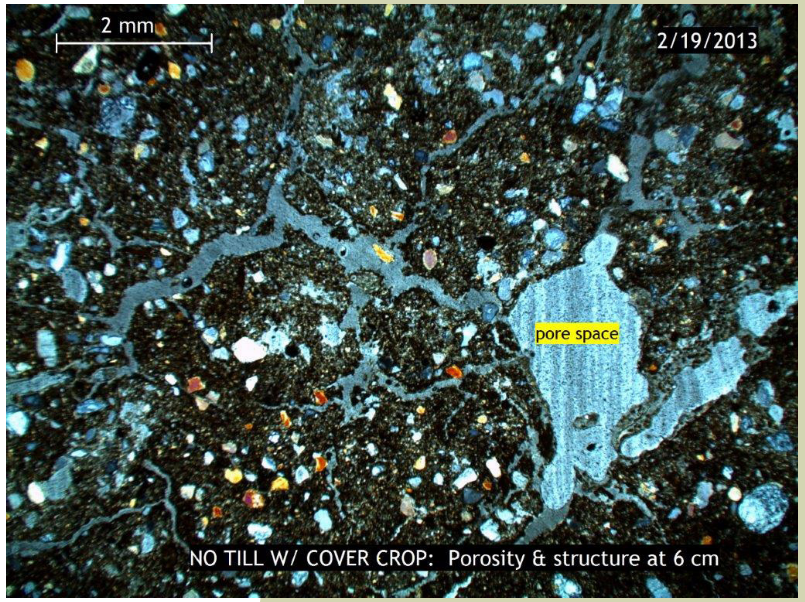
The main difference with a no-till cover crop system is you will have more residue, above ground and below ground which attracts a lot of microorganisms. Like plants, the soil's microbes require nitrogen as an energy source and will get fed before the cash crop. The carbon penalty is soil temperature-related and carbon load sensitive. When soil temperatures get above 65 degrees F, the microbe population explodes. Every 10 degrees, the population doubles, and this explosion sucks up nitrogen and other nutrients. A planned surface application of ammonium sulfate (AMS) in early spring will be pre-empting the carbon penalty. Adding AMS to my nitrogen plan to stop the carbon penalty is the single best decision I made to improve my no-till yields.

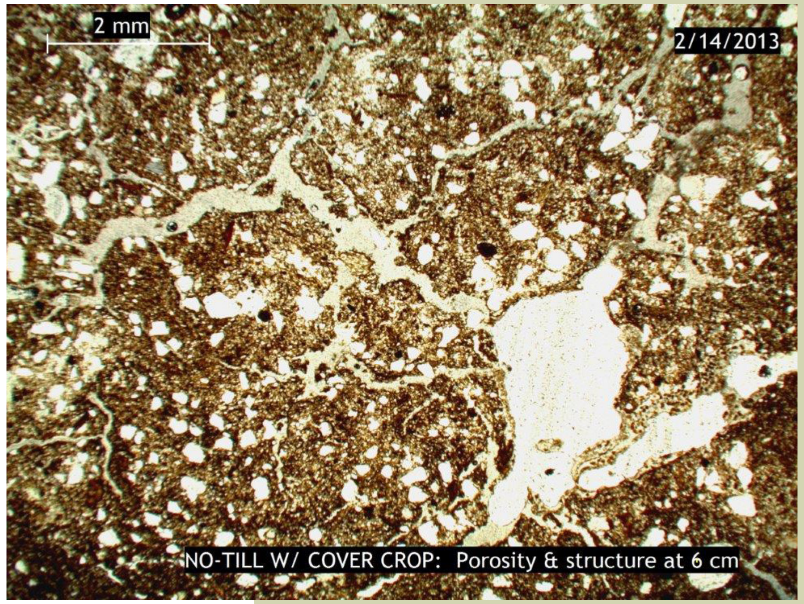
We participated in the Iowa Nitrogen Initiative in 2022 with three N rate trials to find the optimum rate in our no-till cover crop system. The Iowa Nitrogen Initiative is a public-private partnership coordinating on-farm scientific research trials. This is an excellent way to get on-farm research that fits your cropping system. I highly recommend checking out this website: https://bit.ly/NitrogenTrials

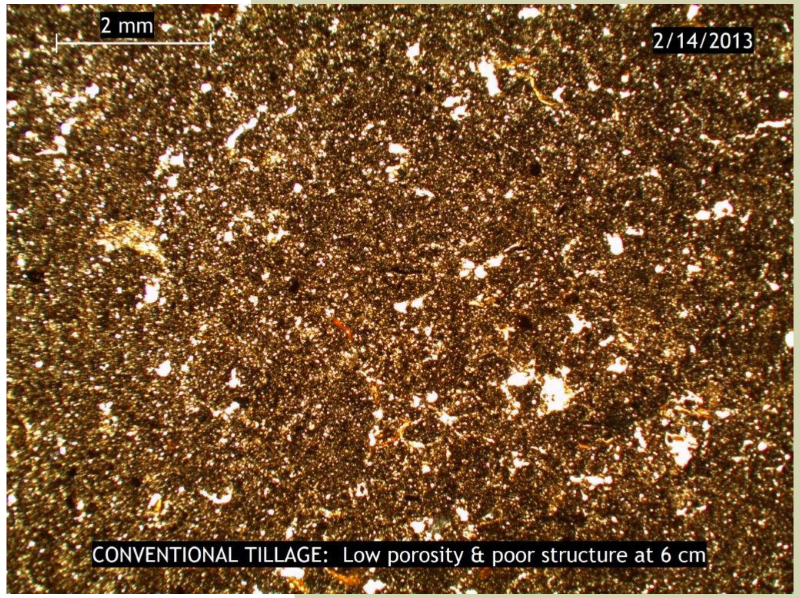
Terminating Cover Crop

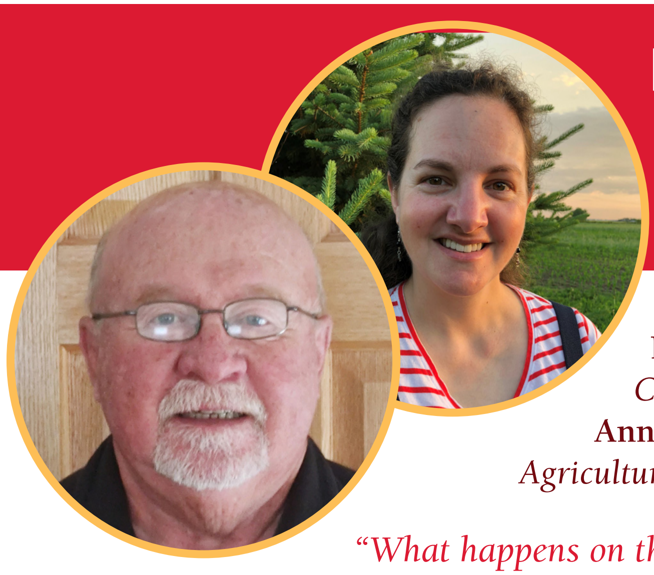
When terminating rye in the spring, trade-offs exist for maximizing cover crop growth and planting the cash crop. The proper timing of cover crop termination varies by field and crop on a situation-specific basis. My priority is to plant the cash crop into green rye timely if soil conditions are fit, then terminate the cover crop later with a PRE and insecticide. If you don't use an insecticide, remember to scout for armyworms because cereal rye is a great host plant. Remember, plant when the soil is fit and don't worry about the rye and manage for insects.

The no-till cover crop is a great system for farmers and the environment. Field efficiencies improve, and healthier soils improve agronomics for plant growth. In all my years of planting cover crops, I've never once worried about allelopathy or seedling diseases. I worry about nitrogen management because it is important to our bottom line and state. The new Iowa Nitrogen Initiative will be a great research program for you to get started on this spring. Your family and neighbors will enjoy the green cover crop fields in the springtime, and after that first hard pounding 3" rain, you'll be hooked! Like my friend Denny Vittetoe says about his no-till fields, "It keeps getting better every year!" He's right.









Protecting Source Water for Winterset: The Story of Cedar Lake

By **James Gillespie**, *Assistant Commissioner, Madison County Soil and Water Conservation District,* **and Anna Golightly**, *Conservation Assistant, Iowa Department of Agriculture and Land Stewardship*

"What happens on the land in the watershed is connected to the health of the lake, and everyone connects with the lake because of its importance to the community."

Cedar Lake has been very important to the city of Winterset and the community around the lake since it was built in 1939. It has provided habitat for wildlife and offered teaching and recreational opportunities for all ages, but its most important function has been to supply water for the city of Winterset. Cedar Lake became a water supply in 1940, and since 1995 it has been the only source of drinking water for the city of Winterset. Taking care of the watershed is key for protecting water quality and quantity in the lake today and in the future.

The lake was built to hold 350 million gallons of water, and that water comes from a 10,700 acre watershed in central Madison County. The primary land use in the watershed is agricultural, with about 75% of the acres being in corn or soybean production and another 4.5% in hay and other row crops. Developed areas, such as roads, residential areas, and a small portion of the city of Winterset, make up less than 10% of the watershed.

Whatever happens in the watershed can affect the lake; when erosion occurs in the watershed, whether it be from farm fields, streambanks, or construction sites, that sediment can eventually end up in the lake. After many years, siltation has caused the lake's water storage capacity to decrease, which has become a major issue for the community. In 1973, a lake bottom survey showed that water storage capacity had decreased to 115 million gallons, so in 1979 the spillway was raised to increase the lake's storage capacity to 315 million gallons, but a study in 1989 showed that the capacity in the lake had again declined. **As the community of Winterset continues to grow, having a sustainable source of water that can supply residents now and into the future is crucial.**

There was an active watershed project from 2002 to 2006, which helped address water quality concerns (nitrates) and siltation, but the project couldn't reverse the sedimentation that already occurred. Winterset Municipal Utilities (WMU) started the Cedar Lake Rehabilitation Project in 2008 and developed a plan to dredge the lake to regain water storage capacity. Dredging was completed in 2014, but WMU realized that the work to protect Cedar Lake was not done.

Partners including WMU, Madison County, the Madison County Soil and Water Conservation District (SWCD), the Iowa Department of Natural Resources (DNR), the Iowa Department of Agriculture and Land Stewardship, the USDA Natural Resources Conservation Service (NRCS), and local farmers and landowners formed a Source Water Team to identify the next steps for protecting Cedar Lake. The DNR contracted with Tetra Tech to develop a Source Water Protection Plan (SWPP). After gathering input from the Source Water Team and data from on-the-ground assessments, including a roadside survey of land uses and a Rapid Assessment of Stream Conditions Along Length (RASCAL) survey of Cedar Creek and its tributaries, the SWPP was completed in 2018.

The SWPP included a description of the watershed (Source Water Protection Area), an inventory of potential contaminant sources, and an action plan. The action plan included best management practices, stream restoration, fisheries management, programmatic and regulatory actions, an education and outreach program, monitoring and adaptive management, and technical and financial assistance.

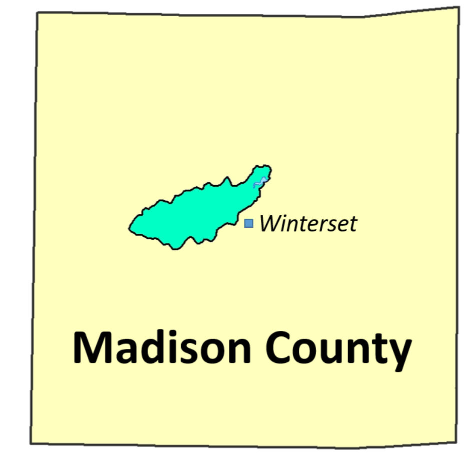
Two things happened to help put the SWPP into action. In 2018, WMU hired a consultant to focus on outreach and education within the watershed. Then, in 2019, Cedar Lake Watershed was selected by the NRCS to receive special funding from the National Water Quality Initiative (NWQI). Cedar Lake was one of two projects that were the first in the nation to focus on source water protection specifically.

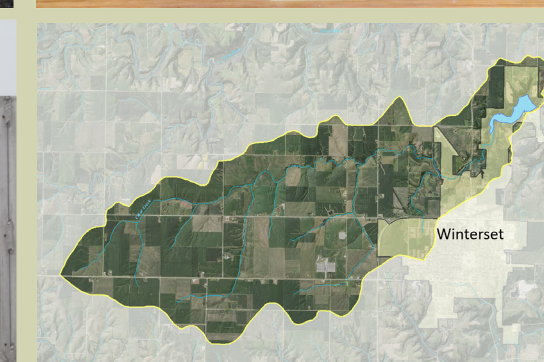
The consultant reached out to farmers, landowners, and residents in the watershed and set up visits to tour farms and learn about what issues or concerns people had with the land they operated in the watershed. When they identified areas that would benefit from conservation practices, the consultant put them in touch with the local NRCS office for technical support for practices and financial assistance through NWQI.

Landowners have been making improvements in Cedar Lake Watershed for a long time, but the outreach efforts of the consultant and the availability of NWQI funding has increased the pace of conservation in the watershed. In addition to the acres of reduced tillage and no-till farming, terraces, grassed waterways, wetlands, and other conservation practices that have been there for years, many new practices have been completed: 9,716 feet of terraces, four water and sediment control basins, one grade stabilization structure, nearly an acre of grassed waterways, and over 700 acres of cover crops.

The consultant's outreach efforts got the ball rolling, and the NWQI funding for conservation practices helped build momentum, but nothing would be accomplished in the watershed without the commitment of cooperating farmers and landowners. Several of those people from Cedar Lake Watershed have been recognized in recent years; the Iowa Farm Environmental Leader Award has been presented to four farm families in the watershed, and Madison County SWCD presented its annual Conservation Award to a Cedar Lake Watershed farmer in 2022.

The story of Cedar Lake is a story of connections; efforts to protect the lake have brought together urban and rural communities, as well as bringing together several municipal, county, state, and federal government entities. What happens on the land in the watershed is connected to the health of the lake, and everyone connects with the lake because of its importance to the community.





Miscanthus × giganteus as a soil architect and regenerator of water holding capacity

By Jessica Nelson Ph.D. Candidate, Soil and Environmental Science, Iowa State University

There are many potential environmental and economic benefits to perennializing agricultural landscapes with perennial biomass crops (1-5). **With these potential benefits, it is important to understand more deeply how Miscanthus improvessoil structure, what mechanisms are responsible for it, and what this could mean for society.** With the future climate in the Midwestern US predicted to become wetter and warmer with more intense rains, this increases the potential for flood events (6, 7). Improving soil structure via Miscanthus and other perennial crops could not only benefit the local agroecosystem, but when applied collectively over large areas, the impact of an increase in soil water storage could reduce property damage and deaths due to these floods (8, 9). This further supports the need for using perennials on marginal land.

Current research is looking at these potential mechanisms for the increased water holding capacity (WHC) of perennial Miscanthus and how it compares with annual maize and alleyway grasses. **According to previous research, soil around Miscanthus showed ~16% more WHC than neighboring maize** (10). We are aiming to look at the possible ways Miscanthus impacts WHC indirectly and directly. We hypothesize that, indirectly, Miscanthus is increasing pore space and WHC via the microbial community. In addition, we are investigating the hypothesis that Miscanthus has a direct influence by increasing pore space and WHC through rhizodeposits and/or physical aggregation around greater root biomass. It is possible that both mechanisms are at play for increased pore space and WHC under Miscanthus.

To test these hypotheses, we have laid out the following research questions and testing methods. What is the difference in WHC between Miscanthus, maize, and perennial grasses across the full soil water retention curve? To measure this difference, we will use HYPROPs (Figure 1) to get the data for the wetter end of the curve and a WP4C machine for measuring the drier end of the SWRC. Is there an increase in porosity around Miscanthus roots as compared with maize? If so, how is the pore size distribution (PSD) of the aggregates around Miscanthus different than maize? We can quantify porosity and PSD in aggregates with X-ray CT Scanning (Figure 5a). Focusing on these aggregates, is there a difference in the aggregate stability of soil between these plants? For aggregate stability, we will use wet sieving, the SLAKES app, and the aggregate durability index to gather data. What is the difference in microbial communities, functional groups, and abundance between these crops? We will use microbial biomass and metagenomics to determine this. Are the extracellular polymeric substances (EPS) produced in the soil around Miscanthus higher than these other two plants? For quantifying EPS and origins of carbohydrates, we are using cation exchange resin extraction and anion exchange chromatography. Does the percent of organic matter and total carbon differ between the soils?

The organic matter in our samples will be analyzed via loss on ignition and total C. What is the difference in root density between these three plants? After running the sample soil cores on the HYPROPs, we will be measuring root mass density.

Image Caption: Figure 1. HYPROPs collecting data for soil water retention curve.

The samples for this project were collected from the three LAMPS (long-term assessment of Miscanthus productivity and sustainability) sites (Figure 2). These sites are in Northwest, Central, and Southeast Iowa to cover a range of temperature, moisture, and soil conditions. Randomized, replicate blocks of Miscanthus were planted in three consecutive years (2015-2017) in this chronosequence experiment, thus allowing investigators to consider stand age independently of growing season. Our samples were collected between September 29th and October 6th, 2022.

So far, we have highlighted that at the Northwest LAMPS site, the porosity in soil around Miscanthus compared with maize is not significantly different, while at the Central site, Miscanthus has significantly higher porosity according to the results from the aggregate X-ray CT scanning (Figure 3). We will be following this up with another scanning to confirm these results across all LAMPS sites for the difference between Miscanthus, maize, and perennial grasses. We also have preliminary results of the PSD within these aggregates (Figures 5c and 5d) that we are using to explore the possibility of predicting water held by aggregates (Figures 4 and 5b). With the results from the tests mentioned above, we will be able to conduct future greenhouse experiments to further refine the mechanisms at play.

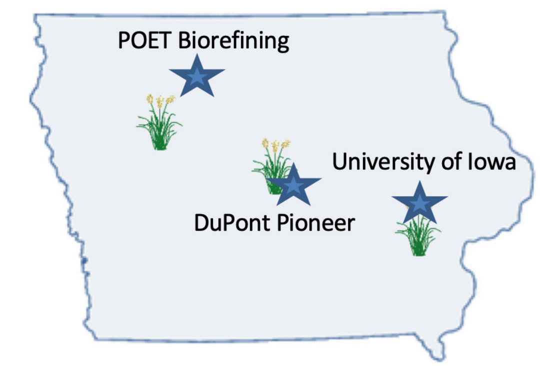
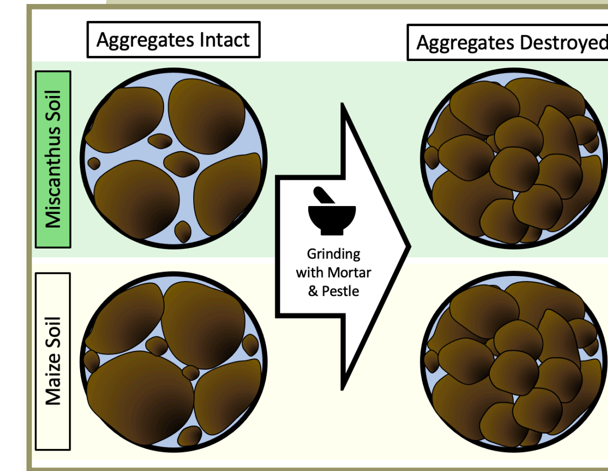


Figure 2. Emily Heaton, LAMPS PI; LAMPS locations (grass image) in Northwest, Central, and Southeast Iowa. These areas also correspond to emerging bioeconomies (star symbol) and processing facilities



Marshall McDaniel, ISU; Figure 4. Intact and destroyed aggregates to test the difference structure makes on water held by aggregates.

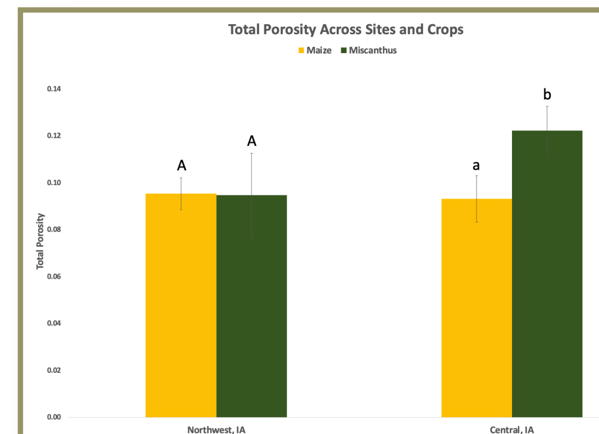


Figure 3. Total porosity of aggregates for the Northwest and Central LAMPS sites with data collected from X-ray CT scanning.

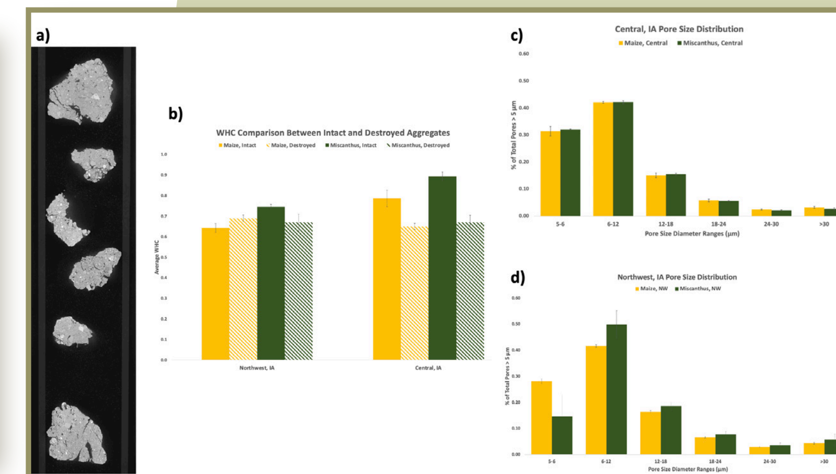


Figure 5. a) Slice of 6 aggregates arranged in a tube inserted into machine; b) Data for water holding capacity (WHC) between intact and destroyed aggregates from Northwest and Central LAMPS sites; c) pore size distribution within aggregates as a percentage of total pores >5µm for Miscanthus and maize at the LAMPS Central site; d) pore size distribution within aggregates as a percentage of total pores >5µm for Miscanthus and maize at the LAMPS Northwest site.

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Integrating poultry in vegetable production systems

By Anne Carey *PhD Student/Graduate Research Assistant, Horticulture & Sustainable Agriculture*

"Livestock animals with small sizes and land requirements, such as chickens and poultry, are ideal animals to integrate with vegetable production."

The practice of combining crop production and animal husbandry is not a new concept. When humans developed agricultural systems 10,000 years ago, farms were integrated systems providing the essential food needed to sustain society while utilizing the manure generated by livestock to improve the soil fertility. This practice continued until the 20th century when the improvement of farm machinery and the development of synthetic fertilizers allowed for increased specialization (MacDonald & McBride 2009). Farms did not need to rely on the muscle or manure from their livestock to work their fields or feed their crops, so many farms began to dedicate their production exclusively to crop production or livestock production.

Agricultural specialization has led to great gains in production efficiency, decreasing food costs and increasing crop yields, but it has also led to large nutrient imbalances. Currently, Iowa alone produces 68 million pounds of manure each year from its hog and poultry production (Konopacky & Rundquist 2020). Animal manure contains high levels of nutrients, such as nitrogen and phosphorus, which, when not properly stored, can cause air quality pollution through volatilization of gases and, when leached into waterways, can cause eutrophication and water quality concerns.

Simultaneously, crop production in the United States uses over 20 million tons of synthetic fertilizer annually (Mosheim 2019). The increased use of synthetic nitrate fertilizers has contributed to severe environmental degradation, including soil erosion, nitrate pollution of waterways, and depletion of soil organic matter (Sulc & Franzluebbers 2014).

Crop-livestock integration strategies look to cycle nutrients on the farm by raising animals and growing crops on the same land, most often at different times. In these systems, animals forage on crop residue after the crop is harvested or on a cover crop intentionally planted for animal grazing. The animals deposit their manure directly on the cropland, providing fertility for crops.

Combining the widespread benefits of cover cropping with animal integration has the potential to greatly increase soil health benefits. Previous research with cattle integrated with row crop production has found increases in soil aggregate stability, microbial biomass, and soil organic matter (Acosta-Martinez et al. 2004). But vegetable systems, often with small land areas and specific production challenges, are not well suited to cattle.

Livestock animals with small sizes and land requirements, such as chickens and poultry, are ideal animals to integrate with vegetable production. Poultry manure is a particularly rich source of fertility for crop production, containing all 13 essential plant nutrients. Compared with cattle manure, poultry manure contains almost four times as much nitrogen, three times as much phosphorus, and 11 times as much potassium (Laboski & Peters 2012). Research has shown the application of poultry manure to improve physical properties of the soil, as well as vegetable yield and quality increases (Hilimire et al. 2013). **In an integrated system, the grower also benefits from a chicken's natural instinct to forage and scratch.** Chickens grazing in orchards have been found to decrease insect pest populations and reduce weed biomass and seedbanks (Clark & Gage 1996).

Our research, funded through the Organic Agriculture Research and Extension Initiative (OREI), hopes to provide information to growers on the feasibility of poultry-vegetable integration production systems. In-field research is being conducted at the Iowa State University Horticulture Research Station. This research is investigating the vegetable quality and yield, soil health indicators, weed and insect pest populations, and chicken growth efficiency and welfare in an integrated system. The chickens are housed in chicken tractors (Fig 1), or mobile floorless coops, and rotationally graze around the plots, moving once per day. One treatment introduces chickens in June to forage on vegetable residue after a spring crop is harvested. The second treatment introduces chickens in August to graze on a cover crop of cowpea and teff, two quick-growing, warm-season species (Fig 2). As food safety risks are a large concern for growers when considering adopting an integration model, we are collecting samples to evaluate the presence of Salmonella. Finally, any enterprise incorporated on a farm must provide profits or decrease costs to be financially sustainable. We are conducting an economic analysis and developing a decision-making tool for growers to use when considering adopting a poultry-vegetable integration strategy.

The project will conclude in 2023. As people seek to practice sustainable agriculture, protecting our water and building healthy soil, information on management strategies such as this, which cycle nutrients and reduce off-farm inputs, will become increasingly valuable.

GETTING INTO SOIL & WATER - 2023

Fig 1. Chicken tractor in plot at ISU Horticulture Research Station 2022. Tractor design by Brandon Carpenter.

Fig 2. Cover crop of cowpea and teff at ISU Horticulture Research Station after 60 days of growth, just before chickens are introduced to graze.

Fig 3. Freedom Ranger chickens in chicken tractor in 2021.

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Cover Crops: A Conservation Crop Rotation

By Haley Shaw *Soil Conservationist, NRCS Indiana*

Utilizing cover crops is a common cropping system across the United States that usually takes place after a crop field is harvested. The practice of cover cropping is a system used by some producers; however, it may not be a feasible practice for all producers to adopt into their cropping system. There are several advantages and disadvantages to adopting cover crops into cropping systems that should be taken into consideration. There are a variety of different mixes that can be used for cover crops, ranging from single-species mixes to more complicated multi-species mixes. The mix a producer chooses is dependent on different factors, including, but not limited to, time, budget, climate, and availability.

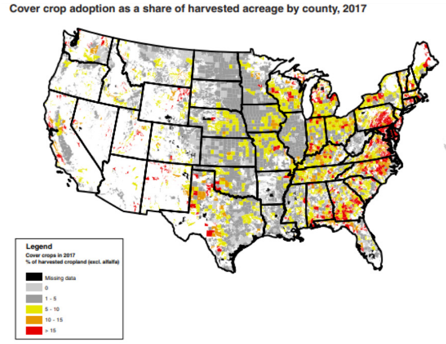
Cover crops have many benefits that can be used to have a positive impact on the soil. Soil erosion decreases when cover crops have been planted (Cover Crops). This is because cover crops offer the soil protection from the wind and rain. When rain falls, it will hit the foliage of the cover crop at full velocity and stop, then it falls more gently onto the soil. Because the raindrop has been slowed down, the raindrop will not displace as much soil, which in turn reduces water erosion and crusting. Crusting is a phenomenon that occurs when finer particles of the soil are cemented into a hard layer that does not retain moisture well and can cause planted row crops to exert extra energy into breaking through the surface of the soil. Another benefit of cover crops is they can provide a nitrogen source for next season's crop and help keep nitrogen from leaching into groundwater (James J. Hoorman). This happens when the cover crop uses residual nitrogen from the soil for its own growth, and then when the cover crop is terminated, it is used as green manure, which provides nitrogen back into the soil and is available for the next crop. These are just a few of the environmental benefits that cover crops have to offer.

While there are many benefits to growing cover crops, there are also several disadvantages to cover crops. Producers may not have the time in the season to be able to plant cover crops. If the weather is harsh or unseasonably different from average past years, it may be difficult for producers to be able to get into the field to harvest all their acres and plant a cover crop. Cover crop mixes can get expensive if a specialized mix is purchased. A general rule of thumb is the simpler the mix, the cheaper the mix will be. However, that is not always the case, and the cost of seed may be a determining factor in whether to implement the practice.

Climate and weather are another reason why producers may not be able to plant a cover crop mix, for example, the growing season is too short to get a good establishment in before the ground freezes. Producers have to weigh the benefits against the disadvantages of cover crops in order to determine if adding cover crops to their cropping system is a worthwhile venture.

In Figure One (Wallander), there is a map depicted of the United States showing the adoption of cover crop acres in the year 2017. It is broken up by percentage, with the red counties being the highest adoption rate. Counties colored black had no data to report, and areas colored white are not cropped acres. This figure shows that cover crops are a system that can be implemented anywhere in the United States.

Cover crop adoption as a share of harvested acreage by county, 2017



Note: County boundaries are clipped to show only cropland. Non-cropland appears white. Missing data occur when county-level estimates cannot be publicly released due to an insufficient number of observations in a county.

Cover crops are used in addition to normal cropping systems to provide benefits to the soil. They can be useful in reducing soil erosion and nutrient management. Cover crops can be purchased in a variety of mixes. However, producers must weigh the benefits of having cover crops versus the disadvantages of having cover crops because it may be a system that just will not work for the producer, whether it be because of weather that year, the cost of inputs, or the cost of time. Nevertheless, cover crops are important across the United States.

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Soil Judging Creates Scientists: Grounding abstract knowledge in the roots of reality

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As a soil judging coach for ISU, I am often asked, "How do you judge soil?" I could answer by succinctly describing the handbook, but that would put you to sleep. The premise of this article is not to describe soil judging for what it is — but for what it does. **I believe that philosophically, soil judging provides an avenue to create cognitive linkages between abstract knowledge from the classroom, the contextual hierarchy of the natural world, and an understanding of the inherent ambiguity of reality.** Ultimately, soil judging creates a scientist.

We acquire knowledge through various mediums, e.g., hands-on experience, lectures, literature, diagrams, abstract models, equations, music, art, and so on. The modes of learning in which we learn are diverse. Moreover, the modes by which we learn best are highly varied among individuals. Yet, most of our learning occurs in a classroom, guided by a textbook, with our success evaluated by an exam. But how often are scientists taking exams to successfully apply knowledge to reality? Never.

The application of knowledge is strongly tied to the medium in which the information was obtained. In the classroom, that knowledge is largely abstract. It is a compilation of facts, a generalization of rules, and an assemblage of categories. Exceptions and caveats are removed to simplify our learning experience and accelerate our assimilation of information. Therefore, we often address real-world problems in the same manner. The exceptions are overlooked, the categories are definitive, and the rules are universal.

The pedagogical wizards of the earth sciences are no strangers to the obstacles presented by the classroom setting. And as for soil scientists, we certainly do move mountains to bring the abundant diversity of the earth's soils to our students. But I shared the same experience as many during undergrad. I remember long drives during 4-hour field trips with maybe an hour of hands-on activities and classroom labs where we fumbled with jars of dirt of unknown origins.

Like us, soils are a product of their environment. We know a lot about people based on their birthplace, culture, family, peers, and faith because they are the foundation of the individual. And with that information, we can predict how people will interact with the world. Similarly, the sediments, the hillslopes, the climate, the flora, and the fauna create the soil individual. And the culture of the soil-landscape gives contextual clues into the nature, origin, and distribution of the soil body.

The abstract knowledge for soil judgers is the handbook. They have yet to see the soil landscape through the framework of the handbook but read it, nonetheless. The handbook describes how to characterize the shape and slope of the soil-landscape and its lithological origins. The soil and its various horizons are described by their morphology, orientation, and depth in the trench and by the modes of transformation and translocation of the material. The chemical data are given to aid taxonomic classification. The sum of the soil's parts is extended to interpretation to determine how suitable the soil is for building a basement or septic tank, how much water the soil can hold, or how agriculturally productive the soil is.

The abstract knowledge, however, must be synthesized with sensory and contextual knowledge to get the full picture. The stink of the air next to the low-lying depressional marsh may give clues to saturated conditions where thick black muck likely exists over a mottled matrix. The judger may look above to the eroded hillside and observe a droughty slope riddled with stones, where much of the fines have washed downward to form a dense-clayey matrix, which they work in their hands.

The continuity and complexity of soil bodies confound abstract and contextual knowledge synthesis. The hillslope segments aren't discrete. The parent materials are often mixed with multiple origins. Boundaries between horizons vary from abrupt to diffuse. The continuity of the soil body does not align with the discrete classification criterion. General rules and guidelines that were given break down. Thus, the soil judger is required to make judgment calls, applying what is known to the observed and the unknown.

And when soil judgers recognize the gap between the abstract and reality, the cognitive linkages fuse. They find themselves standing on the shoulders of giants. They recognize that science is a boundless pursuit of the truth and become inspired to continue the mission. They become scientists.


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