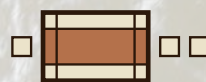




at IOWA STATE UNIVERSITY

GETTING INTO SOIL & WATER

2014



Soil & Water
Conservation Club

A Letter from the Soil & Water Conservation Club President



Hello Reader,

On behalf of the Iowa State Soil and Water Conservation Club (SWCC), I would like to present the 2014 edition of Getting into Soil & Water. Each year, for the past six years, our club creates this publication in the effort to help educate and familiarize people with issues and topics relating to soil and water that effect not only Iowa, but the world.

The Iowa State Soil and Water Conservation Club is a diverse group of students who are passionate about learning about and promoting soil and water conservation through various conferences, outreach events, and SWCC meetings we conduct on campus at Iowa State University. To help convey our message, we have created a Ground Water Flow Model (GWFM) that helps demonstrate the effects of pollution on water quality. The club manufactures, presents, and sells these models across the State of Iowa and throughout the United States. We have even sold our GWFM's to various countries around the world!

This publication would not have been possible without the help of the publication committee as well as the authors of the contributing articles that you will find within this publication. Further, the Soil and Water Conservation Club would not be able to participate in any of these activities without our dedicated members and faculty adviser, Dr. Rick Cruse.

Thank you to all of the guest speakers, students, and faculty who have helped make my year as president a successful one.

Sincerely,

Anthony Miller

2013 SWCC President



2013 Soil & Water Conservation Club Members.



2013 Soil & Water Conservation Club Publication Committee.

Club Members

Win Cowger*
Jace Klein
Nathan Smith
Emily Swanstrom
Jill Stephenson
Abigail Peterson
Julie Perreault
Carolina Covington

Catherine DeLong*
Holly Hallman
Rebecca Clay
Eric Stuart
Emma Haven
Emily Martin
Taylor O'Bryan
Debbie Aller*

Anthony Miller
Ron Tigner
Deborah McDonough*
Ligia De-Oliveira-Serrano*
Karl Gesch*
Ashley Waller*
Dr. Rick Cruse*

*Publication Committee Member

TABLE OF CONTENTS

- | | |
|---|--|
| <p>2 A Letter from the Soil & Water Conservation Club President
<i>Anthony Miller</i></p> <p>4 A Letter from the Agronomy Department Chair
<i>Kendall R. Lamkey</i></p> <p>5 Developing a Passion for Soil & Water Conservation
<i>Dr. Steven Mickelson</i></p> <p>7 Bacteria in Iowa's Water: Risks, Sources, and Strategies
<i>Jodi Enos-Berlage</i></p> <p>10 Agricultural Potential in Brazil and Future Challenges
<i>Igor Rodrigues de Assis</i>
<i>Raphael Bragança Alves Fernandes</i></p> <p>12 Soil and Water Conservation Districts: Making a Difference for Over 60 years
<i>Steve Fales & Clare Lindahl</i></p> <p>14 Sediment Accumulation Rates Still Increasing in Iowa's Natural Lakes
<i>Christopher T. Filstrup, Adam J. Heathcote, & John A. Downing</i></p> <p>18 Ephemeral Gully Erosion Presents a Unique Conservation Opportunity
<i>Karl Gesch</i></p> | <p>20 New Satellites for Soil Moisture: Good for Iowans!
<i>Brian K. Hornbuckle</i></p> <p>24 The Importance of Soil Organisms: Dr. Seuss Knows
<i>Marty Adkins</i></p> <p>26 Gulf of Mexico Hypoxia: Why Blame Iowa Farmers?
<i>Tom Isenhardt & Richard Cruse</i></p> <p>28 Precision Agriculture
<i>Amy Kaleita</i></p> <p>30 A Lifetime of Having Water Giveth and Taketh Away
<i>Hank Kohler</i></p> <p>34 A Brief History of Soil Erosion Estimation in the United States
<i>John M. Laflen</i></p> <p>37 Sustainable Cropping Systems for Harvesting Corn Stover for Biomass
<i>Ken Moore, Kendall Lamkey, Roger Hintz, Scott Flynn, Nickolas Bowden, Jeremy Singer, Keith Kohler and Dustin Wiggans</i></p> <p>39 The Challenge of Soil Conservation
<i>John Pesek</i></p> <p>42 Bioturbation: an Underestimated and Overlooked Driver of Soil Formation
<i>Mary Tiedeman & Lee Burras</i></p> |
|---|--|



Deborah C. McDonough
Editor

The suggested format for citing an article from this publication is:

Author. 2014. Title of Article. Page(s) of Article. In Deborah C. McDonough (ed.) Getting Into Soil and Water: 2014. Iowa Water Center, Ames, IA.

All content ©2014 The Iowa Water Center. All rights reserved.

A Letter from the Agronomy Department Chair



One of the great things about working at Iowa State University is the students. Everyone has a different perspective on students, but all parents want their children to attend a great institution like Iowa State University, and be successful. Students bring a life and vibrancy to a city like Ames that it would not otherwise have. From my perspective, I see students as future leaders of agriculture. Students at Iowa State

University in the College of Agriculture and Life Sciences are going to be our future farmers, agronomists, industry leaders, technology developers, and thought leaders. Students are what bring me to work each day with a passion to keep moving forward. They bring me the hope and peace of mind that the future of agriculture is going to be left in great hands.

Here at Iowa State University, we have many future agricultural leaders as is evidenced in the annual production of Getting into Soil & Water by our Soil and Water Conservation Club. Getting into Soil & Water has become a very popular publication in the State of Iowa for its clear, insightful, and timely articles on factors related to two of our most important natural resources, soil and water.

In rainfed production environments, it is easy to take soil and water for granted, especially when both are in adequate supply. However, when one of the two becomes short in supply, the importance of the other increases dramatically. For example, the drought of 2012 illustrated just how important soil water holding capacity was for crop production. One of my favorite quotes is from the former president of the University of Illinois, Andrew S. Draper and it is inscribed on the outside of Davenport Hall at the University of Illinois (full disclosure, I am an Illinois native and University of Illinois alum, but a Cyclone forever): “The wealth of Illinois is in her soil and her strength lies in its intelligent development.” This is as true of Iowa as it is for Illinois and this quote describes what our students are doing with the production of Getting into Soil & Water.

Enjoy.

Sincerely,

Kendall R. Lamkey

Chair, Department of Agronomy, Iowa State University



Developing a Passion for Soil and Water Conservation



I grew up on a small farm in Northwest Iowa where our family raised corn, soybean, oats, pigs, chickens, and cattle. We even had a few milk cows. Compared to today's farmers, we had a diverse farm operation. But that type of operation was pretty typical for Midwest farmers in the 1960s and 1970s. My three brothers and I spent most of our daytime hours working with our livestock, pulling weeds in the

fields, or tilling the soil, at least when we weren't in school. We had some of the cleanest corn and soybean fields in the county. Some of this was due to effective herbicides, but a lot was due to cultivation between the rows and physical removal of weeds by hand. Having a clean looking field was very important in our part of the State and my dad would often stop the car on the way to church for one of us to get out and remove a weed he had seen from the car. In those days, we moldboard plowed our fields in the fall to cover up the residue and to prepare the fields for easy planting in the spring.

Conservation tillage wasn't a topic of discussion for our family. Our focus was on maximizing our yields without much thought of sustainability and soil erosion was pretty severe in our fields. During strong rainfall events, rills and gullies were frequently created in low lying areas of our fields from the runoff. When the strong winds of winter would blow, the snow drifts in the road ditches were often black from the wind erosion of our soils. It was during these years that I developed a passion for learning about ways to conserve the soil on the farm that I might someday inherit. When I attended college, I took courses in soil science, soil fertility, soil

management, soil and water conservation engineering, water quality, soil-root relations, soil-plant relations, soil physics, surface hydrology, ground water hydrology, and many others in order to fulfill this passion of mine. My goal was to ultimately work with farmers to reduce soil erosion and to protect our water resources from nonpoint source pollution.

Today I am a professor in the Department of Agricultural and Biosystems Engineering. My teaching, research, and outreach efforts over the past 32 years have focused on assessing and designing agricultural best management practices for reducing soil erosion and for improving the surface water quality leaving farm fields. I am proud of the soil and water research that my Iowa State University colleagues and I have conducted because it has helped inform Midwest farmers and producers about how to create a sustainable farming model that protects our land and water resources.

My hope is that as you read through the articles in this publication, you will also develop a passion for soil and water conservation. Although we have come a long way over my lifetime in improving farming practices that protect our land and water resources, we still need practical solutions to reduce the nutrients that enter our water bodies and creative solutions for producing sustainable models that ensure future generations will have plenty of quality soil and water.

Sincerely,

Dr. Steven Mickelson

Chair, Department of Agricultural and Biosystems Engineering, Iowa State University

keeper of the land



i'm an
agronomist

applying science to fuel & feed our global society

www.ImAnAgronomist.net



IOWA STATE UNIVERSITY
Department of Agronomy

Bacteria in Iowa's Water: Risks, Sources, and Strategies

Jodi Enos-Berlage, Ph.D.

Professor of Biology, Luther College, Decorah, Iowa



Fig. 1. Children playing and exploring in Northeast Iowa streams. Photo by Emily Neal, Luther College Discovery Camps.

Iowans treasure their contact with the State's water resources. Opportunities for experiencing Iowa's waterways abound, and include swimming, tubing, fishing, wading, canoeing, and exploring. Humans are inevitably drawn to water. This magnetic attraction is especially the case for children, who eagerly enter water for exploration, play, and refreshment (Fig. 1). These activities not only bring joy, learning opportunities, and peacefulness to those who experience them; they also have a major economic impact as Iowans and non-Iowans spend associated dollars.

Unfortunately, human contact with many of the State's water bodies comes with a risk, due to high levels of bacteria. The State of Iowa categorizes streams, rivers, and lakes as impaired if their quality is below the standard for its designated use. Many factors can cause impairment, from high levels of nitrates to dying fish. Significantly, bacteria are the number one cause of impairments in Iowa's assessed waterways, being listed as a cause in 43 percent of Iowa's impaired rivers and streams (U.S. EPA, 2012). Bacteria-polluted streams may also contaminate ground water sources that are used for

drinking water. This risk is increased in areas of the State, such as Northeast Iowa, that have exposed limestone bedrock, with sinkholes and underground streams that can link surface and groundwater sources.

Scientists test for bacteria by collecting a water sample and counting the number of *Escherichia coli* bacteria (*E. coli*) in a 100 milliliter sample (approximately half a cup) (see Fig. 2). *E. coli*'s habitat is the digestive tract of warm-blooded animals. Thus, if *E. coli* is present, it indicates fecal contamination and the possible presence of other gastrointestinal tract microbes that can cause disease, including *Salmonella*, *Listeria*, *Cryptosporidium*, and a variety of viruses. Infections with these microbes can lead to fever, vomiting, abdominal cramps, and diarrhea. Dehydration and life-threatening complications are also possible. The higher the level of *E. coli* in a stream, the greater the chance that someone in contact with that stream will become ill (Pruss, 1998; USEPA, 1984). Children and those with compromised immune systems are at higher risk.

Many sources can contribute to bacterial contamination in water bodies, including livestock or wildlife that have direct access to the water, faulty human septic systems, or run-off from concentrated animal feeding operations or fields that have been spread with manure or pastured with livestock. In addition, streambed sediments themselves have been shown to serve as a reservoir for *E. coli*, where these bacteria can persist for months. Disturbance of these sediments by fast current conditions or livestock can significantly increase stream *E. coli* levels (Muirhead, 2004).

Bacteria levels in Iowa streams usually increase after rain-fall. In our work measuring bacteria levels at ten sites in a Northeast Iowa watershed, average *E. coli* levels increased in response to rain at every site (compare Fig. 3A to 3B, note scale change). During dry weather, *E. coli* levels generally measured in the hundreds to several thousand for every 100 milliliters of water, but after rain events, many samples were in the range of 10,000-100,000 *E. coli* per 100 milliliters, and some reached over a million (Wittman, 2013). The amount of rainfall, prior soil moisture, and timing of sampling (relative to rainfall) appeared to influence *E. coli* levels. These data are consistent with wet weather *E. coli* sources, such as field-applied manure or manure storage or feedlots that lacked runoff controls.

Interestingly, under dry weather conditions, there was a shift in terms of which watershed sites were contributing

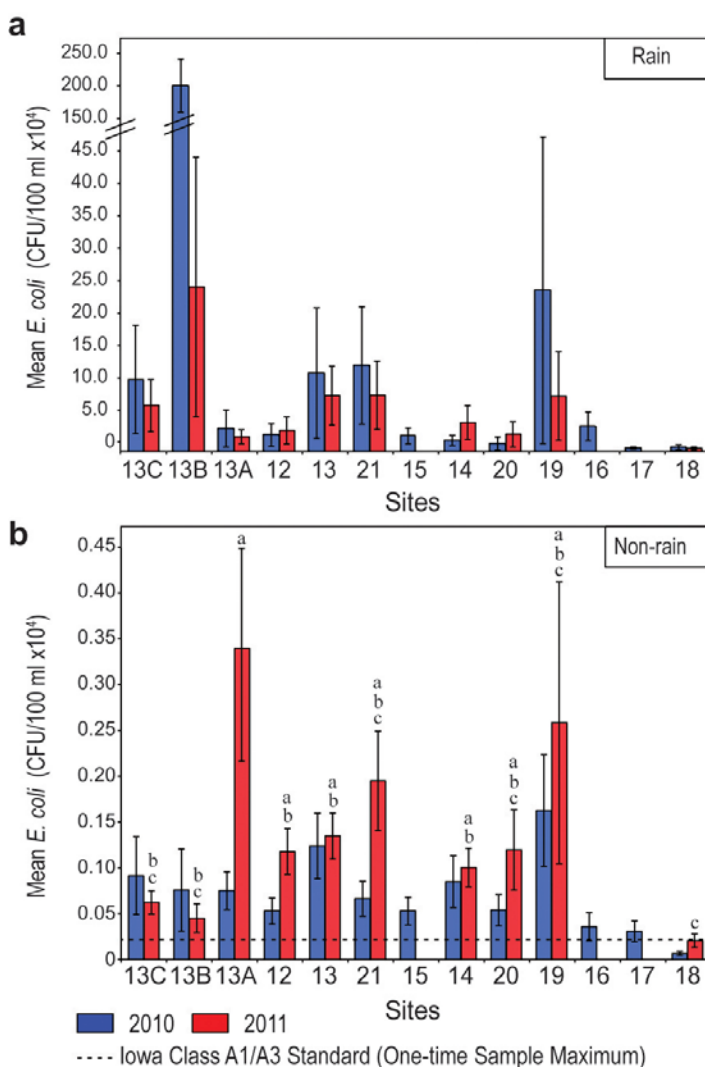


Fig. 3 Average *E. coli* levels at 10 sites in a Northeast Iowa watershed. Data were collected after > 0.5 inch rain events (A) and during non-rain conditions (B). Blue and red bars represent data collected in 2010 and 2011, respectively. Vertical lines represent standard error. The Iowa State water quality *E. coli* standard (single sample maximum) for streams designated as primary contact recreational use is 235 CFU *E. coli*/100 mL and is indicated by the dashed line.

the highest levels of *E. coli* (compare Fig. 3A to 3B), suggesting different types of sources. Possible dry weather sources include direct deposition of fecal matter into the stream by livestock or wildlife, disturbance of fecal bacteria in stream sediments, or human septic input. While we did not find evidence of septic input, we did find that upland sites with high *E. coli* levels had substantial lengths with direct livestock access. Although dry weather sources of *E. coli* generally result in much lower numbers than wet weather sources, their total impact should not be underestimated, because most of the

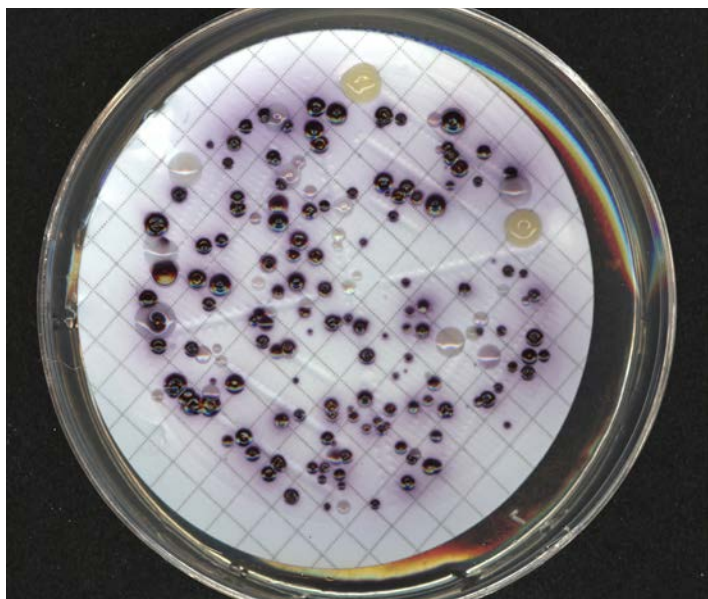


Fig. 2. Sample results from a northeast Iowa stream. Purple dots represent *E. coli* bacteria present in 100 milliliters (approximately 1/2 cup) of stream water. Photo by Robert Fitton, Luther College Biology Department.

time precipitation is not occurring. Further, at least in our study, dry weather *E. coli* levels peaked in July and August, when recreational activity in the water was most likely.

Fortunately, there is much that can be done to reduce bacterial pollution in Iowa's waterways, and encouragingly, bacterial pollution responds relatively quickly to change, with significant improvements possible in one or two years. For wet weather *E. coli* sources, strategies include feedlot runoff controls, manure storage structures, manure management practices, expanded vegetative areas along streams, and manure application during warm, dry conditions (which favor bacterial die-off). Strategies for dry weather sources include restricting livestock access to streams, providing off-stream water sources, and updating aging septic systems. Educational and financial resources, such as cost-sharing opportunities, can be found through local extension agencies and soil and water conservation districts.

Bacteria-polluted streams may also contaminate ground water sources that are used for drinking water.

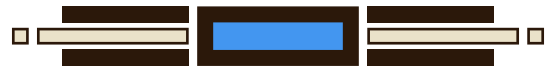
Iowa's children are a segment of the population that comes into close and regular contact with Iowa's water resources. Not only is this population at higher risk from bacterial pollution, they will also play a critical future role in addressing the State's water quality challenges. Water quality-based laboratories and field trips (see Fig. 4) can be designed to engage students at all levels of education. Analysis of water samples is technically doable, tangible, and appropriate for a wide range of budgets and expertise (Enos-Berlage, 2012). Water quality projects align well with the new K-12 science educational standards, as well as current science education initiatives in the 4-H program. Perhaps most importantly, these projects connect science education to a real-life challenge present in one's own community. Impaired water project sites for these types of experiences are widely (and unfortunately) available. Iowa's citizenry cares deeply about the State's water resources. Investments in education may very well have the largest long term impact.

"In the end, we will save only what we love. We will love only what we understand, and we will understand only what we are taught."

- Baba Dioum, Senegalese conservationist



Fig. 4 Students (Jake Wittman, left and Andrew Weckwerth, center) and faculty (Jodi Enos-Berlage, right) from Luther College monitor water quality in a northeast Iowa stream. Photo by Suos Imsouchiv, Luther College Publications Office.



References

- Enos-Berlage, J. L. 2012. Development of a water-quality lab that enhances learning and connects students to the land. *American Biology Teacher*. 74: 471-478.
- Muirhead, R. W., R. J. Davies-Colley, A. M. Donnison, and J. W. Nagels. 2004. Faecal bacteria yields in artificial flood events: quantifying in-stream stores. *Water Research*. 38: 1215-1224.
- United States Environmental Protection Agency, 1984. Health Effects Criteria for Fresh Recreational Waters. EPA-600/1-81-004, 33 p
- US Environmental Protection Agency. 2012. Watershed assessment, tracking, and environmental results: Iowa assessment data for 2012. http://ofmpub.epa.gov/waters10/attains_state.report_control?p_state=IA&p_cycle=2012&p_report_type=A
- Wittman, J., A. Weckwerth, C. Weiss, S. Heyer, J. Seibert, B. Kuennen, C. Ingels, L. Seigley, K. Larsen, and J. Enos-Berlage. 2013. Evaluation of land use and water quality in an agricultural watershed in the USA indicates multiple sources of bacterial impairment. *Environmental Monitoring and Assessment*. 185: 10395-10420.

Agricultural Potential in Brazil and Future Challenges

Igor Rodrigues de Assis

Raphael Bragança Alves Fernandes



The amount of food, wood, and fiber offered in the world has considerably increased during the last 40 years, according to the 2013 annual study provided by the Food and Agriculture Organization (FAO). However, it is still a challenge for the world to keep up with this increase in comparison to the planet's population growth. In 2005, the world population was around 6.453 billion people and in 2025, the FAO expects that this number will reach 7.851 billion. In this scenario, the need to increase production is evident. This can be achieved with an increase in productivity in areas that are currently being farmed and also through the expansion of area that is already being used for production. For the second option, there are just a few countries in the world with space available for this use. From statistical data provided by FAO and by other Brazilian organizations, Scolari (2012) affirmed that 90 percent of the suitable and non-cultivated areas in the world are in South America and Africa. In addition, according to the FAO annual statistical report of 2013, 50 percent of available land with agricultural potential is in Brazil and Angola.

Brazil is a country with an area of 2.1 billion acres and is

located in South America. It is the fifth largest country in the world, just being smaller than Russia, Canada, China, and United States. With regards to its location, 92 percent of its territory is located in the intertropical zone (within the Tropic of Cancer and Tropic of Capricorn), has good climatic conditions for plant growth throughout almost the entire year, and has suitable conditions for considerable wildlife and plant biodiversity.

Another important topic is Brazilian soils. The majority of the soil (around 60 percent) is highly weathered (also called Latossolos) and despite low fertility and generally high acidity, it has good physical conditions. The soil's good physical condition aids in the management, enabling a good structure, suitable porosity and as a consequence, good conditions for root growth. On the other hand, the low fertility makes the agriculture production highly fertilizer dependent, which is generally imported.

In 2005, data from the FAO and research institutes in Brazil showed that the situation of the United States of America is a little different: it has already transformed around 45 percent

In 2025, the FAO expects that [the world population] will reach 7.851 billion. In this scenario, the need to increase production is evident.

of its area into agricultural lands leaving a forest remnant of 33 percent. Apart from that, the United States works with extreme climatic conditions, which compromises production during part of the year. This situation is also observed in other countries that have larger areas than Brazil, which helps affirm Brazil's agricultural potential.

An increase in specialized workforce and a more effective use of technology are just a few reasons Brazil is turning into one of the greatest agricultural exporters, with a four percent share of the international commerce. Brazil is one of the main exporters of oilseeds and livestock products. The Brazilian scenario is developing to consolidate the country as a leader in exploration and agricultural production (food, fiber, and bioenergy), respecting and keeping its biodiversity, maintaining its soil and water quality, and guaranteeing the food, hydric, environmental and socioeconomic safety of the Brazilian people.

Aside from acquiring highlights in the international market of agricultural products, Brazil still has many challenges. The productivity of some varieties of produce and livestock exportation are still low. This is a factor of high importance to Brazil because an increase in productivity means a greater pressure to increase the agriculture border, and consequently, forest areas need to be preserved. The support of new technologies with a focus on productivity can still increase significantly, which would deserve greater government funding and private investments. Other challenges for the country are the additional investments in infrastructure and logistics, in particular: roads, storing facilities, ports, research, development, and innovation. From an economic point of view, financial stability must be combined with perspectives that favor private investment, and in particular, those that seek a reduction in taxes.



Soil and Water Conservation Districts: Making a Difference for Over 60 years

Steve Fales, Story County Soil and Water Conservation District Commissioner

Clare Lindahl, Executive Director, Conservation Districts of Iowa

Today, in your county, a Soil and Water Conservation District is beginning another day of work protecting Iowa's soil as we grow more corn and soybeans than any other State in the nation. Your District has been doing this work for over 60 years.

Soil and Water Conservation Districts were formed across the nation in response to the devastation of the 1930's Dust Bowl which brought ecological, economic, and social misery to tens of thousands of Americans as a result of farming the land without conservation. Districts were charged with restoring and protecting the soil to ensure continued productivity, and they did so by encouraging the use of an array of conservation practices.

Today there are 3,000 Soil and Water Conservation Districts and 17,000 Soil and Water District commissioners across the nation. In Iowa alone, there are 100 Soil and Water Conservation Districts with 500 commissioners. Every county has a Soil and Water Conservation District and all Iowans, urban as well as rural, are served by them. Commission boards are comprised of five commissioners, who are elected for a four-year term on a non-partisan ballot during the general election. Assistant commissioners can be appointed by the board at any time to assist in the work of the commissioners.

Soil and Water Conservation Districts provide Iowans with education, technical assistance and funding to implement

conservation practices on agricultural and urban land. They work with many partners to accomplish this, most often with the Natural Resources Conservation Service, Iowa Department of Agriculture and Land Stewardship-Division of Soil Conservation, and the Department of Natural Resources; but they also partner with local governments, hunting, commodity, and environmental organizations.

One of the duties of the commissioners is to identify and investigate environmental problems in the county, and to raise

funds through tree sales, grant writing, and other efforts to address these problems. Commissioners are also responsible for allocating millions of federal, state, and local dollars to implement conservation practices in their counties. Bringing conservation education to all Iowans, urban as well as rural, is a significant and necessary part of this work, and county commissions frequently host field days,

workshops, and meetings with state, local, and national leaders. They do this work to protect soil and ensure sustainable agriculture, to protect our water, and to provide habitat for birds, fish, and other wildlife. This work is vital to the economy of our State and the quality of life of its residents and millions of annual visitors. A Soil and Water Conservation District has a hand in nearly every conservation project in the State.

Conservation districts have many strengths, one of them is the ability to provide a way for conservation-minded citizens

***Soil and Water Conservation
Districts provide Iowans with
education, technical assistance
and funding to implement
conservation practices on
agricultural and urban land.***

to influence and participate in local soil and water stewardship. In fact, virtually every successful conservation project in Iowa has started with one person and an idea; and every project, large and small, has had a champion. Let's look at a couple of examples.

Coralville Mayor John Lundell has shown us how one person can lead by example and champion conservation in his own front yard. In 2013, Mayor Lundell's need for a new driveway, and concern with clean water in his community, led to the installation of a 2,313 square foot permeable paving driveway at his residence. The project allows rainwater to be absorbed and cleansed rather than running off, overwhelming, and polluting local water bodies. Mayor Lundell worked with the Johnson County Soil and Water Conservation District to accomplish this project. Says Mayor Lundell, "[t]hey [the Soil and Water Conservation Districts] have always been there with great advice and guidance and information on what the next steps should be and then of course financially they have also been a great partner with us." Further, he also hopes his project is a catalyst for others to do the same.

A champion is often defined as a hero or winner and also as an advocate for a cause. Steve McGrew, a farmer and Soil and Water Conservation District Commissioner in Mills County, is a champion in both senses of the word. His manner of going against the norm and incorporating conservation into his farming operation is courageous and everyone downstream is a winner because of it. To minimize his impact on Iowa's waters and to ensure continued productivity on his land, Steve utilizes many conservation practices, one of which is the inclusion of cover crops. Steve's efforts don't stop at the edge of his field. In the last year alone, he has shared his experiences with cover crops, and other conservation practices, with hundreds of other farmers, hoping that others will adopt conservation practices on their land.

Many opportunities exist with Iowa's Soil and Water Conservation Districts. They work at the county level for a reason: to provide local solutions to local conservation issues. If you have a conservation idea or have a question about conservation, start by contacting your Soil and Water Conservation District (<https://idals.iowa.gov/FARMS/index.php/districtMap>) and ask them how you can assist with an existing project or propose how you can partner to start a new project. Initiating conservation practices on your land, helping to educate others, assisting with the organization of a fundraiser, and becoming a Soil and Water Conservation District Commissioner yourself are all ways to be a conservation champion!

The cause for conservation needs champions more now than ever, as we continue to lose soil at an unsustainable rate and Iowa's waters remain some of most troubled in the nation. Anticipated population increases will require farmers to produce more crops which will increase demands on Iowa's natural resources. The expansion of towns and cities will lead to more parking lots and impervious surfaces that will shed pollution into our waters. Today, nearly 600 of Iowa's streams, lakes, and rivers are considered impaired or highly polluted. We know the technical solutions to our problems, all we need now is the grassroots motivation to solve them, and champions like you to plant a seed for change.



Sediment Accumulation Rates Still Increasing in Iowa's Natural Lakes

Christopher T. Filstrup¹, Adam J. Heathcote^{2,1}, and John A. Downing¹

¹Ecology, Evolution, and Organismal Biology Department, Iowa State University

²Département des sciences biologiques, Université du Québec à Montréal

Human activities in Iowa watersheds have dramatically altered the rate at which sediments accumulate in lake bottoms. Lakes fill in with sediment and become shallower through time, a natural process called lake succession. In this natural process, lakes are transformed from lakes, to marshes, and finally to meadows over thousands of years. Human activities can greatly increase sediment accumulation rates in lakes, thereby accelerating this process so lakes fill in on timescales of decades to centuries. In Iowa natural lakes, it currently takes approximately two years to accumulate a half-inch of sediment, compared to 22 years before European settlement of the region in 1850 (Fig. 1; Heathcote et al., 2013).

In Iowa, interpretation of sediment cores from natural lakes suggests that intensification of farming practices led to increased erosion that was primarily responsible for these

increased sediment accumulation rates. In sediment cores pre-dating 1850, up to 75 percent of lake sediment consisted of materials eroded from the watershed, and the largest increases in sediment accumulation rates occurred in the 1950s (Heathcote et al., 2013). The 1950s was a period of agricultural intensification in the Midwestern United States, in which crop yields increased by almost four times because of consolidation of farmland, mechanization, and increased fertilizer and biocide application (Tilman et al., 2002). Sediment accumulation rates from sediment cores suggest that an average of 68.1 tons of sediment have been lost per acre of watershed since 1850 (Heathcote et al., 2013).

Sediment accumulation rates have increased in Iowa lakes despite the United States spending \$5 billion annually to reduce soil erosion.

Increased accumulation of erosional materials in lakes may also result from stream bank erosion, which is currently an area of intense debate among agriculture producers, environmentalists, and lake and watershed managers. Along with increased annual precipitation, artificial drainage of agricultural fields (i.e., tile drains) may be driving increased stream flow and subsequently stream bank erosion in the Midwestern United States (Schottler et al., 2013). Lake sediment accumulation rates represent combined watershed erosional losses from upland soils and stream banks, so both sources likely contributed to the 68.1 tons per acre sediment loss in

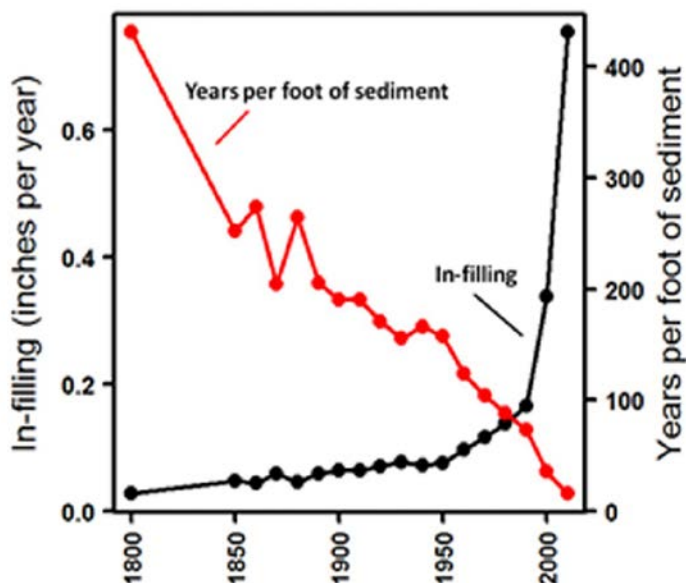


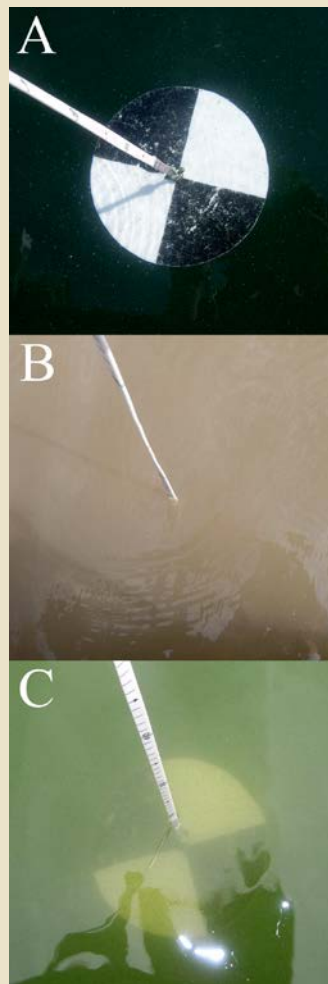
Fig. 1 Average in-filling by decade for Iowa's natural lakes since 1800. The black line represents in-filling rate in inches sediment per year. The red line represents the number of years it would take to accumulate one foot of sediment.

Iowa watersheds since 1850 (Heathcote et al., 2013). Identifying the primary sources of sediment on a watershed-by-watershed basis is critical to the development of effective management practices to mitigate sediment erosion.

Soil erosion and runoff of nutrient-rich water from agricultural fields can also contribute to sedimentation problems in Iowa lakes by fueling large algal blooms that transport a lot of organic matter to lake bottoms. Phosphorus commonly limits algal production in freshwater lakes, so processes that increase phosphorus loading to lakes will increase the amount of algal biomass produced in lakes (Dillon and Rigler, 1974). In sediment cores from Iowa natural lakes, up to 31 percent of sediments accumulated since 1850 consisted of material related to the production of algae, and organic matter accumulation rates have tripled since 1950 (Heathcote et al., 2013). Management strategies to mitigate sedimentation problems in Iowa lakes must address both sediment erosion in watersheds and algal biomass production in lakes.

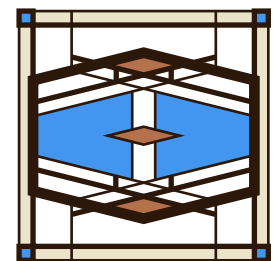
Sediment accumulation rates have increased in Iowa lakes despite the United States spending \$5 billion annually to reduce soil erosion and nutrient losses from agricultural fields (Winsten and Hunter, 2011), suggesting that current management strategies are ineffective. Management strategies to curb sedimentation problems in Iowa lakes will ultimately depend on the severity of the problem and the primary source of sediments on a lake-by-lake basis. If soil erosion from agricultural fields primarily contributes to lake sedimentation, then management strategies targeting the most erosion-prone fields will be needed, whereas stream bank stabilization will be needed if sediments primarily originate from stream bank erosion. If sediments are largely composed of algae-related materials, then management strategies to reduce nutrient loading should be emphasized. Regardless of the severity or source, management strategies will require concerted, long-term efforts from agricultural producers, watershed residents, and water quality and watershed management agencies.

Water Transparency in Iowa Lakes



The severity of lake sedimentation and the types of particles contributing to it are easily identifiable by looking at the transparency and color of water, respectively. The Secchi disk, a disk with alternating black and white patterns (pictured in Fig. 2), is commonly used to determine water transparency of lakes. A Secchi disk is still visible at great depths in lakes with clear waters that are relatively free of particles, but quickly disappears at shallow depths in lakes with murky waters with a lot of suspended particles (Fig. 2A compared to 2B,C). Lakes with clear waters typically have low sediment accumulation rates, whereas lakes with murky waters typically have high sediment accumulation rates. Murky lakes can either appear brown or green depending on the primary source of sediments. Inorganic particles that eroded from watersheds or were resuspended from lake bottoms, such as silt, clay, and sand are abundant in lakes with murky, brown waters (Fig. 2B). Organic particles, such as algae, are abundant in lakes with murky, green waters (Fig. 2C). This simple, low-cost technique for assessing lake water quality can often be a very informative, preliminary approach for identifying sedimentation problems in Iowa lakes.

Fig. 2: Images of Secchi disks at 7.9 inches depth from three Iowa lakes during the 2013 sampling season. (A) West Okoboji Lake (Dickinson County) on August 28, 2013. (B) Lake Miami (Monroe County) on July 8, 2013. (C) White Oak Lake (Mahaska County) on August 5, 2013.



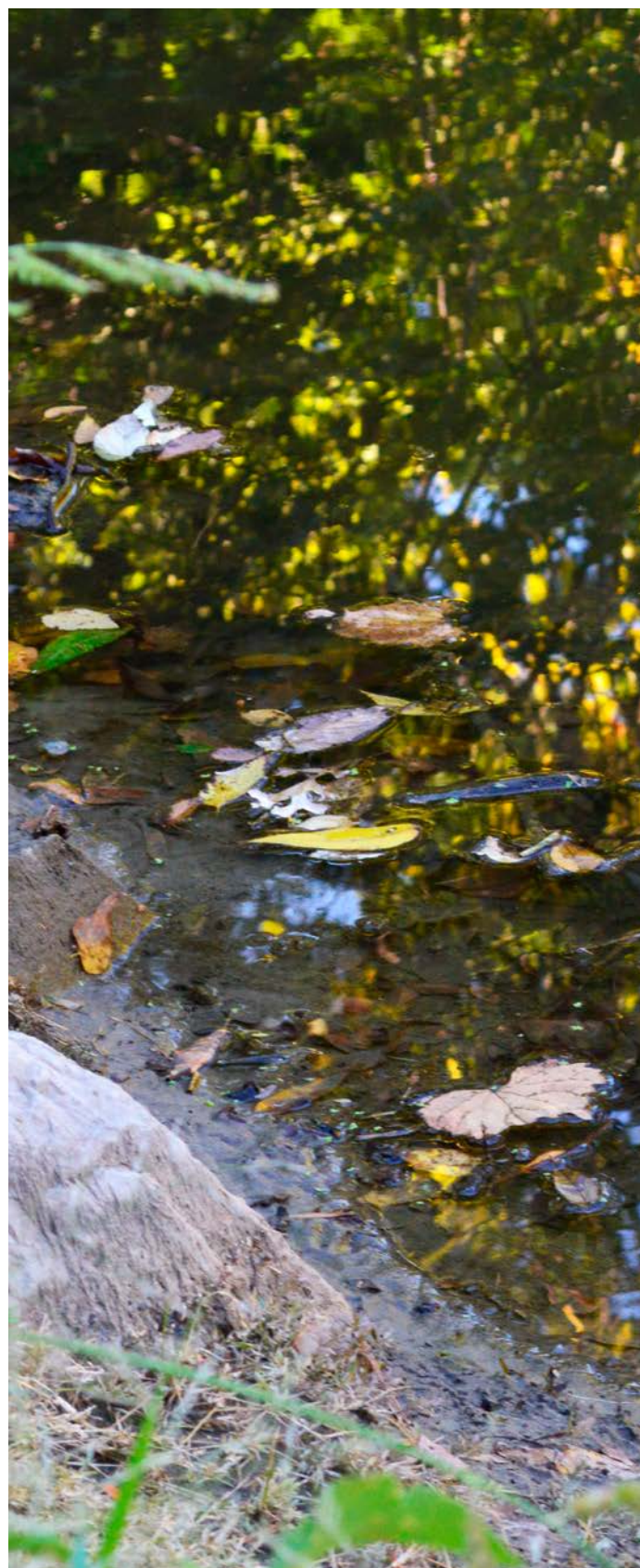
References

- Dillon, P. J., and F. H. Rigler. 1974. The phosphorus-chlorophyll relationship in lakes. *Limnology and Oceanography* 19: 767–773.
- Heathcote, A. J., C. T. Filstrup, and J. A. Downing. 2013. Watershed Sediment Losses to Lakes Accelerating Despite Agricultural Soil Conservation Efforts. *PLoS ONE* 8: e53554.
- Schottler, S. P., J. Ulrich, P. Belmont, R. Moore, J. W. Lauer, D. R. Engstrom, and J. E. Almendinger. 2013. Twentieth century agricultural drainage creates more erosive rivers. *Hydrological Processes*. DOI: 10.1002/hyp.9738. 1–11.
- Tilman, D., K. G. Cassman, P. A. Matson, R. Naylor, and S. Polasky. 2002. Agricultural sustainability and intensive production practices. *Nature* 418: 671–677.
- Winsten, J. R., and M. Hunter. 2011. Using pay-for-performance conservation to address the challenges of the next farm bill. *Journal of Soil and Water Conservation* 66: 111A–117A.



The Iowa Chapter of the Soil and Water Conservation Society is **PROUD** to sponsor the ISU Soil and Water Conservation Club!

www.iaswcs.org



Protecting Our Land and Water Resources

Developing solutions and determining best management practices to protect and conserve the soil and water resources of Iowa, our nation, and the world using engineering and technology.

IOWA STATE UNIVERSITY

Department of Agricultural and Biosystems Engineering

www.abe.iastate.edu

Ephemeral Gully Erosion Presents a Unique Conservation Opportunity

Karl Gesch

Graduate Research Assistant, Department of Agronomy, Iowa State University



Fig. 1: Ephemeral gullies that formed in Iowa during spring 2013. Photo by Sharon Rasmussen.

Iowans farm some of the most productive soils on Earth. The history of superb agricultural production in our State is due to many factors such as fertile soils, intelligent management practices, technological innovation, and constantly improving agronomics. While all of these have contributed to Iowans' agricultural successes, this article will focus on the first two: soils and how we use them.

Soil erosion is simply the detachment and transport of soil particles. It is a critical issue in Iowa and worldwide. Losing topsoil has on-site drawbacks such as diminished soil productivity and also has off-site consequences such as impaired water quality.

When rainfall strikes soil, it can flow downward into the soil, which is called infiltration, or flow over the surface as runoff. This water that runs across soil can transport loose soil particles. Runoff causes soil erosion if it has sufficient power to detach and transport soil.

Soil erosion is an incredibly complex phenomenon. As in other scientific fields, soil scientists try to separate the complicated subject of soil erosion into simpler categories that

can be investigated more easily, efficiently, and effectively. One type of soil erosion that is receiving increasing levels of interest is ephemeral gully erosion.

What is an ephemeral gully?

Ephemeral means temporary and a gully is a channel through which water can flow, so an ephemeral gully is simply a temporary channel. The fundamental concept behind an ephemeral gully is that it re-forms in the same location due to topography but disappears when it is refilled with more soil. Figure 1 shows an example of an ephemeral gully.

Topography is the shape of the land surface. On landscapes where runoff naturally flows together into areas with relatively lower elevation, the water is said to be concentrated and forms channels by eroding soil. This concept is illustrated in Figure 2. Because a landscape's topography does not change rapidly, concentrated runoff and erosion reoccur in the same locations during every sufficiently large rainfall. This process of soil erosion due to topographically concentrated runoff is known as ephemeral gully erosion.

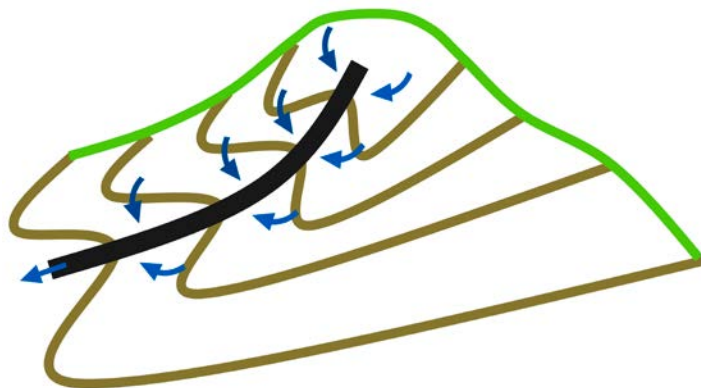


Fig. 2: This example 3D hillslope shows brown contour lines, or areas of equal elevation. Runoff (blue arrows) concentrates into a common area of lower elevation (at the bends in the contour lines) and forms an ephemeral gully (the gray curve).

If an ephemeral gully always re-forms in the same landscape locations, it would seem logical to think that it would continuously erode until it is so deep or wide that it becomes permanent. However, human intervention can erase ephemeral gullies. Tillage operations drag soil into the channel and fill it with sediment, which masks the ephemeral gully.

When the next rain storm occurs the channel filling will be undone. Runoff concentrates in the exact same positions; thus ephemeral gully erosion occurs in the exact same positions. This repeated process of erode and fill perpetuates soil loss via ephemeral gully erosion.

While it may seem that ephemeral gully erosion poses an insurmountable challenge, this phenomenon can actually be curtailed with relatively simple conservation practices.

Why does ephemeral gully erosion matter?

The ephemeral gully cycle is characterized by alternating periods of ephemeral gully erosion followed by channel refilling. The fact that this process repeats itself means that soil losses will also be repeated. When ephemeral gullies erode, they contain concentrated runoff that can convey, or transport, soil particles with relative ease.

As an analogy, think of a school lunch tray as a soil particle. When a lunch tray is placed on a tray return belt, it is carried away into the kitchen, where it becomes somebody else's responsibility. A tray return system like this can rapidly and efficiently transfer many lunch trays out of the cafeteria into the kitchen. Ephemeral gullies are like conveyor belts that quickly transport soil (lunch trays) away from farm fields (the cafeteria) and deposit it elsewhere (the kitchen). When eroded soil is transported into reservoirs, adjacent fields, streams, and ditches it can cause problems such as sedimentation and diminished water quality.

Imagine that too many lunch trays are placed on the tray return at one time. The lunch trays will stack up in the kitchen

so quickly that the kitchen staff might not be able to do its job properly. Similarly, when too much soil is deposited into streams or reservoirs, these water bodies may lose their capacity to function naturally. Now imagine that some of the lunch trays contain sticky food residues. These trays may require additional washing or the excess food may clog sinks. In the same manner, some eroded soil particles contain excess chemicals or nutrients that can disrupt aquatic ecosystems.

The potential problems don't end for the kitchen staff. If all of the clean lunch trays are used up faster than they can be washed before the next day, then the students and teachers must eat their lunch without a lunch tray. While it is still possible to have lunch without lunch trays, it will be more difficult for diners to carry the same amount of food. Likewise, if soil erodes faster than nature replenishes it (which happens very, very slowly), the productivity of that soil will decrease. Eroded soils can still be used to grow crops, but they will have diminished yields.

What can we do about ephemeral gully erosion?

While it may seem that ephemeral gully erosion poses an insurmountable challenge, this phenomenon can actually be curtailed with relatively simple conservation practices. For example, installing permanent grassed waterways in landscape positions where runoff tends to concentrate can greatly reduce ephemeral gully erosion. Perennial grasses impede concentrated runoff and reduce its ability to detach and transport soil particles. Furthermore, no-till soil management prevents additional topsoil from being eroded when ephemeral gullies re-form after having been filled.

Ephemeral gully erosion is complex and can potentially cause on-farm and off-farm problems. However, by implementing basic conservation measures we can limit ephemeral gully erosion, protect our productive Iowa soils, and maintain high environmental quality for all Iowans.

Further Reading

- Fenton, T.E., M. Kazemi, M.A. Lauterbach-Barrett. 2005. Erosional impact on organic matter content and productivity of selected Iowa soils. *Soil & Tillage Research*. 81(2):163-171.
- Gordon, L.M., S.J. Bennett, C.V. Alonso, R.L. Bingner. 2008. Modeling long-term soil losses on agricultural fields due to ephemeral gully erosion. *Journal of Soil and Water Conservation*. 63(4):173-181.

New Satellites for Soil Moisture: Good for Iowans!

Brian K. Hornbuckle

Associate Professor, Department of Agronomy, Iowa State University
bkh@iastate.edu

My wife recently asked “Do we still need rain?” Unfortunately *we don't really know* the answer to this question here in Iowa! We can compare the year-to-date amount of precipitation with Iowa climate, but it won't tell us how much of that water was captured by the soil and thus the current amount of soil moisture available to support the row-crop agriculture that dominates our State.

Take 2013 as an example. After a record-setting wet spring was followed by another dry summer, we may be at near-normal levels of annual precipitation, but we do not know the fraction of water that actually infiltrated into the ground and was not lost as runoff into rivers, lakes, and streams.

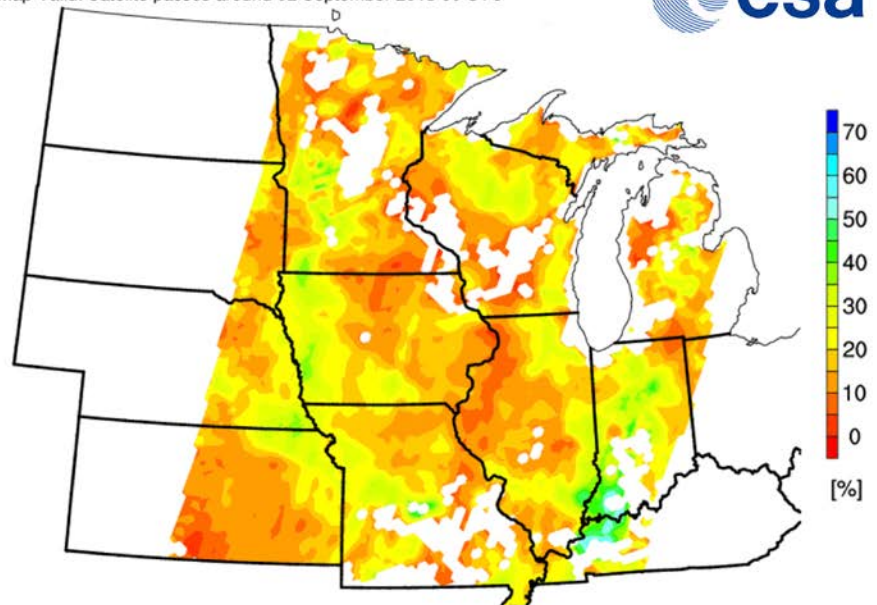
In addition to providing crops with water, soil moisture

also plays a large role in the timing and amount of precipitation through its influence on the water and energy budget at Earth's surface (e.g. Findell and Eltahir, 2003). Water evaporated from the soil and transpired by plants transfers energy from Earth's surface to the atmosphere, increases the humidity, and subsequently influences the likelihood of precipitation.

Currently we enter each growing season “blind” as to whether or not there will be enough soil moisture and precipitation to support productive crops. If we could keep a running inventory of the water stored in Iowa soils, and if we had better weather forecasts that extended farther into the growing season, farmers could make decisions on what to plant (a drought-tolerant hybrid?), crop management (in-



SMOS Satellite: Soil Moisture (0-5cm)
Map Valid: Satellite passes around 02 September 2013 00 UTC



Iowa Environmental Mesonet
Map Generated 08 Sep 2013 12:00 PM

Figure 1: At left, the European Space Agency's Soil Moisture and Ocean Salinity (SMOS) satellite mission. At right, data from a single pass of the SMOS satellite over the Midwest U.S. Wet soils are marked by cool colors, dry soils by warm colors.

crease plant–density?), nutrient management (when to apply nitrogen?), and soil management (reduce tillage to keep as much water in the soil as possible?) in order to maximize yield. Public and private entities that support farmers would also benefit.

The ability to keep track of soil moisture will likely become more important in the future. Wetter springs are expected to become more common in Iowa, but so is the occurrence and severity of drought (Hatfield and Takle, 2014). Despite increases in mean temperatures, water availability will continue to be the most important factor in crop production (Hatfield et al., 2011).

Besides allowing us to better predict crop productivity and make improved forecasts of weather, knowing the current state of soil water would also help address two other issues that are important to our State. When its moisture content is high the soil cannot absorb much more water. Run-off causes flooding and often carries with it eroded soil and chemicals that pollute our bodies of water. *If we knew more about soil moisture, it would be good for Iowans!*

Fortunately we are at the beginning of a new era of soil moisture observations that will be obtained by satellites orbiting Earth. The first global maps of near-surface soil moisture are now being produced about every-other day by the European

Space Agency's Soil Moisture and Ocean Salinity (SMOS) mission (Kerr et al., 2010). An artist's rendition of the SMOS satellite and an example of SMOS soil moisture is shown in Figure 1. Launched on November 1, 2009, the SMOS satellite is a giant step forward from previous satellites because of its ability to "see through" vegetation and observe the soil, even under the tall corn of Iowa.

Soil moisture can be defined as the water stored in soil that is available to plants and hence exchanged between the land surface and the atmosphere via evaporation, transpiration, and precipitation. This water resides in the root-zone of plants, about the first one to two meters of the soil. **Near-surface soil moisture** is the water held in the first three to five centimeters of the soil that can be sensed via satellite. Soil moisture can be estimated

from frequent observations of near-surface soil moisture through the use of models (e.g. Calvet and Noilhan, 2000).

The SMOS satellite carries an instrument which is essentially a special type of camera that is able to record the microwave radiation (and not the visible radiation that our eyes can see) naturally emitted by Earth's surface. This is an example of passive remote sensing, which contrasts with active remote sensing techniques like weather radars that produce their own radiation and record the radiation scattered back. The microwave radiation emitted by land surfaces changes de-

The SMOS satellite carries a special type of camera that is able to record the microwave radiation naturally emitted by Earth's surface. The radiation emitted by land surfaces changes depending on their moisture content.

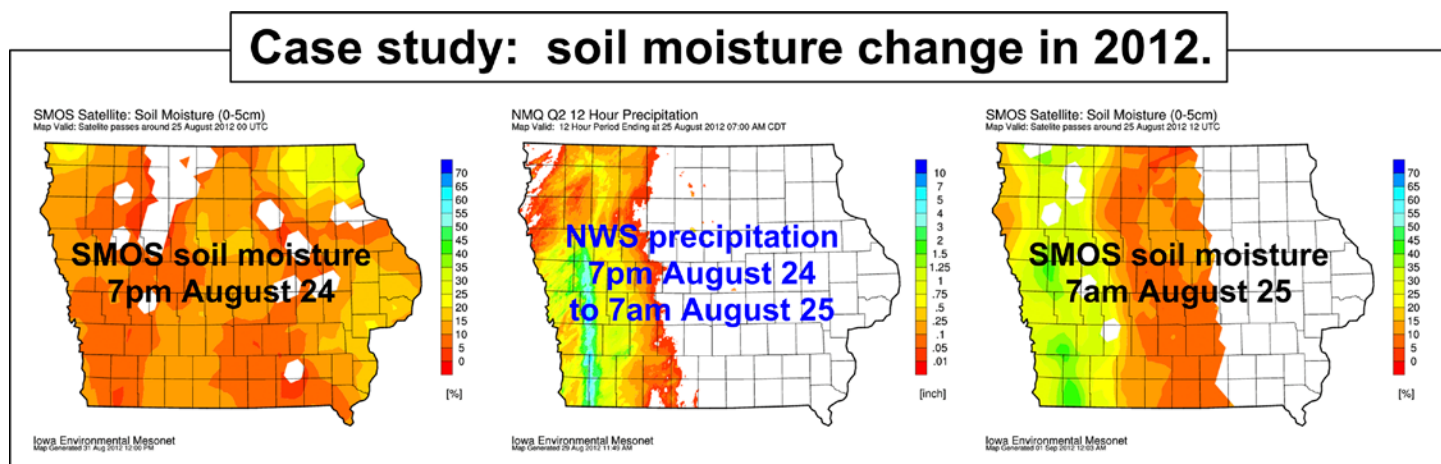


Figure 2: A change in near-surface soil moisture observed by the SMOS satellite following a significant rain event during the summer drought of 2012.

pending on their moisture content. Wet soils emit less microwave radiation than dry soils. Models that relate the microwave radiation measured by satellites to near-surface soil moisture have been developed (e.g. Wigneron et al., 2007).

An example of the quality of SMOS soil moisture is shown in Figure 2. Focus on Page County in Southwest Iowa (the second county from the western border in the bottom row of counties). According to SMOS, near-surface soil moisture was very low, about 5 percent by volume, at 7 pm local time on August 24, 2012, consistent with drought conditions in this area.

Between 7 pm on August 24 and 7 am the next morning, August 25, a significant amount of rain fell in this region. The National Weather Service reported 68 millimeters at a maximum rate of 14 millimeters per hour at one location within Page County. If initial near-surface soil moisture was indeed five percent and if all of this rain infiltrated into the first 20 centimeters of the soil, then a simple water balance gives a resulting soil water content at 7 am of about 40 per-

cent. The SMOS soil moisture product at 7 am on August 25 has a value between 40 percent and 45 percent, as expected.

My research group has tested SMOS data in other ways and found that it is performing as expected. Google “Iowa SMOS data” if you would like to look at the data yourself.

In the coming year an additional soil moisture satellite will begin orbiting Earth. NASA’s Soil Moisture Active Passive (SMAP) mission is scheduled to be launched on November 5, 2014. A picture of the SMAP satellite is shown in Figure 3. SMAP will use both passive and active microwave remote sensing to improve the spatial resolution of near-surface soil moisture observations from about an Iowa county for SMOS (40 kilometers), to about an Iowa township (ten kilometers), the scale at which future global circulation models will be used to make weather and climate predictions (Entekhabi et al., 2010).

What work is left to do? Quite a bit. In order to maximize the benefit of these new satellite missions, the products that they deliver must be validated: that is, the near-surface soil moisture observations must be compared to a “standard.” The simple analysis performed with Figure 2 is not rigorous enough. Validation will be conducted using instruments that directly sample near-surface soil moisture in carefully designed field experiments.

We also believe that the current algorithms used by SMOS and SMAP to translate observed microwave radiation into near-surface soil moisture must be modified in order to account for changes in the roughness of the soil surface caused by tillage that can “confuse” the satellites (Patton and Hornbuckle, 2013).

Once satellite algorithms have been improved and validation is accomplished, I believe that regional water balance models consisting of atmospheric and land surface models, along with schemes that incorporate real-time information regarding soil moisture, river levels, precipitation, and atmospheric conditions, will be created within the next decade. Such a system would be able to give estimates of current and future land surface water conditions, including soil moisture. Then it would be up to us to use this information to make decisions, and as a tool to test actions that Iowans could take to ameliorate the impact of future droughts, floods, and other types of climate variability.

It will be good for Iowans!

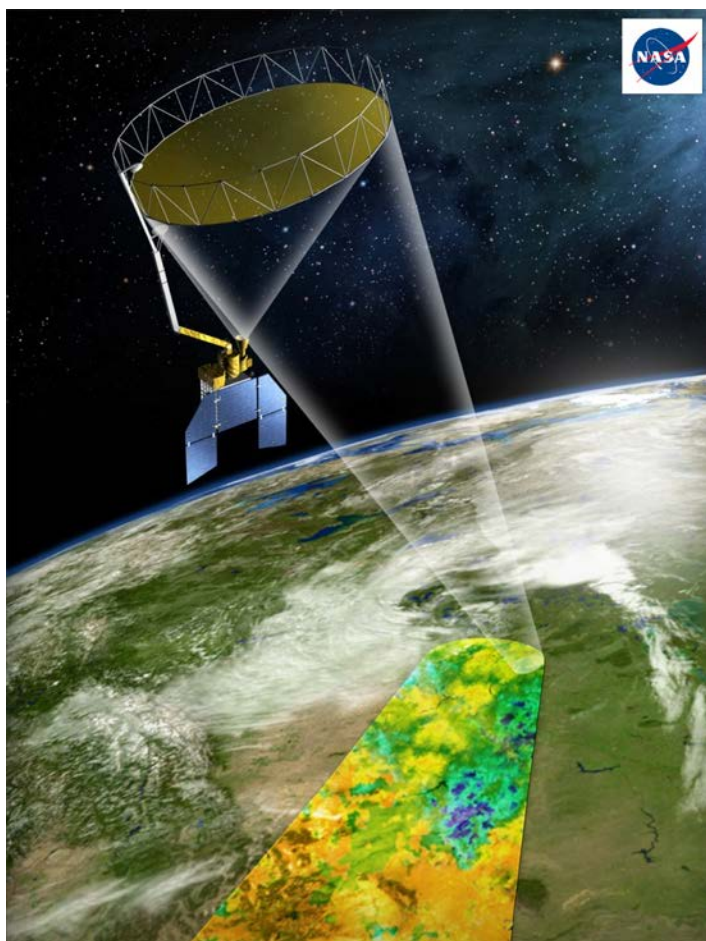


Figure 3: NASA’s Soil Moisture Active Passive (SMAP) satellite mission.



References

- Calvet, J.-C., and J. Noilhan (2000), From near-surface to root-zone soil moisture using year-round data, *J. Hydromet.*, 1, 393–411.
- Entekhabi, D., et al. (2010), The Soil Moisture Active Passive (SMAP) mission, *Proc. IEEE*, 98 (5), 704–716, doi:10.1109/JPROC.2010.2043918.
- Findell, K. L., and E. A. B. Eltahir (2003), Atmospheric controls on soil moisture–boundary layer interactions. Part II: Feedbacks within the continental United States, *J. Hydromet.*, 4 (3), 570–583.
- Hatfield, J. L., and G. S. Takle (2014), Chapter 6: Agriculture, in *National Climate Assessment, United States Global Change Research Program*.
- Hatfield, J. L., K. J. Boote, B. A. Kimball, L. H. Ziska, R. C. Izaurralde, D. Ort, A. M. Thomson, and D. Wolfe (2011), Climate impacts on agriculture: Implications for crop production, *Agron. J.*, 103 (2), 351–370, doi:10.2134/agronj2010.0303.
- Kerr, Y. H., et al. (2010), The SMOS mission: New tool for monitoring key elements of the global water cycle, *Proc. IEEE*, 98 (5), 666–687, doi:10.1109/JPROC.2010.2043032.
- Patton, J., and B. Hornbuckle (2013), Initial validation of SMOS vegetation optical thickness over Iowa, *IEEE Geosci. Remote Sens. Lett.*, 10 (4), 647–651, doi:10.1109/LGRS.2012.2216498.
- Wigneron, J.-P., et al. (2007), L-band microwave emission of the biosphere (L-MEB) model: Description and calibration against experimental data sets over crop fields, *Remote Sens. Environ.*, 107, 639–655, doi:10.1016/j.rse.2006.10.014.



LEOPOLD CENTER
FOR SUSTAINABLE AGRICULTURE

Exploring and cultivating alternatives
that secure healthier people and landscapes in Iowa and the nation.

Research at the Neal Smith Wildlife Refuge
shows that strategic placement of perennial prairie within
corn-soybean fields greatly reduces soil erosion and nutrient runoff.

The new conservation practice will be demonstrated on farms
throughout Iowa in 2014.

Find us on the web:
www.leopold.iastate.edu

Follow us on Facebook:
www.facebook.com/LeopoldCenter

The Importance of Soil Organisms: Dr. Seuss Knows

Marty Adkins

State Resource Conservationist for the NRCS in Iowa



My wife and I have had the joy and privilege of raising four children: one girl and three boys. They are all grown up now but we have so many wonderful memories of the days when our children were young; all the daily routines that come along with having little ones at home. One of my favorite daily, or I should say nightly, routines was the bedtime story.

While reading bedtime stories for four kids spread over 13 years from oldest to youngest, I became a children's literature aficionado. We enjoyed books from authors ranging from C.S. Lewis to Laura Ingalls Wilder, but I have to confess that one of my favorite authors was Dr. Seuss.

I think a real Dr. Seuss classic is Horton Hears a Who. In this story Horton the Elephant, by virtue of his very large ears, is able to hear sounds coming from a tiny speck. It turns out those sounds are coming from a complex and populous community of very, very tiny creatures who live on that speck. Horton ends up saving that community from others who would have accidentally destroyed it simply because they didn't know it existed.

Why am I bringing up this children's story in a magazine focused on soil and water management? If you'll bear with me I'll try to make the connection clear.

For a long time most agronomists have done a pretty good job of understanding and working with soil's physical and chemical attributes. We've looked at soil pH, cation exchange capacity, macronutrient and micronutrient test amounts, availability, etc.

The total biomass of organisms in one acre of healthy soil is equal to that of two fully grown bull African elephants!

At the same time those of us that work directly with farmers have not placed enough emphasis on the essential role of soil biology in soil systems and how it is a driving force in improving soil physical, chemical and hydrological properties.

We have talked some about nutrient cycling, especially nitrogen cycling, but most discussions I have heard on this subject focused on crop uptake and removal as the primary biological component. We have talked about nitrogen-fixing and nitrogen-converting bacteria, but that's about it.

We need to talk more about the incredible array of soil organisms that are part of the process that takes carbon from

the air and turns it into soil organic matter; the soil organisms that help build soil aggregate stability, porosity, and infiltration and water-holding capacity. There is good research work going on in this area and a healthy discussion within the scientific community in this area, but much more needs to be shared with the people that actually work the land for a living. There is so much to talk about.

The variety of organisms living in the soil is astonishing: mammals, reptiles, amphibians, arthropods, earthworms, protozoa, bacteria, fungi, and other macroscopic and microscopic plants and animals are just a few inhabitants of our soils. Dr. Jerry Hatfield from the United States Department of Agriculture National Laboratory for Agriculture and the Environment has stated that the total biomass of organisms in one acre of healthy soil is equal to that of two fully grown bull African elephants! The types and numbers of species in the soil can change significantly spatially, depending on soil and vegetative conditions.

One take-home message we need to be communicating loud and long is how all these living organisms make all the difference in how soils develop and perform agronomically and hydrologically.

The other take-home message we need to communicate is that these organisms don't do so well when they are exposed to sunlight, dried out and deprived of living vegetation for long periods of time.

We need to talk more about how tillage, field traffic and other farming operations impact those soil organisms and in turn how they impact soil aggregate stability, porosity and infiltration and water-holding capacity. Then we need to individually work to help the farmers we serve act on that information by adopting production practices that will ultimately make soils more productive.

We need to do more to educate future farmers, agronomists and engineers so that they understand the soil in a more complete way than I did when I started my career.

We need to emphasize a judicious, almost surgical approach to tillage; tilling only when and where it is absolutely necessary and when no good alternatives exist; recognizing the high cost of tillage on soil structure and the soil organisms that build it.

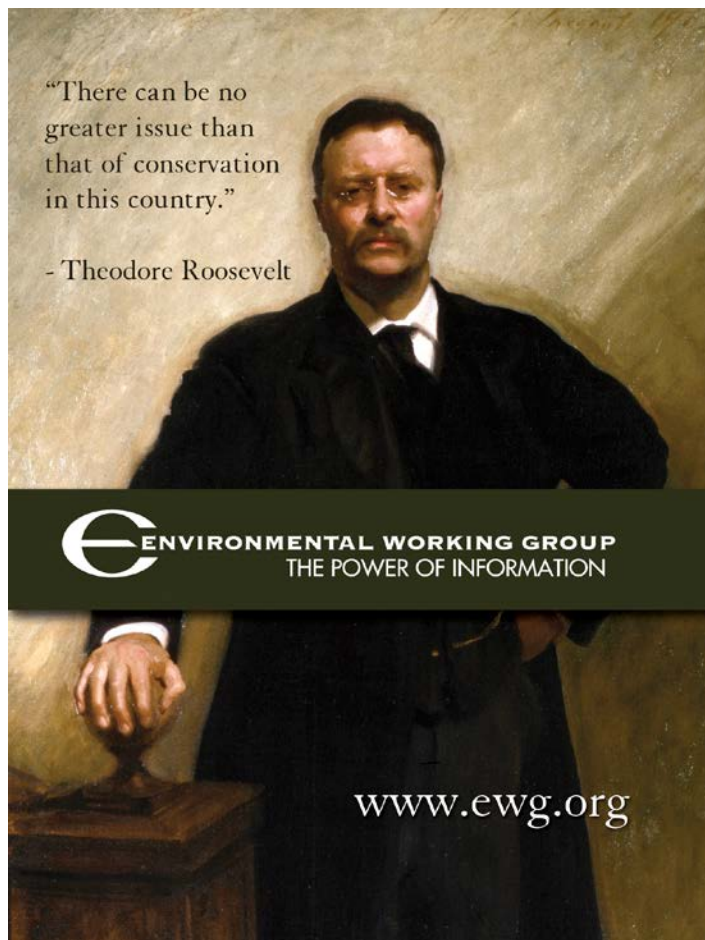
We need to emphasize the importance of keeping something growing from the first day of the growing season to the last, including before primary crop planting and after primary crop maturity (note I did not say harvest). Growing roots to

intercept and cycle nutrients, roots and plant residues to feed the organisms that build the soil.

We need to provide for plant diversity to help meet the diverse needs of the diverse organisms that live in the soil profile.

We need to strategically place deep-rooted perennial vegetation to intercept any nutrients that might be moving above or below the soil surface.

In Horton Hears a Who, a tiny but important world is preserved because someone recognizes that the world is there and takes steps to protect it. We have a similar opportunity. An amazingly complex world lies beneath the surface of the soil. The fungi, bacteria, earthworms and all the rest do their work mostly unseen and un-noticed. Like Horton, we need to recognize that world and help protect it because we, including our children, and all the readers and listeners of bedtime stories in the years to come, will be the beneficiaries.



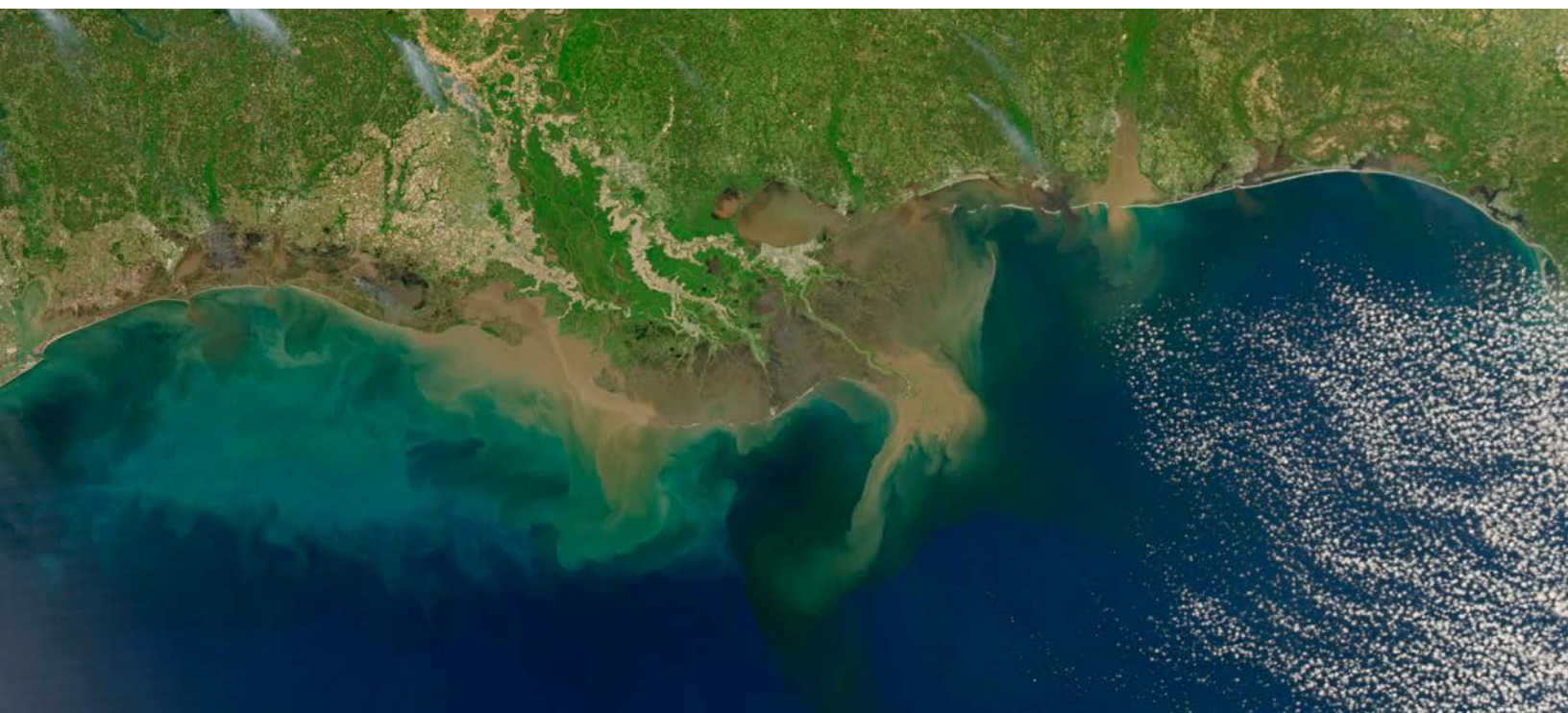
Gulf of Mexico Hypoxia: Why Blame Iowa Farmers?

Tom Isenhardt

Associate Professor, Natural Resource Ecology and Management, Iowa State University

Richard Cruse

Professor, Department of Agronomy, Iowa State University



The Northern Gulf of Mexico has a growing dead zone and Iowa farmers are a major cause! Does this sound familiar? Those that study water quality issues and especially those addressing Iowa agriculture and water quality are bombarded with this and similar statements. What does this statement really mean? It creates images of a lifeless area in the Gulf of Mexico, which in reality is only marginally correct. To understand the validity, or lack of validity, of these statements we must first understand selected important concepts about hypoxia.

We must first understand what 'hypoxia' means and why it is important. Hypoxia occurs when the amount of oxygen in water is insufficient to support oxygen loving (or oxygen

needing) sea life. Typically the concentration of oxygen in water that limits healthy survival of many sea organisms is two parts per million. A concentration of oxygen below two parts per million is referred to as an hypoxic condition or hypoxia.

How might hypoxia develop? At the mouth of rivers and extending into the ocean we normally have two layers of water. Remember salt water, or sea water, is denser than fresh water, the water flowing from a river. Fresh water, because it is less dense, overlays the Gulf's salt water. During much of the year when there is little difference in temperature between the river and Gulf water winds will mix the fresh and salt waters. However, during the summer the differences in temperature

and salinity result in little mixing of the lighter fresh water and denser salt water. During summer the conditions found in this upper water layer also promote the growth of phytoplankton, a type of algae or small aquatic organism. These algae obtain their energy from sunlight through photosynthesis, which releases oxygen. Further, algae form the base of the food chain and are consumed by other larger organisms, normally zooplankton, that excrete fecal pellets, which fall to the bottom of the ocean, along with unconsumed dead algae. When these materials fall to the bottom of the Gulf they are decomposed by bacteria and other microorganisms. The process of decomposition consumes oxygen from the water, which can cause hypoxic conditions to develop in the lower water column when the oxygen is not replenished through the mixing of the water.

These conditions of overabundant algal growth in the upper layer and hypoxic conditions in the lower water column of the Gulf of Mexico typically occur between May and September. Scientists have been routinely monitoring the “dead zone” since 1985, and its size varies from year to year depending on the amount of flow and nutrient flux from the Mississippi River basin. Following the pattern of the coastal currents, the zone will generally extend westward from the river mouth and as far out as the extent of the shallower coastal shelf waters. Sea fish that are quite mobile, for example those that readily swim, can escape or avoid the hypoxic areas. However, shell fish that cannot swim great distances easily, and often have substantial economic value, can neither escape nor live in this hypoxic condition. As Gulf water oxygen levels near the sea floor drop to critical levels over large areas, the shell fish die and the fishing industry suffers the economic consequences.

How is this connected to farming in Iowa? As mentioned, algae share many similarities to plants. Like all photosynthetic organisms, growth is dependent on nutrients, especially nitrogen and phosphorus. These are the same nutrients that farmers use extensively in Iowa and other States growing large areas of row crops. Corn, the dominant row crop in Iowa, is very productive but has even greater success with fertilizer rates that are considerably higher than those required by most other crops.

If crops used all fertilizer applied to the soil, we would have little problem. However, corn, while it responds well to fertilizer application rates, does not use all fertilizer applied in a given year. Typically, corn uses about 50 percent of the fertilizer nitrogen applied to farm fields. Nitrogen, unlike phosphorus which is the other critical nutrient for algae growth, moves with water. Water that drains from farm fields having received high doses of nitrogen fertilizer too often contains relatively high concentrations of the nitrogen containing ion, nitrate. The nitrogen that escapes fields and arrives in the Gulf of Mexico is essentially fertilizing algae growth in the surface layer of water.

The nitrogen that escapes fields and arrives in the Gulf of Mexico is essentially fertilizing algae growth in the surface layer of water.

Phosphorus, unlike nitrogen, does not move readily with water. It is adsorbed to soil particles and if we could keep soil from eroding, phosphorus availability to algae would be greatly reduced. However, row crops, associated tillage practices, and increased frequency of

heavy rain storms are resulting in significant erosion of soil receiving applications of fertilizer and manure that contain phosphorus. As soil is carried in flowing water to river systems, phosphorus is too. Some of the phosphorus absorbed to soil particles is released to the surrounding water, promoting algae growth within the Gulf of Mexico.

The connection between Iowa and Gulf of Mexico hypoxia is real, but how strong an effect the connection has depends on farming choices, management of crops being produced, and weather. The ‘dead zone’ is not a lifeless area in the Gulf of Mexico, it is a combination of extra-abundant life in the shallow water depths caused by nutrient rich water entering the Gulf and an oxygen depleted area near the Gulf bottom resulting from nutrient enrichment of the water above. Iowa’s Nutrient Reduction Strategy (<http://www.nutrientstrategy.iastate.edu/>) is a roadmap for reducing nutrient loads to the Gulf, but like any roadmap, it must be used for this ‘journey’ to be successful.



Precision Agriculture

Amy Kaleita

Associate Professor, Ag & Biosystems Engineering, Iowa State University



When you drive past or fly over a typical Iowa farm, it may seem very uniform – a flat piece of ground with a carpet of more or less identical plants on it. But in fact, lurking underneath that apparent uniformity is a considerable amount of variability. In the early 1990s, the development of yield monitors that tracked grain harvest levels as the combine drove through the field let us start to quantify the extent to which different parts of the field have different levels of productivity. In the late 1990s, the United States government made high-resolution GPS satellite signals available to the public. Connecting these two technologies provided a powerful start to mapping field performance, revealing patterns, and raising questions about how much we might be able to manage this variability. Underlying variations in soil fertility, soil texture, and the way water moves across and through the landscape, among other things, affect crop growth and also how crops respond to inputs and pressures.

But for several decades following the advent of mechanized agricultural production, the emphasis was farming more acres in less time with fewer laborers. This approved moved the farming system toward an industrial model that is very

efficient in terms of time and labor, but perhaps not in terms of the environment. Early adopters of precision agriculture also aimed to maximize productivity by addressing causes of non-uniformity, and by reducing waste in the system by automating more processes like steering. However, as precision agriculture technologies mature, there are opportunities to consider also how site-specific management may reduce the environmental footprint of production agriculture. In this way, we can try to optimize the production system considering productivity, profitability and environmental impact.

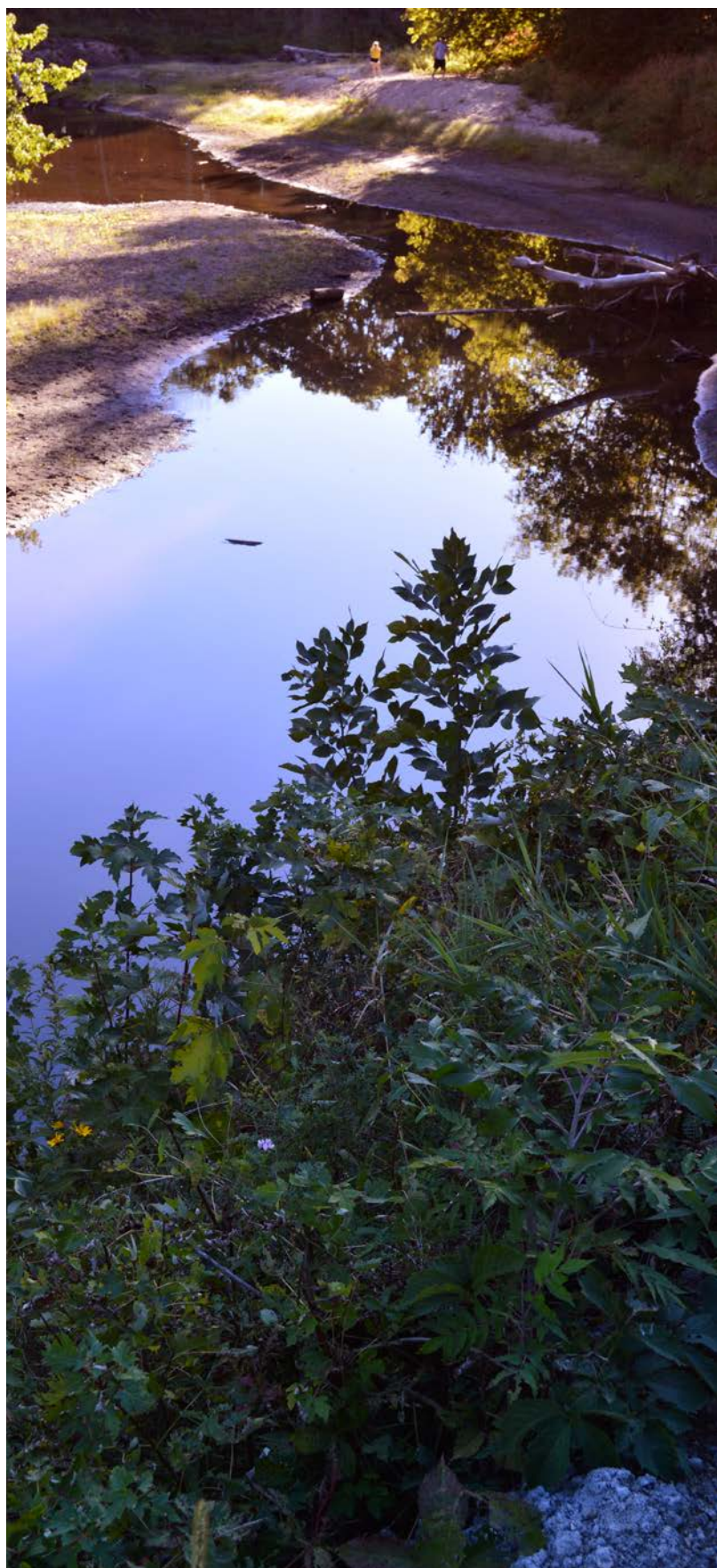
There are many possibilities. For example, imagine that before the season begins, historical maps of crop development under a variety of climate conditions, coupled with weather projections for the coming season, help the farmer determine a population prescription map so that areas that can support more plants get more plants, and areas that can support less get less. As the farmer drives through the field, sensors in the soil monitor water content and temperature, and the planter automatically adjusts seed placement (depth) to get the best germination, which increases eventual crop yield without requiring any more land area. A fertilization prescription is developed from the planting map as well as data from sensors monitoring crop development and soil chemistry, so that fertilizer doesn't go wasted on areas where less is needed, minimizing the risk of leaching of nitrogen. Sensors monitor soil conditions, weather, and plant conditions throughout the season, logging relevant maps and relaying relevant information to the farmer's database. At the end of the season, yield is mapped, and statistical and process models help make sense of how the inputs, intermediate points, and outputs are all related. Decisions about how to do it next year are supported by information.

At the end of the season, yield is mapped, and statistical and process models help make sense of how the inputs, intermediate points, and outputs are all related.

Many of the machinery and control technologies required to vary input application or management of a field exist, but much work remains to develop the most effective input prescription maps, and to predict crop and environment response to different management decisions. First, we need to be able to sense and monitor more data – observe more about what’s going on in the field. We also need to be able to determine which data is the most important in which place and at which time, so that our decision-making isn’t clogged with irrelevant information. Finally, advanced information technologies (think Big Data for agriculture) will help us to translate all that data into actionable information, by helping us detect long term and shorter term patterns, as well as emerging conditions.

As an example, one key observation would be soil water content. In irrigated areas, this can improve water efficiency. In humid regions, a better understanding of soil water patterns may allow for more effective drainage system designs that reduces nitrate loss (for example, controlled drainage or water table management). Better understanding of water patterns in the field can also feed back into fertilization plans, so that fertilizer is not applied at high rates in places in the field where considerable leaching might be expected. At the same time, advances in remote sensing from satellites and aerial vehicles (manned and unmanned) will provide real-time information on crop status. Pesticide and herbicide application could be targeted towards when and where conditions suggest pest pressure. In this way, not only can the farmer save chemical resources, but less agrichemicals may be released into the environment.

Advances in precision monitoring, data analysis, and decision support systems will hopefully support an agricultural system that is multifunctional, providing high productivity as well as ecosystem services.



A Lifetime of Having Water Giveth and Taketh Away

Hank Kohler



I learned at a young age that water would have quite an impact on my life in both positive and negative ways. During my early years growing up on our family farm in Northwest Iowa, it was very evident that without adequate rainfall, times would be tough and my parents edgy. I also found that you can have too much of a good thing.

I remember my father standing on the porch of our farmhouse talking to the life giving and economically impacting rain through the screen door. Most of the time his conversations with the clouds started the same, "That's a good rain, we could use a bit more but it sure is a good rain." If it lasted long enough his tone became euphoric and grateful, "Man, that's a good rain, thank you for such a rain." There were times that the rain lasted too long or came down too hard and his joy diminished with each new 1/10th of an inch in the rain

gauge. "That's enough now, you can stop anytime now. Oh, that's too much, Mama we got too much!"

On those evenings we would wait for the storm to subside, for our sand and gravel farmyard to stop washing into the ditch, and pile in the pick-up to survey the damage. We knew where to look. Head downhill to where the water ways met the fences and left them covered with cornstalks or washed them out completely. We would see our neighbors on the road doing the same and we talked about the fences that needed mending and what crops should be replanted due the 'stump floater' we just endured. Fences and that year's crops, the things that needed immediate attention, were taken care of. The fact that several tons of our farm's most valuable asset, its rich soil, had just disappeared into ditches and neighboring streams wasn't mentioned. Even as a child, I sensed my father knew and he was saddened by the loss.

It was also at an early age that I became infatuated with something else that water gave us: fishing! Worms were dug by the north side of the chicken house where due to shade, the ground was moist. Cane poles, buckets, kids, and crawlers were loaded into the back of the truck and we would drive a few miles of gravel to "Crawdad Creek."





I'm pretty sure that was not the real name of the stream; it may not have been named at all. It wound slowly with big bends and loops through a pasture north of us. Through the passing summers the land owner had gotten used to seeing our pickup truck parked by the bridge and small children circumnavigating thistles and cow pies on the way to its banks. The next hour or so would be filled with sinking bobbers, swings and misses, chubs, shiners, crayfish, and squealing siblings. Oh my, it was fun!

As I grew older both fishing adventures and size of the quarry grew. When the farm schedule allowed, we traveled to streams and sand pits in the area targeting carp that were plentiful to catch and succumbed easily to mom's homemade dough balls. The real treat for the addicted fisherman I had become was our once a year family vacation to Ottertail County, Minnesota. My father had lived there briefly in the 1930's and was familiar with several of the lakes and fish there in. He also yearned to get away from crowds so we sought out small resorts on somewhat secluded waters. It was heaven. We would row an old wooden boat through the morning fog casting large surface lures such as a boss-o-reno towards the lily pads. Loons, kingfishers, and wood ducks provided the background music to nature's perfect setting. Bass and northern pike were caught, but I was the one who was hooked.

My love for the waters in that area and a desire to see where they went, led to an adventure of a lifetime. In the summer of 1979 myself, one of my younger brothers, and two friends journey from there to Hudson's Bay. Following the fur trading routes of the 1600's, we paddle two canoes approximately 1400 miles in 70 days. Eventually my wife Anne and

I settled in Ames, Iowa for good. We raised a family consisting of a son and two daughters. When time allowed, and being self-employed I allowed plenty of it, we visited lakes and rivers nearby.

One of our favorite areas to float and fish was and still is, the Boone River. Just a short 40 minute drive north of Ames, we would usually paddle the stretch from Tunnel Mill to Bell's Mill in Hamilton County. The water may be quite clean or full of sediment depending upon the time of year or recent rains. Three hundred yards in either direction from the stream would probably put you in fields of corn or beans, but that is not what you see from the canoe. Instead, you are treated to majestic green canyons formed by maple, walnut, and gigantic cottonwood trees. Each of our children

has a large and special rock along that route that they chose to have named after them; as we drift along we can check the water level on Andy's, fish by Kerry's, and perhaps camp at Robyn's. Past trips on the Boone River provided peace, quite, and fish for the campfire. Today they also provide memories. When I float the River now, as if in a time machine, I remember where my children released a Smallmouth bass or caught a Catfish. I picture them through the years, fishing, swimming, laughing and I am reminded of something James Earl Jones said in the movie Field of Dreams: "Memories so thick they'll have to brush them away from their faces." I float along covered with them.

While living in Ames, a friend introduced me to an area northeast of Nestor Falls, Ontario, Canada where we could fish and camp on a chain of pristine lakes. When I look back now at my journals from those past trips, I remember much



It was the water that brought us there and gave us so much.

more than just what fish we caught. I have witnessed a young eagle's first flight (take off fine, flying fine, first landing... not so good!). I watched twin moose calves try to keep up with their mother, who was concerned with our approaching group. Like the eagle's landing, their long legged clumsy steps on slippery moss covered rocks didn't go so well. Pictures live of my son flipping pancakes at camp or watching my two girls feed cookies to the same friendly gull that greets us there each year; those are my most precious memories. It was the water that brought us there and gave us so much.

As this article's title indicates, during my lifetime water has also taken away. The self-employment I mentioned earlier was that of managing a restaurant I owned along South Duff Avenue in Ames. We had a lot of traffic out front but a pesky stream behind the building. That stream, Squaw Creek, has a thing about overflowing its banks. It joins the South Skunk River about a half mile downstream from our property, so during flood events we could get a double whammy from both watersheds.

We had to rebuild the store after the floods 1993 and in 1995 we built a four foot high concrete wall around it. That wall, along with heroic efforts from family, friends, and employees kept the water out during several past floods including the big one in 2008. Early on the morning of August 10th,

2010, the wall met its match. Waters poured over it and left what had been a clean, busy restaurant just the day before, in ruins. We had 51 inches of an historic rainfall event and the sediments it carried inside the building. Mama, we got too much! When the water left, a half inch of muck remained clinging to everything. The structure itself was compromised and deemed unsafe. I waved the white flag. Tired of the worry, effort, and with the fear that if it went over the wall once, it will do it again, I decided to settle with the insurance and sell the property. What had been a successful family business for over a quarter of a century was gone overnight.

So you can see water has given me much but also has taken away a great deal.

Now it gives back again. With the restaurant closed, it freed up even more time. In 2011, I formed the Limited Liability Corporation, Learn-2-Fish. Many times a child will ask a parent to take them fishing, but the parent doesn't know where to go, what to do, or have the equipment to do it. I cover all those bases for a modest fee. I want to teach them to fish, but more importantly, I want them to enjoy and appreciate natural areas. They are given a coloring book with pages having descriptions and checklists of the fish they caught, waterfowl and other birds they saw, along with any mammals, amphibians or reptiles they observed. The youngsters I take fishing hold the future of our waters. I believe that if they experience and appreciate a place or activity, they will want to protect these places and activities for future use.

In closing I say to those of you who read this publication, those who are much wiser than I on how to keep our waters clean and safe, Thank You. I applaud your efforts. Those rocks in the Boone River that my children named for themselves will be there for generations to come.

It is my hope that through your work and research the quality of the water in that stream, and others, can be improved and preserved. If you can do that then future families will have the same opportunity to enjoy our waterways as mine has. They will have the same opportunity to start family traditions that create such cherished memories. After all, there are plenty of rivers and lots of rocks.



And the water taketh away.

Building a Culture of Conservation

Empowering others to improve soil health and water quality by implementing conservation practices on their land.

Farmer to Farmer - Iowan to Iowan



www.extension.iastate.edu/ilf



An awareness campaign for ALL THINGS WATER

AS PART OF WATER ROCKS! YOU CAN:

- Request a school or community visit
- Play the award-winning online game "Rock Your Watershed!"
- Watch music videos and other videos about soil and water issues
- Go geocaching in Iowa's state parks
- Become a member of the Conservation Pack
- Become a college intern with the Water Rocks! team



WHAT'S IN YOUR WATER?
VIDEO SERIES



"ROCK YOUR WATERSHED!"
GAME

GET INFORMED. GET INVOLVED.

WWW.WATERROCKS.ORG

A Brief History of Soil Erosion Estimation in the United States

John M. Laflen

Adjunct Professor, ABE, Former Director of the USDA-ARS National Soil Erosion Research Laboratory



Soil erosion is costly. It normally reduces crop yields and damages rivers, ponds, reservoirs and other structures that often receive the eroded sediment. Soil erosion measurements are very difficult and expensive to make. As a result we use computer models to help us estimate how much erosion occurs in farm fields. As one might expect, factors that are important in these model estimates include soil type, management of the fields, slope of hills, length of hills in the fields, conservation practices, and rainfall characteristics. Learning how to use these factors to give a reliable soil erosion estimate has been, and remains, a very difficult task.

The Beginning

In 1915, Ray McClure, a soils student at the University of Missouri was assigned the task of measuring surface runoff as a special problem in one of his classes. Small bare plots were established on the campus and measurements were made after each rainfall and runoff event. He found sediment

in the runoff water and asked his professor, M.F. Miller, what to do with it; he was told to measure it. These were the first measurements of soil erosion in the United States. McClure's measurements were not saved.

The next year graduate student R. M. Vifquain measured runoff and erosion from four plots, also at the University of Missouri. The results can be found in his Master's thesis. In 1917, in the same area as Vifquain's, F. L. Duley initiated a study with seven plots and the results were published in 1923. These results were used by Hugh Hammond Bennett to support his request to Congress for funds to establish the first ten Soil Erosion Experiment Stations (Woodruff, 1987). These stations (plus others) played a major role in soil and water conservation for decades. Five of these stations were located in Iowa at Clarinda, Shenandoah, Castana, Beaconsfield, and Seymour.

The USLE has been applied on every continent except Antarctica, and if climate change persists, it may well be used there.

Universal Soil Loss Equation

It took 20 years of work by dozens of researchers (many of them stationed at one of the Soil Erosion Experiment Stations) to develop the factor relationships, databases and parameters to make a “Universal Soil Loss Equation” (USLE) prediction tool that would work for cotton in Arkansas, wheat on terraced land in Kansas, corn in Iowa, corn for silage in Wisconsin, pasture in Texas, and the hundreds of other combinations of cropping, management, soil, conservation practices, and climates in the United States (Wisch-

meier and Smith, 1961). It is still the primary soil erosion prediction tool used by the United States Department of Agriculture (USDA), although it has been revised several times (Wischmeier and Smith, 1965, 1978; and Renard et al., 1997). These revisions include the Revised Universal Soil Loss Equation (RUSLE) and later, RUSLE2. RUSLE was the primary prediction method for determining highly erodible lands (HEL) in the 1990’s, with RUSLE2 being the current USDA tool for predicting soil erosion on the nation’s lands. This tool is primarily empirical, which means it can be used only for situations similar to those used for its development and it only estimates sheet and rill erosion; it does not include in its estimates soil erosion that occurs in channels or ephemeral gullies as seen in Figure 1.

The USLE has been applied on every continent except Antarctica, and if climate change persists, it may well be used there. The USLE and RUSLE have been used directly, modified or used as guides in the development of erosion prediction in Africa, Australia, and Germany.

Tolerable Soil Loss

In 1941, Smith estimated a maximum rate of soil loss that would support a constant or increasing soil fertility condition. He and others later referred to this concept as “tolerable” or “allowable” soil loss. From limited plot observation he thought the maximum rate should be about 4 tons per acre per year for the Shelby soil in northern Missouri, but in some cases it would be lower. Smith was apparently the originator of the concept of a tolerable soil loss, and it was based on soil fertility. More recently stronger science indicates soils actually form, or renew themselves, at a rate of less than one ton per acre per year.

Replacing the USLE: Water Erosion Prediction Project

While the USLE is good at estimating long term average annual soil erosion, it is very poor for estimating daily or short period soil erosion (Wischmeier, 1959). The inability to deal with the fundamental processes of soil detachment by rain-drop impact and by flow, and the transport and deposition of sediment by flow limits the use of the USLE. Most of the visible erosion occurs in channels, which is not estimated by the USLE (see Fig. 1). If the erosion is visible from the road as one drives, it is not estimated by the USLE.

Four Federal agencies in 1985 initiated the Water Erosion Prediction Project (WEPP) to replace, or supplement, the



Fig. 1 A and B: Examples of ephemeral gullies that formed in Iowa fields in 2013. Soil eroded from these gullies is not considered in typical soil erosion estimations.
Photos ©Stanley Buman

USLE. WEPP combined mathematical model development and fundamental and applied erosion research, along with land management and specific soil conservation goals (Foster and Lane, 1987). WEPP was completed in 1989, with further testing and development through 1995. The model is a daily simulation model that operates on a personal computer. As science and technology improve, and additional needs arise, further changes in WEPP have been made.

The United States Forest Service (USFS) has developed a full web presence for the use of WEPP (<http://forest.moscowfs.wsu.edu/fswepp/>). It is used by the USFS and Bureau of Land Management (BLM) for road design, for remedial treatments after fires and other land disturbances, and other timber and land management issues. WEPP includes a hillslope version, which expands to a watershed version if needed. WEPP has also been used in several Geographic Information Systems (GIS) versions (Flanagan et al., 2013).

An application of WEPP that shows the potential of the model is the daily prediction of soil erosion for the State of Iowa (Cruse et al, 2006) (<http://wepp.mesonet.agron.iastate.edu/>). The Iowa Daily Erosion Project (IDEP) web pages allow the user to map rainfall, runoff, soil erosion, and soil moisture for every day since the spring of 2002.



References

For references cited in this article, please go to: <http://www.water.iastate.edu/>

Clark, D.L, D.R. Janecky, and L. J. Lane. 2006. Science based cleanup of Rocky Flats. *Physics Today*, Vol 59, No 9, pp 34-40.

Cruse, R., D. Flanagan, J. Frankenberger, B. Gelder, D. Herzmann, D. James, W. Krajewski, M. Kraszewski, J. Laflen, J. Opsomer, and D. Today. 2006. Daily estimates of rainfall, water runoff, and soil erosion in Iowa. *J. Soil and Water Cons.* 61(4): 191-199.

Duley, F.L. and M. F. Miller. 1923. Erosion and surface runoff under different soil conditions. U. of Mo., Agr. Exp. Sta. Res. Bull. 63.

Flanagan, D.C., J.R. Frankenberger, T.A. Cochrane, C.S. Renschler, and W.J. Elliot. 2013. Geospatial application of the Water Erosion Prediction

Project(WEPP)model. *Trans. Am. Soc. of Agric. and Bio. Eng.*, Vol. 56, No. 2, pp. 591-601.

Foster, G. R., and L. J. Lane. 1987. User Requirements: US-DA Water Erosion Prediction Project (WEPP). NSERL Report No. 1. West Lafayette, Ind.: USDA-ARS National Soil Erosion Research Laboratory.

Renard, K. G., G. R. Foster, G. A. Weesies, D. K. McCool, and D. C. Yoder. 1997. Predicting soil erosion by water: A guide to conservation planning with the Revised Universal Soil Loss Equation (RUSLE). *Agricultural Handbook No. 703*. U. S. Dept. of Agr.: Washington DC. 384 pp.

Smith, D. D. 1941. Interpretation of soil conservation data for field use. *Agr. Eng.* 22(5): 173-175.

USDA Natural Resources Conservation Service. 1997. 1997 National Resources Inventory. Available at url: www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/nra/nri/results/?cid=nrcs143_013647

Vifquain, R. M. 1917. A study of the absorption and loss of soil moisture. MS Thesis, U. of Missouri. Available U. of Mo. Libraries <http://library.missouri.edu/>.

Wischmeier, W. H. 1959. A rainfall erosion index for a Universal Soil Loss Equation. *Soil Sci. Soc. Am. Proc.* 23: 247-249.

Wischmeier, W. H., and D. D. Smith. 1958. Rainfall energy and its relationship to soil loss. *Trans. Am. Geophys. Union* 39(2): 285-291.

Wischmeier, W. H., and D. D. Smith. 1961. A universal equation for predicting rainfall-erosion losses-An aid to conservation farming in humid regions. *ARS Special Report 22-66*. Agricultural Research Service, U. S. Dept. of Agr.: Washington DC. 11 pp.

Wischmeier, W.H. and D.D. Smith. 1965. Predicting rainfall-erosion losses from cropland east of the Rocky Mountains – Guide for selection of practices for soil and water conservation. U.S. Dept. Of Agric., Agr. Handbook No. 282.

Wischmeier, W.H. and D.D. Smith. 1978. Predicting rainfall-erosion losses – A guide to conservation farming. U.S. Dept. of Agric., Agr. Handbook No. 537.

Woodruff, C.M. 1987. Pioneering erosion research that paid. *J. Soil and Water Conservation* 42(2): 91-92.

Zingg, A.W. 1940. Degree and length of land slope as it affects soil loss in runoff. *Agric. Eng.* 21(2): 59-64.

Sustainable Cropping Systems for Harvesting Corn Stover for Biomass

Ken Moore, Kendall Lamkey, Roger Hintz, Scott Flynn and Nickolas Bowden
Iowa State University

Jeremy Singer, Keith Kohler and Dustin Wiggans
National Laboratory for Agriculture and the Environment

Plant residues remaining in the field after grain crops have been harvested represent the largest potential stock of readily available biomass in the United States. Corn stover is by far the most abundant crop residue with about 75 million available dry tons produced each year. However, corn crop residues are generally returned to the soil for conservation. Residues left in the field reduce soil erosion by wind and water and increase soil carbon. Removal of most of the above ground plant material for grain and biomass will likely have negative environmental consequences unless alternative cropping systems that protect the soil from erosion and sequester soil carbon can be developed and implemented. The goal of this research was to develop corn production systems that use perennial groundcovers to allow removal of crop residue with minimal negative effects on soil and water quality.

This project addressed three primary research objectives: 1) identify groundcover species that are compatible with corn grown for grain and biomass, 2) determine genetic characteristics of corn that enhance its potential to germinate and compete with perennial groundcover; and 3) develop management systems that minimize competition between corn and the groundcover. These objectives were addressed in three experiments.

In the first experiment, 36 potential groundcover species were evaluated by intercropping (growing simultaneously in the same field) them with corn. Corn was planted into strip-tilled groundcovers that had been previously established. Besides the initial tillage each growing season, no other efforts were made to control interspecific competition. Higher corn yields were usually

achieved with low growing groundcover species that were successfully suppressed with strip-tillage. Several species were too aggressive and severely limited grain yield through reductions in corn populations and grain fill. Based on grain yield, persistence and cover, Creeping bentgrass, Colonial bentgrass, Kentucky bluegrass, Tall fescue, and Crested wheatgrass were identified as good candidate species for further development.

In the second experiment, genetic potential for improving the ability of corn to yield in the presence of groundcover was assessed. The premise was that if a genetic component exists and its physiological mechanism(s) can be determined, then corn can be modified via selection for these physiological traits to compete with perennial groundcovers. Thirty-two



Figure 1: Corn growing in a creeping red fescue groundcover.

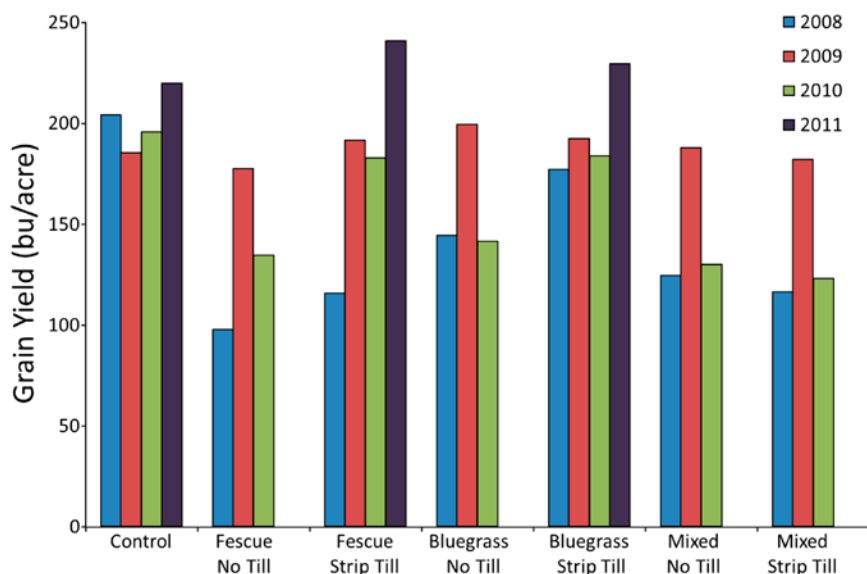


Figure 2: Average grain yields for corn grown with and without ground cover.

corn hybrids were evaluated for three consecutive years in plots with conventional tillage (control), and two groundcovers; creeping red fescue and white clover. Genetic differences among corn hybrids in their ability to tolerate competition from a groundcover were observed and thus it should be feasible to select for this trait in lines that are intended to be grown with perennial groundcovers.

In the third experiment, methods for establishing corn under perennial groundcovers of varying competitiveness were evaluated. Corn grown using conventional tillage and weed control was compared to that grown with Kentucky bluegrass, Creeping red fescue (see Fig. 1) and a mixture of White clover and Red fescue using either no-till or strip-till. Chemical suppression treatments included various paraquat and glyphosate herbicide application strategies. In each of the three years that yields were evaluated, some groundcover treatments yielded as well as the conventionally grown corn (see Fig. 2). In 2008, planting of groundcover plots was delayed by several days due to exceptionally wet conditions. However, planting dates were more comparable in subsequent years and corn grown with groundcover was very competitive with conventionally grown corn. In 2011, the most promising treatments from the previous three

years were continued. The growing season was warmer than usual, particularly mid-summer, and the groundcover species went completely dormant. Presumably due to improved moisture retention in the groundcover plots those treatments out yielded the conventional treatment in 2011. In addition to providing competitive grain yields, the groundcovers increased water retention and helped maintain soil carbon.

Overall, this research demonstrates this it is possible to grow corn with perennial groundcover without taking a yield penalty. Doing so, however, requires chemical suppression of the groundcover and yields may be further sustained by strip tillage. Groundcovers vary in their competitiveness with corn, but none of those evaluated in this study could be used without some form of suppression. Long term there does appear to be potential for selecting and improving groundcover species so that less suppression is required. Finally, there are genetic differences among corn hybrids in their ability to tolerate the presence of a perennial groundcover and therefore potential for developing hybrids that are adapted to a groundcover system.

This work establishes the feasibility of using perennial groundcover to compensate for the environmental effects of removing corn stover as a biofuel feedstock.

However, considerable development work remains to be done to develop robust management practices that will ensure corn growers competitive grain yields. This will require significant investment in the codevelopment of groundcover varieties and corn hybrids along with advanced tillage and other management practices. The good news is that perennial cover crops have excellent potential for addressing the major environmental concerns associated with current corn production practices and it is very likely that groundcover production systems can be developed that do not negatively impact corn yield.

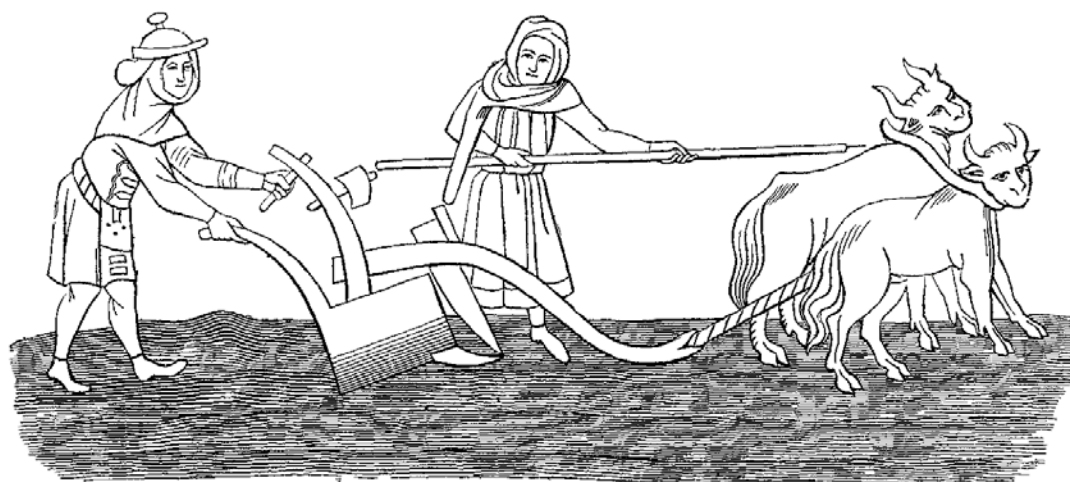
Overall, this research demonstrates this it is possible to grow corn with perennial groundcover without taking a yield penalty.



The Challenge of Soil Conservation

John Pesek

Emeritus Professor of Agronomy, Iowa State University



Anglo-Saxon ploughmen in the Middle Ages.

The rise of civilization accompanied by the invention of agriculture, perhaps 12,000 years ago, and larger concentrations of people, revealed that the use of resources, such as land could be lost for the production of cultivated crops after its repeated use. This eventuality overcame civilizations in Greece, Rome, and elsewhere. As long as there was somewhere else to produce crops and animals, the human response was to move.

Europe was severely depopulated by the Black Plague by 1350, but the riddle of a deteriorating land base still persisted at mid-second millennium when Europeans discovered the Western Hemisphere and realized that there was more land, so they migrated west to new continents. They had lots of land for expansion.

***The U. S. Department of
Agriculture was organized in
1862, during a civil war that was
threatening to destroy the nation.***

It was not until the 20th century that the U.S. formally recognized that soil depletion became a serious national problem after much of our land had been physically destroyed or chemically depleted for profitable crop and animal production. The U. S. Department of Agriculture was organized in 1862, during a civil war that was threatening to destroy the nation. Yet the Soil Erosion Service was not

created until 1933, and was placed in the Department of the Interior. H. H. Bennett, who had a career in agriculture from 1902-1952, was Chief. It was renamed the Soil Conservation Service (SCS) in the Department of Agriculture where it was moved by Congress in March of 1935 with Bennett remaining Chief. He published the first edition of SOIL CONSERVATION in 1939, a text I later used. I had the good fortune of meeting Bennett on our terraced farm in south Texas in late 1945, after separation from military service.

A major advance in soil conservation was made in 1941, after the SCS became staffed, when Angus McDonald wrote "Early American Soil Conservationists" published by the United States Department of Agriculture (USDA) as Miscellaneous Publication No. 449. It summarized the consecutive

publications of eight men covering the period from settlement until the Civil War that dealt with the general problem of soil erosion and depletion from New England to the Gulf South. The writers in their times simply saw, but did not fully understand, all the dimensions and causes of production deterioration we now know to be in addition to erosion.

All of the reports included discussion of soil erosion, how to recognize it, and what could be done about managing or controlling it. The erosive effect of flowing rainwater was mostly slowed by constructing ditches on the contour or with a slight grade, and conducting runoff water off the field in small portions. The land productivity deterioration in the New England, Middle Atlantic, and Southern States before the Civil War was another matter. The loss in fertility could be dealt with and understood with very little knowledge of chemistry. Fertility amendments used were lime, gypsum or marl, livestock manures, and what we now call green manures. Even Boyle's gas laws were not exposed until late in the seventeenth century, and the era of modern chemistry did not begin until the work of Lavoisier, the father of chemistry, during the last half of the eighteenth century. The periodic table of Mendeleev appeared in 1834. How chemistry applied

to crop production did not become elucidated by Justus von Liebig until in the late first half of the nineteenth century, and the influence of nitrogen fixation bacteria by legume nodule organisms was not really recognized until about 1880, after the Civil War.

One should not be surprised that almost all the modern tools for examining the behavior of plants were yet undeveloped; people on the land and in primitive laboratories lacked the knowledge to understand the mechanisms of very complex processes, such as soil deterioration, being observed universally. Soil erosion seemed to have been blamed for a collection of visual or sensed chemical, physical, and biological effects observed in cultivated fields. Limited science did not allow these effects to be separated; visible eroding soil was not the complete picture, but was physically observed and therefore given major blame for lost production capacity. Sometimes that was called "soil washing," but we now know that there was also a removal of plant nutrients, organic matter, loss of porosity, water holding capacity, and soil structure, and not just soil particle removal.

H. H. Bennett presided over the elaboration of the Soil Conservation Service across hundreds of local county offices as a major advisory body to help farmers and others address the technical aspects of soil and water conservation planning and overseeing the work that was done for farming clients. He also saw the need to have a professional and scientific organization to let members act on their own convictions in an association of conservationists. Thus, in November of 1941 a group met to begin organizing what became the Soil Conservation Society of America (SCSA). World War II interrupted, and the decision to proceed with membership solicitation was not made until April of 1945; charter membership for civilians closed September 1st, and for service personnel it closed December 31st, 1945 with 1,269 charter members being signed. The first annual meeting was held in the Morrison House in Chicago from December 12th to 13th in 1946 when the members elected Ralph Musser the first president for 1947 and the *Journal of Soil and Water Conservation* was published in July. A designated founder's portrait of Hugh Hammond Bennett sponsored by members of SCSA (now hanging in the SCSA headquarters building at Ankeny) was painted for and presented at the third annual meeting. In 1953, Bennett was elected president of SCSA.



H.H. Bennett.

Creation of the SCS and the SCSA provided professional and scientific bases not only to organize the professionals in the field, but to provide a nucleus around which they and other scientists could form to identify, study, and report on matters directly related to soil preservation and water quality protection. It also encouraged the elaboration of multidisciplinary curricula and research that provided a range of training tailored precisely for specialists interested in soil conservation and related topics. The USDA created an experimental farm in southwestern Iowa (and in other States) in the mid-1930s that established rainfall runoff and soil loss plots under several cropping systems and studied field terracing on moderately deep loess soils. The Bureau of Plant Industry, Soils and Agricultural Engineering (later the Agricultural Research Service) installed three soil scientists in the Department of Agronomy at Iowa State University who, with their colleagues, also established sets of runoff plots in deeper loess in the 1940s and in old glacial till and on two shallower loess soils in the 1950s, as well as terracing and other experiments leading to a suppression of erosion in different ways. G. M. Browning, later the associate director of the Iowa experiment station, made a key contribution in defining an erosive factor, named the Browning Factor, for unified erosion equations applied to different soils.

Better coordination and publication of observations and research on soil erosion control and water management following the creation of the Soil Conservation Service has led to a reaffirmation that it is the practices of baring the soil surface and regularly stirring it for crop production that make sloping soils vulnerable to raindrop impact and flowing water. Well into the 20th century, tillage was essential to cover residues and prepare a seedbed that allowed seeding and the emergence of crops, and subsequent tillage was necessary to control the ubiquitous weeds. In the meantime, the Mangum terrace would appear in the form of level or graded types, depending on soil permeability, and later morphed into parallel terraces, some of which became bench terraces with special drainage structures. While water control structures and use of sod-forming crops in cropping systems play important roles in soil protection where used, they are costly and have not uniformly been applied especially after the middle of the past century when much of the former sod-forming crop acreage was converted to annual grain and oilseed production. The advent of herbicides about mid-century and later of selective herbicide resistant crops reduced the need for post-seeding tillage, and more powerful farm machinery and geographic positioning of operations in fields made possible more precise management of the planted crops. But not all erosion-prone land is treated under current best manage-

ment practices for crop production so we are not very close to protecting our soils for posterity—something that is essential if the human race is to persist.

Paraphrasing another, it will take the whole race to protect and maintain the food producing capacity of our soils in perpetuity; there is no one else to do it. And there does not appear to be a substitute for productive soil to produce our food anywhere on the horizon.



References

- McDonald, Angus 1941. Early American Soil Conservationists; U. S. D. A. Miscellaneous Publication No. 449.
- Pritchard, R. Wayne 1965. The First Twenty Five Years; Journal of Soil and Water Conservation 20:123-127.
- GOOGLE, NCSU Libraries [hccp://d.lib/ncsu.edu/collections/catalogue/ua023_007-007-bx0021-003-002](http://d.lib/ncsu.edu/collections/catalogue/ua023_007-007-bx0021-003-002)



Visit the Iowa Water Quality Initiative's website www.CleanWaterIowa.org to find information on conservation practices, success stories and the latest news and events on water quality in Iowa.

Bioturbation: an Underestimated and Overlooked Driver of Soil Formation

Mary Tiedeman, M.S., Iowa State University

Dr. Lee Burras, Professor of Agronomy, Iowa State University



Fig. 1 Mima Mound Natural Area Preserve in Washington State. This pimpled landscape formation is associated with burrowing animal activities. Photograph by Birdie Davenport, Washington State Department of Natural Resources.

Beneath our feet lies a tremendous ecosystem: soil is a dynamic medium encompassing both living and non-living materials. Each of these components contribute to the overall characteristics of and processes inherent to the soil environment. In this article, we will discuss specifically the imprint that animals leave on soils and landscapes.

Within the soil profile, many living things participate in a process called bioturbation. Bioturbation is the physical displacement of soil by organisms. Earthworms do it by decomposing and burying leaf litter. Gophers do it by foraging and burrowing belowground. Trees are even accredited to soil mixing by lifting subsoil upwards as they fall over. Other common organisms attributed to this process include badgers, crawfish, ants, and termites.

While bioturbation is a very simple concept, it can drastically change soil characteristics like soil structure, color, bulk density, and pH, which in turn can effect soil fertility. On a larger scale, it can alter the shape of landscapes (Fig. 1). A number of scientists have studied this relationship between

organisms and soil, including Charles Darwin. Nearly 140 years ago, Darwin published a book on earthworm activities in soils. His findings showed that over time, worms influence the downward movement of stones in the soil profile.

In more recent years, Dr. Donald Johnson of the University of Illinois expanded Darwin's idea to explain the presence of subsoil stone lines across landscapes. This phenomenon can be seen throughout the world (including Iowa) in soils that are currently, or were previously, churned by living creatures. Dr. Johnson also popularized the term "biomantle," which is the area of the soil profile most influenced by biological mixing.

How is bioturbation influencing soils in Iowa? To discuss this idea, we will draw on some examples from Mary Tiedeman's Master's thesis on ant activities in a remnant prairie in central Iowa. This study, located at Doolittle Prairie State

Preserve in Story County, was executed by comparing physical and chemical characteristics of ant-colonized soils with relatively "uninhabited" adjacent soils.

At Doolittle Prairie, soils under ant colonization have thicker, lighter colored topsoil and thinner, darker subsoil than adjacent soils (Fig.

2). Soils influenced by ants are also structurally different. Instead of containing loose granules commonly associated with prairie soils, those colonized by ants are dominated by very fine granules and medium prisms (Fig. 3).

Subsoils of mounds contain higher levels of nitrogen than

It can drastically change soil characteristics like soil structure, color, bulk density, and pH, which in turn can effect soil fertility.



Fig. 2 Subsoil influenced by bioturbation. Dark material from the topsoil was mixed and incorporated with the subsoil to create a marbled pattern.

adjacent soils. Ant bioturbation even influences pH. In unaltered soils, the pH steadily increases from around 6.0 at the surface to 8.0 at a depth of meter. In ant-altered soils, pockets of alkaline, or low pH, material from the subsoil can be

found in the acidic top soil, and vice versa. In areas where ants have completely mixed the soil, pH is closer to 7.0, while other areas are far more variable.

These alterations by ants at Doolittle are dramatic enough to change the classification of ant mound soils. The unaltered soils are either Aquic Hapludolls or Typic Hapludolls. The bioturbated soils are either Typic Vermudolls or Haplic Vermudolls. Ultimately, these data relay that ants can induce soil change within a geologically rapid timeframe. Normally, it is thought that soil formation proceeds so slowly that hundreds, if not thousands, of years are necessary to express the amount of change needed to induce a change in soil classification.

On a large scale, activities of ants are influencing the downward movement of coarse fragments and are actively mixing the top 75 centimeters of the soil profile. Since soil began forming at Doolittle Prairie over 8,000 years ago, ants have churned all but the wettest soils. It is likely then, that ants have upturned nearly all of Iowa's soils as well. For this reason, it may be more appropriate to assume our soils are "prairie-ant" or "forest-ant" derived instead of simply "prairie" or "forest" derived.

Ants are tremendous creatures. They comprise nearly 25 percent of the planet's terrestrial biomass (equal to humans) and inhabit every stretch of the earth, except for Antarctica.

Though people don't often reflect upon the diversity, density, and expanse of ants, they should! Ants are fascinating organisms that have the ability to drastically alter their surrounding environments.

It is important to relay that many organisms participate in soil mixing and all are worthwhile to investigate. Doolittle Prairie alone is home to many burrowing organisms, including gophers, worms, and crawfish, all of which have a unique role in changing the soil environment. For this reason, more research is needed on bioturbation both in Iowa and around the world. Through scientific discovery, we can develop a more comprehensive understanding of the imprint that these humble creatures have had on our soils and landscapes.



Fig. 3 Characteristic aggregate structure seen under ant bioturbation at Doolittle Prairie State Preserve. Left hand image is an example of medium prismatic structure. Right hand image highlights movement of very fine granules of light material from the subsoil to the topsoil.



IOWA STATE UNIVERSITY

University Extension



*If you would like to receive future publications,
or to be considered as an author for future
article submissions, please contact the Iowa
Water Center.*

*2218 Agronomy Hall
Ames, Iowa 50011-1010
(515) 294-7850*