



getting into SOIL & WATER 2013



Letter from the Soil & Water Conservation Club President

Hello Reader,

On behalf of the Soil and Water Conservation Club, I would like to present our annual publication, *Getting into Soil and Water 2013*. We produce this publication in order to educate people on the issues that affect soil and water from floods, drought, conservation and other related topics. The issues that are raised in this publication not only affect Iowa but the whole world. Iowa State University Soil and Water Conservation Club members are able and encouraged to witness conservation practices at work or discover areas that could have conservation practices implemented.

This last year, our club was recognized by the Soil and Water Conservation Society; we received the chapter achievement award. I would like to thank all who worked on this year's publication, the editorial board, and contributing writers. The Soil and Water Conservation Club would not be able to promote conservation without dedication from its members and facility advisors Dr Rick Cruse, and Dr. Amy Kaleita-Forbes.

Regards,
Jordan Foss
2012 SWCC President



Club Members

Back Row: Danielle Koester, Nathan Smith, Ethan Bahe
Middle Row: Ethan Cook, Stefan Miller, Samuel Bernard, Anthony Miller, Ron Tigner
Front Row: Leisha Neumann, Andrew Paxton, Jamie Harrington, Jordan Foss



Table of Contents

- | | | | |
|----|---|----|---|
| 4 | A Message from the Iowa Water Center
Melissa Miller | 22 | Community-wide Urban Storm Water Planning Utilizing LiDAR, the WinSLAMM Model, and GIS
Ramanathan Sugumaran, John DeGroot, and Bernard Conrad |
| 5 | Soil and Water Conservation in Ghor Province, Afghanistan
Mohammad Arif Yaqubi | 26 | What's New with Energy Crops?
Emily Heaton |
| 8 | Iowa Nutrient Reduction Strategy
Dean Lemke and Shawn Richmond | 28 | Technology for Soil and Water Conservation Practices
Amy Kaleita-Forbes |
| 10 | Water Rocks! Youth Water Education Program
Jacqueline Comito and Ann Staudt | 30 | Environmental Implications of the Corn-Soybean Cropping System
Matt Liebman |
| 12 | Curbing Agricultural Runoff Pollution: Lessons from the Clean Water Act
Susan Heathcote | 32 | Soil Erosion: What Is Tolerable?
Rick Cruse |
| 15 | What Soils Are Made Of and How They Develop
Gerald Miller | 34 | A Drought That Lingers
S. Elwynn Taylor |
| 18 | Human-induced Soil Change in Iowa: Two Contrasting Examples
C. Lee Burras, Yury Chendev, Mostafa Ibrahim, Beth Larabee, & Tom Sauer | 37 | Why Do Iowa Farmers Grow Corn?
Gretchen Zdorowski |



Samuel Bernard
Editor

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A Message from the Iowa Water Center



Melissa Miller
IWC Program Coordinator

The Iowa Water Center is pleased to participate in this annual student publication, *Getting Into Soil and Water*, now in its fifth year. With a focus on water research, outreach and education, IWC is especially proud of the information put forth in this

publication year after year. This issue is no exception; the topic of water and its inseparability with soil is more relevant than ever with the state and much of the country experiencing water shortages with the recent drought.

The Iowa Water Center consistently looks for ways to relate natural resource science to the broader community. In response to the growing trend of social media, the Iowa Water Center joined Facebook and Twitter this past year. You can find us on both sites posting soil and water related articles, infographics, contests, events and more. 'Like' us at [facebook.com/IowaWaterCenter](https://www.facebook.com/IowaWaterCenter) or @IowaWaterCenter.

This past year has also brought about two other venues to increase web presence: a new, interactive website and a bi-monthly e-newsletter, *News Flow*. The Iowa Water Center website, water.iastate.edu, features a wealth of information for researchers, educators, students and the general public. From Center news to employment opportunities to educational resources for all ages, the new website offers something for everyone interested in learning more about soil and water. The e-newsletter *News Flow* is released the second and fourth Tuesday of every month. This newsletter is a great venue for contributed stories, events and the latest funding announcements from local and national sources.

If we are to move forward with our goal of a sustain-

able planet, we must engage each other in the discussion of soil and water issues. To help accomplish that goal in Iowa, the Iowa Water Center has developed a directory of experts in the water and soil fields, available on our website. This compilation of names, contact information and research areas of expertise is maintained by self-submissions; all who consider themselves of particular knowledge in a certain subject are invited to submit their information. The Iowa Water Center particularly applauds the ISU Soil and Water Conservation Club for capturing the written products of diverse experts addressing soil and water issues in a single quality document. It is through information dissemination regarding the world of soil and water that we can engage an audience beyond the research community. This issue of *Getting Into Soil and Water* again helps meet that goal.



Soil and Water Conservation in Ghor Province, Afghanistan

By Mohammad Arif Yaqubi

Introduction

Ghor is one of the central provinces of Afghanistan where more than 90% of the population works directly in the agriculture crop and livestock sectors. [See Figure 1.] Three decades of conflict, poverty, and natural disaster have decimated the natural environment of Afghanistan. At the same time, a growing population requires more agricultural production. The farmers are generally uneducated at all levels. They use traditional

equipment for the cultivation, harvesting and irrigation of their lands.

Soil texture in most agricultural areas of the country, including Ghor Province, is silty clay. In general, atmospheric humidity and soil moisture levels are very low and, in addition, Ghor has only seasonal precipitation. During the dry season the plant cover dies after a few months and the soil becomes susceptible to natural forces like wind and flood, which easily cause erosion. Annually, millions of tons of soil wash away during



Figure 1: Map of Ghor Province, Afghanistan



Figure 2: Terraces help increase soil moisture and reduce erosion within a small watershed in Ghor Province, Afghanistan.

floods which fill the rivers with sediment, while winds blow off the topsoil in the dry season.

Rain Fed Lands - Problems

Of all the agricultural lands in Ghor, most are rain-fed with one seasonal harvest. Another use of the rain-fed lands is for animal forage. The amount of both crop production and animal forage depend on moisture from rain and snow that infiltrates into the ground. During times of drought, the crop harvest is poor and forage is hard to find. Other problems in these lands include overgrazing, and farmers using the scarce trees and shrubs to heat their homes and cook their food during the harsh winters, leaving the soil bare. These factors create obstacles for soil and water conservation.

Rain Fed Lands - Solutions

To address some of these challenges, the Afghan Government along with international donors work to design projects to solve the environment challenges. One of these efforts, a five year project designed and implemented by Catholic Relief Services (CRS) and funded by US Agency for International Development (USAID), was implemented in Ghor Province, as a pilot in small watersheds. The project had different components. One

component was to help communities reduce soil erosion from flood and wind. The project randomly selected different villages in small watersheds which were under severe soil erosion every year and where the farmers were at risk. The project hired local laborers to dig terraces on the hillside (2x1x0.5 meters) to collect water during times of snowmelt and rain. The purpose of this project was to protect the soil, help accelerate plant growth, and save moisture in the ground for rain-fed plants, as well as to increase the flow of local springs. The strategy of the project was to cover a certain area as a pilot to show the people how the system protects the soil and increases production of plants. When other communities saw the success of the pilot program they became interested in doing the same near their villages. [See Figure 2.]

Irrigated Lands - Problem

Much of the infrastructure, including irrigation canals, has been destroyed and the level of farm production has decreased. Water that was once controlled by irrigation systems now washes over the land causing of soil erosion. The water that was once channeled to irrigated lands is now wasted.

Lack of proper irrigation canals and unexpected flood from heavy snows followed by hard rain have together reduced agriculture production and directly affected the environment of the once irrigated areas. Top soil is washed away by flooding of the irrigated fields while streams

and rivers eat away nearby fields. This uncontrolled water also damages green areas, and destroys soil texture creating mud which turns to dust in the hot sun and blows away. The farmers do not use proper crop rotation methods which could protect the land from flooding and make it more productive.

Irrigated Lands - Solutions

Through cooperation of the Afghan Government, the Ministry of Energy and water (MEW), and the US Government, a project has been funded to efficiently use



Figure 3: Area to be irrigated along the Hari Rud (rud means river in the local language of Dari).

water from the Hari Rud River near Chaghcharan, the provincial capital of Ghor. On both sides of the river, rehabilitation of canals is underway which will help farmers to increase their production. By more efficiently irrigating about 800 hectares, this project will improve food security and boost the local economy. [See Figure 3.]

Conclusion

In the past, lack of awareness and little knowledge of the people about the environment and the importance of soil and water resources, as well as a lack of a national environmental policy has influenced how soil and water resources are conserved or wasted. Soil and water conservation is important for rural livelihoods and economic growth. To address the soil and water conservation needs, the international community with the support of the Afghanistan government, has been assisting communities and farmers through nongovernmental organizations to provide both technical and financial assistance to improve soil and water resource conservation. Soil and water conservation is one of the top priorities of Islamic Republic of Afghanistan Government strategy. The international community also contributes to this important sector on which human lives depend. However, soil and water conservation requires much more serious attention from everybody at every level.

Soil and water conservation is important for rural livelihoods and economic growth.

WATER AND SOIL QUALITY MATTER TO US ALL

WATER ROCKS! is a statewide K-12 water education campaign that challenges and inspires Iowa's students towards greater appreciation of our water resources.



Our team visits schools, hosts field days and other events at no cost. Visit the websites to learn more.



www.waterrocks.org

The Iowa Learning Farms is a statewide program that empowers others to improve soil and water quality by implementing conservation practices on their land.



www.extension.iastate.edu/ilf



Iowa Nutrient Reduction Strategy



*Dean Lemke and Shawn Richmond
Water Resources Bureau, Iowa Department of
Agriculture and Land Stewardship*

Overview

The Iowa Nutrient Reduction Strategy is a science and technology-based framework to assess and reduce nutrients to Iowa waters and the Gulf of Mexico. It is designed to direct efforts to reduce nutrients in surface water from both point and nonpoint sources in a scientific, reasonable and cost effective manner.

The Iowa strategy has been developed in response to the 2008 Gulf Hypoxia Action Plan that calls for the 12 states along the Mississippi River to develop strategies to reduce nutrient loading to the Gulf of Mexico. The Iowa strategy follows the recommended framework provided by EPA in 2011 and Iowa is only the second state in the Mississippi River Basin to complete a state-wide nutrient reduction strategy.

The Iowa Department of Agriculture and Land Stewardship and Iowa Department of Natural Resources worked with Iowa State University over a two-year pe-

riod to develop the strategy and nonpoint source science assessment. The Iowa strategy outlines a pragmatic approach for reducing nutrient loads discharged from the state's largest wastewater treatment plants, in combination with targeted practices designed to reduce loads from nonpoint sources such as farm fields. The resulting strategy is the first time such a comprehensive and integrated approach addressing both point and nonpoint sources of nutrients has been completed.

In this document, steps are outlined to prioritize watersheds and limited resources, improve the effectiveness of current state programs, and increase voluntary efforts to reduce nutrient loading from nonpoint sources.

Iowa's many successes in conservation programs can be duplicated using the tools known to work, such as targeted, voluntary conservation measures, in conjunction with research, development and demonstration of new approaches.

This strategy recognizes the continued need to work with farmers, industry and cities to optimize nutrient management and lessen impacts to streams and lakes. It also recognizes success is highly dependent on many

complicated factors, and new technologies will also need to be developed, tested and implemented.

As Iowa is a national and global leader in the production of food and renewable fuels, a goal of this strategy is to make Iowa an equal national and global leader in addressing the environmental and conservation needs associated with food and renewable fuels production. All Iowans have an impact on nutrients in surface water and can play a role in reducing those impacts over time.

To address nutrient transport from nonpoint sources the strategy uses a comprehensive, first of its kind scientific assessment by 23 scientists working over a 2 year period of conservation practices and associated costs to reduce loading of nutrients to Iowa surface waters. The strategy identifies five key categories to focus the efforts in addressing nonpoint sources and identifies multiple action items within each category-

- Setting Priorities
- Documenting Progress
- Research and Technology
- Strengthen Outreach, Education, Collaboration
- Funding

By harnessing the collective innovation and capacity of Iowa agricultural organizations, ag businesses and farmers the strategy takes a significant step forward towards implementing practices to improve water and soil quality.

Information and Outreach

The Iowa Department of Agriculture and Land Stewardship, Iowa DNR and Iowa State University have hosted two public meetings and hosted a webinar to educate

Iowans about the strategy and answer questions. The webinar has been archived and can be viewed on the nutrient strategy website at www.nutrientstrategy.iastate.edu. In addition, presentations are being made to farmers, certified crop advisors and others in the agriculture industry as part of ISU Extension and Outreach's ongoing educational meetings. The public comment period for the Iowa Nutrient Reduction Strategy has been extended by two weeks until Jan. 18, 2013. The full report, additional information and place for comments can be found at www.nutrientstrategy.iastate.edu.

All Iowans have an impact on nutrients in surface water and can play a role in reducing those impacts over time.

Moving Forward

While the positive effects of any individual nutrient control practice may not be noticed immediately, the cumulative impact of these actions will result in long-term water quality improvements in Iowa, plus downstream waters from Iowa to the Gulf of Mexico.

This strategy is the beginning. From this, operational plans will be developed through the Water Resources Coordinating Council, which is already underway. This is a dynamic strategy document that will evolve over time as new information, data and science is discovered and adopted.

There still is a need for development of additional practices, testing of new practices, further testing of existing practices, and verifying practice performance at implementation scales. This strategy encourages the development of new science, new technologies, new opportunities, and the further engagement and collaboration of both the public and private sectors.

The path forward to reducing nutrient impacts will not be easy, but this strategy is a key step towards improving Iowa's water quality while ensuring the state's continued, reasonable economic growth and prosperity.



Water Rocks! Youth Water Education Program

By Jacqueline Comito and Ann Staudt

Today's Iowa students are tomorrow's landowners, farmers, scientists, teachers, decision-makers and voters. Water Rocks! is an Iowa State University Extension and Outreach youth water education campaign integrating STEM (science, technology, engineering and mathematics) and the arts.

Water Rocks! inspires young people to think, learn and create in a world where boundaries are as blurry as the flow of water within a watershed. The more young people understand the relationship between agricultural practices, rural/urban land management choices and the health of our natural resources, especially soil and water, the more likely they will be receptive to making decisions to protect these resources in the future.



Dr. Jacqueline Comito, Director of Water Rocks!, teaches about watersheds, water quality and quantity issues, and biodiversity inside the Conservation Station's learning lab. Photo courtesy of Water Rocks!.

In a national study, youth told researchers that the most effective water education was through technology, social media, and enjoyment of the outdoors (Water=Equals 2011). Water Rocks! builds on this framework, delivering fun and engaging water education lessons through classroom visits, the interactive Conservation Station trailer, songs, videos, Water Rocks! website, Rock Your Watershed! computer game, and hands-on enhanced learning activities.

In 2012, the Water Rocks! team participated in 111 outreach events, many of which were school visits and outdoor classrooms. Over 15,500 people were reached—90% were youth in grades K-12. The Water Rocks! team, consisting of five full-time staff and six undergraduate student interns, provides high energy, engaging lessons combining issues of water quality and soil health, agriculture and the environment through multiple learning modules.

All Water Rocks! materials are tested with youth and educators and are revised until proven successful. Teacher evaluations have been highly positive. For more information about scheduling a school visit or 2013 event or to find downloadable classroom materials, visit www.waterrocks.org. All Water Rocks! programming and materials are free to schools and the public.

From April to October, Water Rocks! uses its fleet of Conservation Station trailers to conduct outreach and education events. The Conservation Station fleet contains three trailers equipped with rainfall simulators, hands-on interactive demonstrations, and multiple interchangeable educational modules utilizing photographs, posters, computer animations, simulations, music and video media. Staffed by the Water Rocks! team, the Conservation Station can be part of school visits, outdoor classrooms, and community events (county fairs, farmers' markets, field days, environmental appreciation events, etc.).

Today's youth are highly motivated and engaged through technology; the Water Rocks! website (www.waterrocks.org) engages youth through positive stories, photographs, videos and an interactive, competitive computer game, Rock Your Watershed!. This game challenges students to select land management practices for ten parcels of land in a shared watershed. Profit (from agricultural crop production) and water quality parameters (sediment, nitrogen, and phosphorus) must be balanced to yield a high score, under changing precipitation conditions each year. Rock Your Watershed! is based on scientific data correlating soil erosion, nutrient transport, precipitation, and land management practices in Iowa.

Music and videos are at the heart of Water Rocks!. We are developing a series of songs, music videos and humorous short videos for different age groups, grades K-12. The video team uses its creative, award-winning style to engage students about different elements of

water and soil. These videos are being filmed across the state and feature pirates, rubber ducks, farmers and conservation dogs. Starting in April 2013, new videos will be posted monthly on the Water Rocks! website and YouTube channel.

Future plans for Water Rocks! include teacher/peer mentor training summits, a high school student competition, Water Rocks! geocaching in Iowa's state parks, and an expansion of the Rock Your Watershed! game to include additional choices and levels.

Our goal is to teach youth to think, analyze and solve environmental problems, with multiple age-appropriate, experiential tools to help accomplish this. We value a hands-on approach to education and our

team continues to design additional creative, engaging educational aids to teach complex water quality issues. Most importantly, we make it FUN! Through learning about their environment and exploring the landscape around them, we strive to inspire youth to live differently in the world.

Water Rocks! is a partnership of Iowa State University Extension and Outreach, Iowa Department of Natural Resources (USEPA Section 319), Leopold Center for Sustainable Agriculture, and in cooperation with the Iowa Water Center and Iowa Learning Farms. Water Rocks! helps fulfill objectives of both the 2012 Iowa Nonpoint Source Management Plan and the Iowa Department of Natural Resources Strategic Plan that call for a state-wide public awareness campaign. For more information, go to www.waterrocks.org.

Through learning about their environment and exploring the landscape around them, we strive to inspire youth to live differently in the world.



Ann Staudt, WR! Science director, introduces Edgewood-Colesburg 2nd graders to the Conservation Dogs at a May 2012 outdoor classroom field day. Photo courtesy of Water Rocks!.

Curbing Agricultural Runoff Pollution: Lessons from the Clean Water Act



Big Creek Lake northwest of Des Moines was one of several public lakes to suffer significant algae blooms during summer 2012, including this one, which took place in September over Labor Day weekend.

Susan Heathcote
Water Program Director, Iowa Environmental Council

Iowa faces numerous clean water challenges, but the state's most widespread, serious and vexing problem is polluted agricultural runoff--especially the nutrients nitrogen and phosphorus--which enter waterways each time it rains with sufficient intensity to create water runoff.

The agricultural runoff problem is particularly challenging to solve because it comes from across Iowa's landscape where over 90 percent of the land area is in farms. Cities and industries also contribute to this pol-

lution, mainly through discharges of treated wastewater to waterways (called point sources because the pollution comes from a discrete pipe). But most of this pollution comes from runoff leaving farm fields and other land areas (called nonpoint sources)(see Table 1).

Nitrogen and phosphorus are naturally present in waters and necessary for healthy aquatic systems. However, too much nitrogen and phosphorus can cause algae blooms that turn water green, create foul odors, and spoil outdoor recreation. Algae blooms cause fish kills by decreasing dissolved oxygen in the water. Cyanobacteria, a type of toxic algae, can make water unsuitable for drinking and swimming.

Table 1: Sources of Nitrogen and Phosphorous Pollution in Iowa waters

	Municipal, industrial, and other point sources	Agricultural and other non-point sources
Nitrogen	8%	92%
Phosphorus	20%	80%

Source: <http://www.iowadnr.gov/portals/idnr/uploads/water/standards/nbsum.pdf?amp;tabid=1585>

How do we fix this problem?

In November 2012, a state government team released Iowa's Nutrient Reduction Strategy, an approach intended to help resolve this serious problem. It proposes to reduce runoff pollution from farms by ramping up the state's current all-voluntary approach along with new mandatory pollution control technologies proposed for cities and industries.

Given the serious impacts and widespread nature of agricultural runoff pollution, Iowa's strategy must consider new approaches in addition to current voluntary programs. One place to look for ideas is 40 years of successful pollution reduction from point sources under the federal Clean Water Act (CWA).

When the CWA passed in 1972, our major water pollution problems were from untreated sewage and industrial wastes discharged without adequate treatment into our rivers and lakes. By setting specific water quality standards for pollutants and requiring cities and industries to treat these pollutants before they discharge to waterways, the CWA achieved tremendous progress across the country.

Setting clear goals

Following the CWA model, establishing clean water standards for nitrogen and phosphorus is the first step to solving this pollution problem. Iowa currently lacks numeric standards limiting nitrogen or phosphorus. Iowa's current standards include only narrative limits that apply to nitrogen and phosphorus that say water should be free of "aesthetically objectionable" or "acutely toxic" conditions. Unfortunately, by the time these conditions are present, significant pollution has already occurred. Setting numeric pollution limits provides clear goals to prevent pollution of Iowa's rivers and lakes.

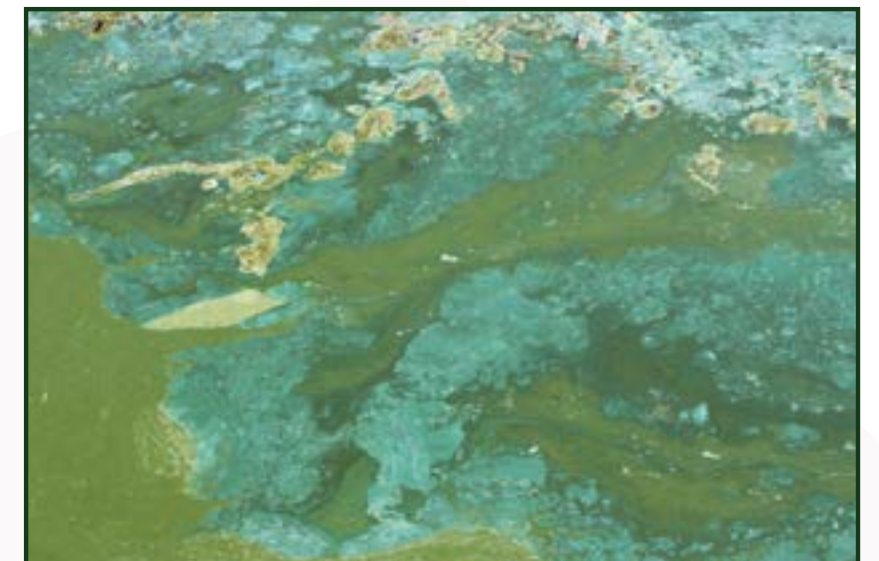
Matching solutions to the problem

In addition to setting goals, a key reason for the success of the Clean Water Act has been its two-tiered approach to pollution control by cities and industries:

- Common-sense, basic limits everyone follows: Technology-based limits for all industries and municipalities determine a basic level of required treatment that is both technically and economically achievable. These limits utilize treatment technologies that are proven to effectively remove pollutants, and they allow the facility to choose from several different options.
- Additional action when and where it is needed: If technology-based limits are insufficient to achieve clean water goals, additional treatment is required to meet water quality based pollution limits. Again, the facility is allowed to choose between different treatment technologies to achieve these limits.

The Clean Water Act does not regulate agricultural non-point sources of pollution. However, it is possible to consider state pollution control requirements for these sources modeled after the CWA's successful two-tiered strategy:

Common-sense basic conservation: Implementation of stewardship plans for all farmland would help protect soil and water resources. Like technology based limits for point sources, performance goals for these plans could be based on effective, affordable conservation practices, but also would allow each farmer to choose



On the Friday prior to Labor Day weekend this summer, state officials issued a water quality advisory about blue-green algae at Big Creek Lake and two others. They suggested the public avoid contact with the algae blooms, which can pose health hazards to people and animals.

Iowa's strategy must consider new approaches in addition to current voluntary programs.

any of several practices that meet the plan's goals and the farmer's needs.

Additional action when and where needed: Where the farm stewardship plan is insufficient to meet water quality goals, farmers could partner with their neighbors--and with cities and industries that are also contributing to the problem--to implement targeted practices in their watershed to meet water quality goals.

Equal accountability for all

Under the Clean Water Act, clear goals for cities and industry and a measurable cleanup plan insures accountability for point source pollution and has resulted in significant water quality improvements. With new research on the effectiveness of conservation practices included in the Nutrient Reduction Strategy, the ability of conservation professionals to provide farmers science-based solutions that support both agricultural productivity and clean water has improved dramatically. The Clean Water Act model suggests combining these solutions with meaningful accountability will achieve results for Iowa's clean water goals.

References

<http://www.iowadnr.gov/Environment/WaterQuality/WatershedImprovement/WatershedBasics/WatershedPollution.aspx>

<http://www.nutrientstrategy.iastate.edu/>

<http://cfpub2.epa.gov/npdes/generalissues/water-technology.cfm>



What Soils Are Made Of and How They Develop



Gerald Miller

Department of Agronomy, Emeritus, Iowa State University

Soil is defined as media that supports plant growth and plant development. A soil consists of solids and spaces between the solids (voids). The solids include inorganic and organic materials. Inorganic materials include minerals such as quartz, feldspars, and mica. Organic materials are decayed products that originated as plants or animals. Voids are occupied by gases and liquids, primarily air and water. All soils contain solids and voids in varying ratios. Changes in a soil are driven by physical, chemical and biological processes which act on the organic and inorganic components resulting in different ratios of solids and voids over time. Not only does the ratio change, the size of the components also change.

To be classified as soil material the size of the inorganic material must be less than 2 mm (~25 mm = 1 inch). The largest particles are sand, which range in size from 2 to 0.05 mm, while silt-sized particles range from 0.05 to 0.002 mm. Particles smaller than 0.002 mm are clay. Inorganic material greater than 2 mm are either gravel, cobbles, or boulders as size increases.

Soil development refers to the changes that occur over time in soil material extending from the soil surface to a given depth below the ground surface, generally 60 to 80 inches. The vertical section is a soil profile. The development process requires two ingredients. First, a raw parent material in which the soil forms. In Iowa, this

parent material can be deposits from glaciers, water or wind or bedrock such as limestone, sandstone or shale. The second ingredient is differentiation of one or more layers, called horizons, within the soil profile.

Jenny (1941) in his classic work identified five soil factors that influence soil development. These are: 1) parent material, 2) climate, 3) living organisms, 4) topography and slope, and 5) time. The interaction of these factors results in soils with different physical, chemical and biological properties as one traverses across the landscape. These different properties allow for the differentiation

of soil horizons within the soil profile (Figure 1). The primary soil horizons found in Iowa soils are: A, topsoil a dark colored organic enriched horizon; B, the subsoil where products of weathering accumulate, and C, the parent material, a horizon containing loose, non-weathered material deposited by glaciers, wind or streams. Other soil horizons that occur in some Iowa soils include: O horizon, representing an accumulation of organic debris above the

A horizon; E, a surface or subsurface horizon formed in soils that experienced development under forest vegetation; and R horizons where the parent material is bedrock.

Other researchers have developed additional soil forming models built on Jenny's model. One of these models, which is widely accepted model for soil development, was proposed by Simonson (1959). He proposed four major processes that change parent material into a soil. He focused on horizon differentiation stating that the

Soil development refers to the changes that occur over time in soil material extending from the soil surface to a given depth below the ground surface.

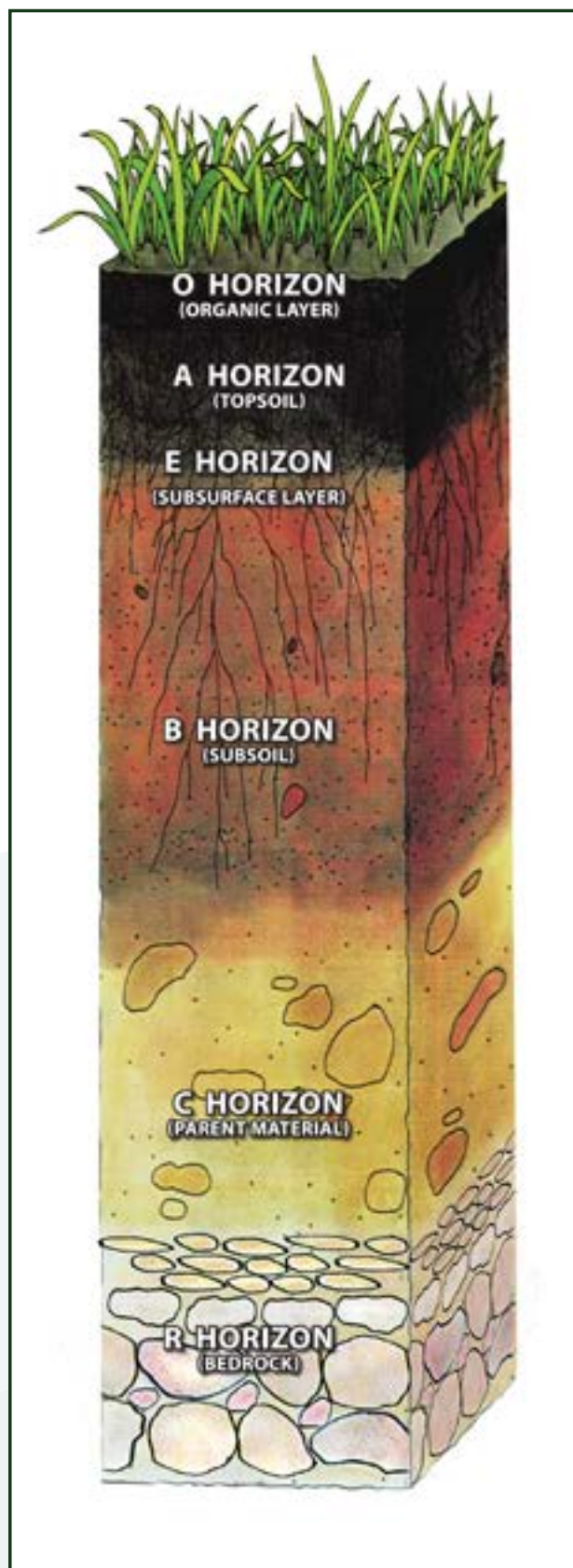


Figure 1. A generalized soil profile showing the six primary horizons (USDA NRCS, 2007, p. 5).

processes in soil formation involved: 1) additions, 2) losses or removals, 3) transfers or translocations, and 4) transformations. An example of additions is the accumulation of organic material. Other examples are dust deposits from wind and sediments deposited on the soil surface from flooding.

Losses or removals involve the infiltration of water into the soil profile which dissolve carbonates and salts. Percolating water move these soluble materials downward in the soil profile. The decay of plant residues into organic matter results in the loss of carbon as a gas in the form of carbon dioxide. The movement of sand, silt, and clay particles across the soil surface as the result of erosive wind and water is another example of losses and removals.

Transfers include the downward movement of clay-sized particles located in the topsoil horizon to the subsoil. This involves the infiltration of water in the topsoil and its downward movement carrying fine clay particles to the B horizon.

Transformations occur when fine silt-sized inorganic particles weather and form smaller clay-sized particles. Another transformation defines the form of iron in the soil. The presence or absence of aerobic conditions in a soil will determine the form of iron oxides that occur, either ferric (oxidized) or ferrous (reduced).

The overall process of soil development and horizon differentiation can be characterized as weathering. Weathering is alteration of the parent material and inorganic component of the soil by the interaction of physical, chemical and biological action. The weathering process determines how fast or slow a soil develops.

A young or recently developed soil may consist of only an A and C horizon. Other soils may have an A, a weakly developed B horizon with minimal clay accumulation characterized by color and structure differences. Most Iowa soils occupying stable landscapes have an A horizon and strongly developed B horizon characterized by clay accumulation, strong color differences in contrast to above and below horizons, and aggregations of the solid material which form discernible structural features. Profiles developed under the influence of forest vegetation contain observable E horizons as well as developed B horizons.

A common question asked is how old are most of Iowa soils. In order to answer that question one must remember that some physical, chemical and biological actions result in soil proper-

ties that formed very recent. Generally, soil scientists consider observable and measureable properties found in the A, E, and B horizons when considering the age of a soil profile.

The age of the soil profile and the age of the parent material are not the same. For example, Iowa parent materials range from the most recent flood deposit of thick sediments to glacial deposits that occurred more than 600,000 years before present. Since soil profiles are a product of the soil forming factors that influenced their development, the age of Iowa soils range from less than 100 years in age to 3,000 to 5,000 years old. An A horizon on a stable landscape can develop from raw parent material in less than 100 years (Hallberg, et al., 1977). Also, soil on a steep slope that has experienced accelerated surface erosion may have a very young A horizon and a recently modified E and/or B horizon. In Iowa, upland soils occupying stable landforms have properties that reflect the influence of climate and vegetation that has been present during the past 3,000 to 5,000 years (Ruhe, 1969).

References

- Jenny, Hans. 1941. Factors of Soil Formation – A System of Quantitative Pedology. McGraw-Hill, New York.
- Hallberg, George R., Nyle C. Wollenhaupt, and Gerald A. Miller. 1978. A Century of Soil Development in Spoil Derived from Loess in Iowa. Soil Science Society of America Journal 42: 339-343.
- Ruhe, R. V. 1969. Quaternary Landscapes in Iowa. Iowa State University Press, Ames. 255 p.
- Simonson, Roy W. 1959. Outline of a Generalized Theory of Soil Genesis. Soil Science of America Proceedings 23: 152-156.
- USDA Natural Resources Conservation Service. 2007. From the Ground Down: An Introduction to Iowa Soil Surveys. 17 p. <ftp://ftp-fc.sc.egov.usda.gov/IA/news/GroundDown.pdf>



Human-induced Soil Change in Iowa: Two Contrasting Examples

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The crops of Iowa yielded 100's of trillion of calories in 2012. Those calories are feeding 100's of millions of chickens, pigs, cattle and other livestock. They also help fuel millions of vehicles. So directly and indirectly they are feeding people and fueling our economy. Credit for this amazing production begins with farmers and extends through the entire agricultural sector. But part of the credit has to be given to the very land being farmed. Simply put, Iowa has amazing soils. Their natural productivity is the envy of the world. Their favorable re-



Figure 1. A typical fencerow separating two typical fields. Note the two feet change in elevation from one field to the next even on this "flat" landscape.

sponse to farming is exceptional. Iowa is globally recognized as the place where agriculture thrives because of its soils. That recognition began in the mid-1800's. That recognition will likely continue for another 150 years...or even longer. However, it is wrong to think Iowa's soils are so naturally resilient that nothing changes them.

Agriculture has, is and will continue to cause changes in our soils. That change will likely be proportional to the yields we get from our soils. To think otherwise would require ignoring the basic tenets of ecology and thermodynamics. Over 90% of the diverse prairies, forests and wetlands of Iowa have been replaced by near monocultures of row crops and forages. At the very least this means the type, amount, and timing of humus additions and losses to soil has changed. Le Chatelier's Principle tells us this must result in a new equilibrium for the soil. Confounding equilibrium are the other changes associated with soil use. Farming, especially tillage, has unintentionally resulted in 20-plus billion tons of soil erosion since statehood in 1846. Evidence of erosion is observable even when driving across flat landscapes (Figure 1). Another driver of soil change is land drainage. Iowa has roughly a million miles of tile

lines and thousands of miles of drainage ditches (Figure 2). Their sole purpose is to improve the water and oxygen balance for cropping on our 10 million acres of poorly drained soils. But perhaps the least examined change is simply how the soil profile has evolved due to the inputs added to insure a continual improvement in yields. Over Iowa's



Figure 2. The new norm for tile fields.

history, those inputs sum to hundreds of tons per acre and billions of tons statewide.

This paper discusses two studies that examined soil change in Iowa resulting from normal agriculture uses. Both have been briefly described in earlier editions of

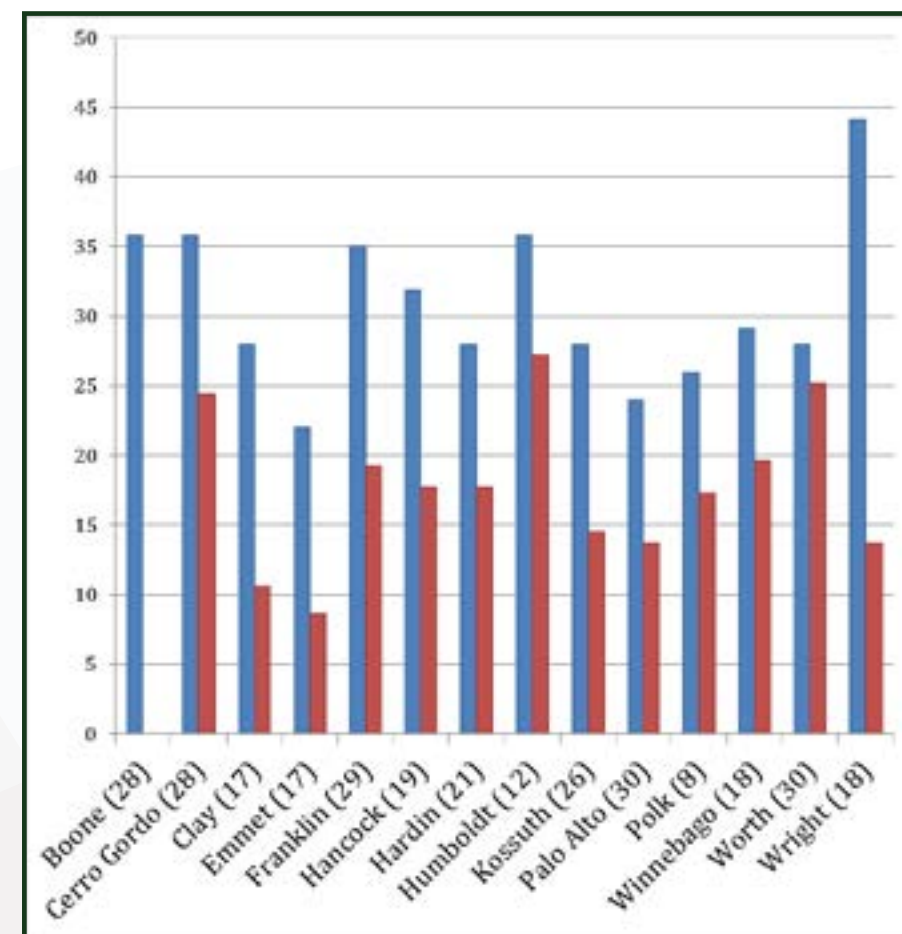


Figure 3. Comparison of original and final O-horizon thickness (x-axis in inches) in 14 representative Palms pedons from around north-central Iowa. Y-axis shows county where sampling occurred followed by the number of years, in parentheses, between original and final descriptions. Data is from Larabee (2004).

this publication. The first study looks at the impact of up to 30 years of tile drainage and cropping on a "peat." The second looks at the impact of 150 years of cropping on a soil that naturally formed in loess under forest. These studies were selected because their soils are very different and their response to farming has been very different.

Organic soils are amazingly productive when drained, so they are almost always drained. Traditionally they are most valued for truck crops – e.g., the aptly named town, Celeryville, is located in the middle of Ohio's organic soil and truck cropping region. Organic soils develop in shallow lakes, ponds and other stillwater environments. These are places where cattails, sedges and other hydrophytes thrive during the growing season and then fall over and sink underwater during winter. Those submerged residues slowly and incompletely decompose. Over thousands of years the cycle of rapid growth followed by partial anaerobic decomposition produces peats that can be 10's of feet thick.

Peats and other organic soils are some of the easiest soils for humans to degrade. They have very, very low bulk densities so when drained they are incredibly susceptible to wind erosion. "Black snow" in fields and ditches is a common indicator of a nearby wind eroded organic soil. Drainage also causes rapid subsidence since organic matter is buoyant in water but collapses without water. Finally, drainage exposes the organic matter to oxygen and aerobic decomposition, which is tens to hundreds of times faster than anaerobic decomposition. This releases a flush of nutrients, which the microorganisms that are doing the decomposing use to speed up decomposition.

For these reasons organic soils - or, more technically, Histosols - are used in soil science as an indicator for human im-

pacts. Iowa has about 100,000 acres of organic soils around one-half of that area being the Palms series (Miller, 2010). Or at least the soil maps of Iowa show about 100,000 acres of organic soils. The amount that really exists is undoubtedly less given Beth Larabee's (2004) findings. Larabee's research goal was to document what if any changes had occurred in the Palms soils due to farming during the late 20th century. She did so by describing and analyzing soils collected from the exact location where NRCS had identified 15 representative pedons of Palms. Her research took her across north-central Iowa. She was most interested in the thickness and properties of the O-horizon, which is roughly synonymous with "peat" thickness. Larabee found the "average" Palms experienced about 1 inch of loss per year over the 30-year period she examined. This is substantial loss for any soil and especially for Histosols. Figure 3 shows side-by-side comparisons of the thickness of the peat (O-horizons) in NRCS representative pedons and Larabee's. Figure 4 illustrates that Palms degradation was inversely proportional to the length of time between sampling by NRCS and Larabee. All told Larabee's research indicates the Palms is on a path of extinction with all vestiges of O-horizons being eliminated in the next 25 years. In some cases – e.g., Emmet County, the entire representative pedon is probably already gone.

At the opposite end of organic soils are well-drained upland soils formed from loess. These soils are ideal for cropping and are highly resistant to change - provided erosion is managed. In all likelihood Iowa's farming reputation was established based on the ease at which

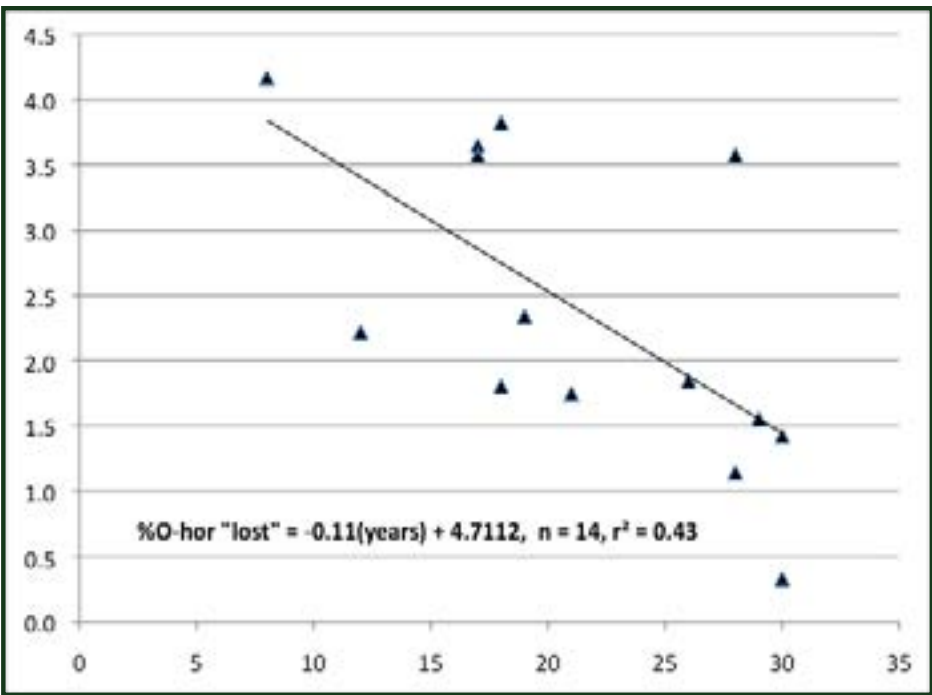


Figure 4. Rate of O-horizon loss as a percent (y-axis) of original O-horizon thickness for 14 representative Palms pedons from north-central Iowa (data from Larabee, 2004). The x-axis shows the number of years elapsed between original and final soil descriptions.

Over 90% of the diverse prairies, forests and wetlands of Iowa have been replaced by near monocultures of row crops and forages.

pioneer farmers obtained high yields on the state's many loess-derived soils. They readily infiltrate and drain water yet retain amazing amounts of plant available moisture for the growing season. They generally have high weatherable mineral contents, which translates into high native fertility. Their textures, bulk density, structure all facilitate robust root growth. And most loess soils have well developed A horizons with high organic matter contents. As a result studying change in them is probably representative of the norm for Iowa.

This is exactly what Professor Yuri Chendev did. In 2008-2009 he completed a detailed analyses of change resulting from long-term cropping on the Fayette soil at four sites in Johnson County. His research, which was part of his Fulbright Visiting Scholarship, was an extension of comparable work he conducts in western Russia.



Figure 5. A Fayette profile that has never been cropped (left) and one that has been cropped for 150 years (right).

Chendev selected the Fayette soil and Johnson County for several reasons. First, it is a common, highly productive loess-derived soil, covering over a million acres of eastern Iowa (Miller et al, 2010). Second, it is almost exclusively cropped, having a B-slope CSR off 85. Third, and why Johnson County was selected, there are fields with Fayette soil that were cleared of forest in order to crop beginning 150 years ago. Contiguous fields were converted from forest to cropping beginning 100 and 50 years ago, respectively. Equally importantly there is a contiguous forested site that has never been cropped. Finally, these sites are unusually flat for the Fayette soil. This means their erosional histories are minimal and the full impact of farming is expressed in the soil profile.

Chendev found every property of the Fayette profile differed according to duration of cropping (Chendev et al, 2012). Each difference was proportionally to time period of cropping. The A horizon thickened by about 10 inches and there was a corresponding increase in structure quality. The degree of faunal burrowing increased through 60 inches while porosity decreased in the upper 15 inches. Iron and manganese mottling became more pronounced to 60 inches. Perhaps most interesting, the thickened A horizon caused each of the other seven horizons shift deeper even as they maintained their original individual thicknesses. Taken collectively these changes – and other changes not described here-

in - mean the Fayette, which is naturally an Alfisol, is becoming a Mollisol. In other words, cropping created a soil that is as akin to a prairie-derived soil as it is to a forest-derived one.

Combining the research by Larabee and Chendev indicates that long-term cropping is definitely changing Iowa's soils. It is too simple to think all of those changes are degrading the soil. Each field has its own history both natural and agriculturally. As a result knowing a field's history and its boundaries is becoming as important to soil science as understanding parent material, native vegetation, landscape position, and drainage class.

This finding is simply a confirmation of basic scientific tenets but it has profound ramifications relative to how people see the soils of Iowa.

References

Chendev, Y.G., C.L. Burras and T.J. Sauer. 2012. Transformation of forest soils in Iowa (United States) under the impact of long-term agricultural development. *Eurasian Soil Sci.* 45:357-367.

Larabee, B.E. 2005. Evolution of the Palms (Terrestrial Haplosaprist) soil in Iowa, 1969-2001. Unpubl. MS thesis. 141 p.

Miller, G.A., T.E. Fenton, B.R. Oneal, B.J. Tiffany and C.L. Burras. 2010. Iowa soil properties and interpretations database. ISPAID Version 7.3. Iowa State University – IA. Ag. H. Ec. Exp. Station. 30 p.

Community-wide Urban Storm Water Planning Utilizing LiDAR, the WinSLAMM Model, and GIS

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Introduction

Urban storm water runoff can be a significant cause of water quality impairment of rivers and lakes and contribute to flooding due to altered hydrological systems. In order to effectively and efficiently manage urban storm water runoff, there is a need for up-to-date and accurate information about the land surface in urban areas as well as software models that can be used to effectively simulate the real world environment. We are developing mechanisms to couple the Windows Source Load and Management Model (WinSLAMM) to a Geographic Information System (ArcGIS) in order that WinSLAMM can be more efficiently applied to urban

watersheds. Additionally we are examining the use of highly detailed Light Detection and Ranging (LiDAR) derived topographic data to more accurately characterize urban watersheds. ArcGIS and the WinSLAMM have been used in a pilot study to examine sediment and phosphorous runoff from an urban watershed within the University of Northern Iowa campus.

Urban Hydrology and Water Quality and Quantity

Urban stormwater frequently contain oils, pesticides, nutrients, and bacteria that can negatively influence stream and lake ecology. In addition, poorly managed urban areas can drastically alter the natural runoff patterns in a watershed leading to more water more quickly running off the land surface leading to more frequent and severe flooding events. Impervious sur-

faces (houses, roads, parking lots, etc.) reduce infiltration (see Figure 1) while traditional drainage systems (storm sewers) convey large volumes of water quickly to streams. Monitoring and improving urban stormwater runoff has become an important concern for municipalities throughout the United States with regulation coming under Municipal Separate Storm Sewer permitting under the Clean Water Act.

Urban watershed management is complex due to the varying spatial environment (land use/cover, topography, and stormwater network), economic interests, and policy environment. In general,

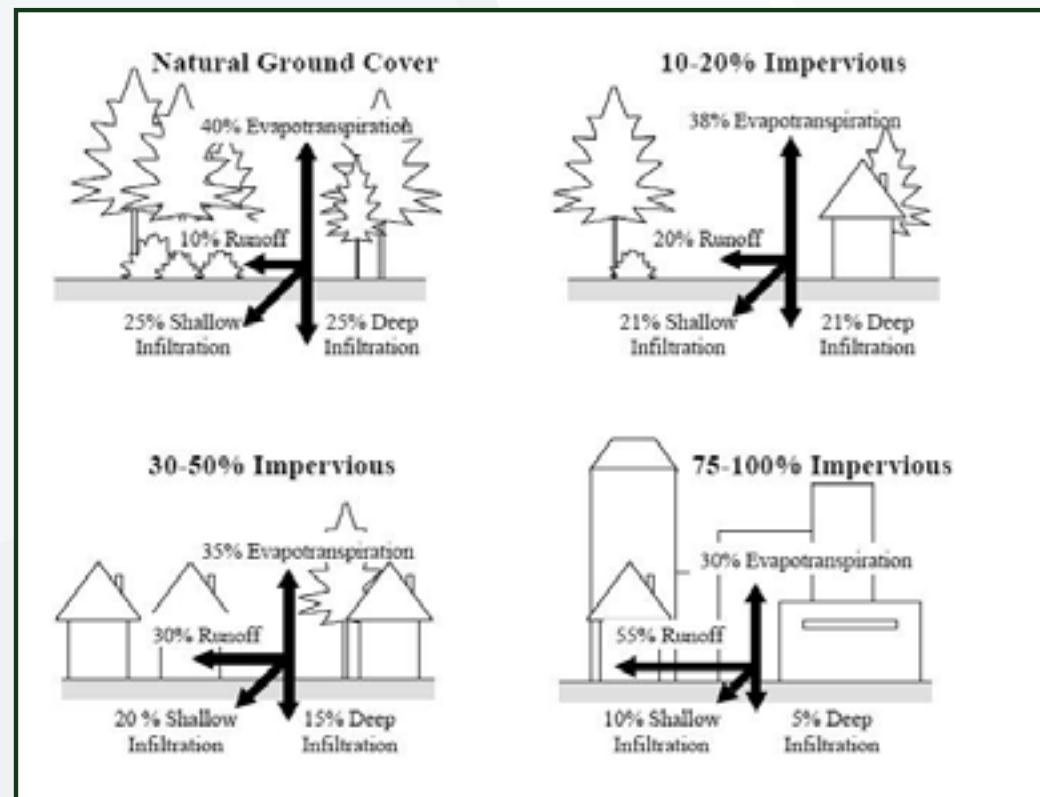


Figure 1.



Figure 2.

municipalities are not well equipped for handling the complex issues involved in stormwater management and would benefit from modeling tools that are not overly complex but which can provide greater insight into the nature of their jurisdiction's stormwater systems and the advantages of implementing stormwater control measures. As communities locally learn to better manage runoff volumes and loads, the collective effort can reduce the overall hydrologic and water quality impact on Iowa's lakes, rivers and streams.

Using WinSLAMM with GIS and LiDAR Data

Due to the complex nature of urban hydrology modeling techniques are necessary to estimate the quantity and quality of water runoff and also to investigate how implementation of Best Management Practices (BMPs) might influence urban hydrology. The present WinSLAMM system is the result of several decades of research and development and is based on actual field observations. The model has been effectively utilized for a variety of urban stormwater management modeling applications (Pitt and Voorhees 2004). Although WinSLAMM is used to estimate runoff and pollutant loadings across urban areas it lacks an explicit connection to GIS software. This project attempts to more effectively integrate GIS data (especially LiDAR elevation) with WinSLAMM, develop a freely available ArcGIS toolset that will make it easier to utilize WinSLAMM for urban watersheds, and to demonstrate the efficacy of using ArcGIS and WinSLAMM.

A pilot study has been completed in which WinSLAMM applied to the University of Northern Iowa campus in

order to estimate runoff and sediment and phosphorus loss. This work was carried out in conjunction with the Facilities Planning Department. ArcGIS was utilized for developing input parameters for WinSLAMM including LiDAR elevation data (Figure 2). Iowa is one of the few states in the USA which has detailed LiDAR topography data for the whole state. The UNI campus contributes runoff to two

branches of Dry Run Creek, which were both on Iowa's list of 2010 impaired waterways reported by the Iowa DNR to the US Environmental Protection Agency.

Special ArcGIS tools were developed to allow more efficient development of WinSLAMM modeling parameters using ArcGIS. Sub-watershed boundaries and a

The GIS tools being developed make it more efficient to carry out WinSLAMM modeling over larger areas such as a University campus or even a small city.

detailed land cover map were developed using ArcGIS and the LiDAR data for the UNI Campus and used to set parameters in the WinSLAMM model. WinSLAMM simulations were carried out to estimate the amount of water running off and the total amounts of phosphorus and sediment leaving the UNI campus (Figures 3 and 4). The western and southwestern areas of the campus are shown to contribute the most sediment and phosphorus.

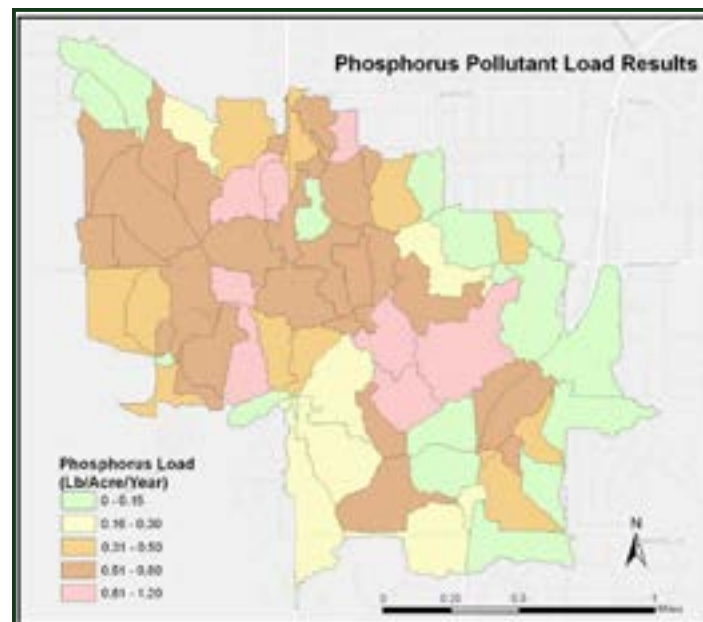


Figure 3.

Five sub-watersheds (Figure 5) were chosen to investigate the potential benefits of introducing a BMP, in this case a bioretention unit. These bioretention units are better placed in a pervious (e.g. grass) area than impervious areas (e.g. cement parking lot). WinSLAMM modeling was carried out with the hypothetical introduction of the BMP's. The predicted reduction in runoff

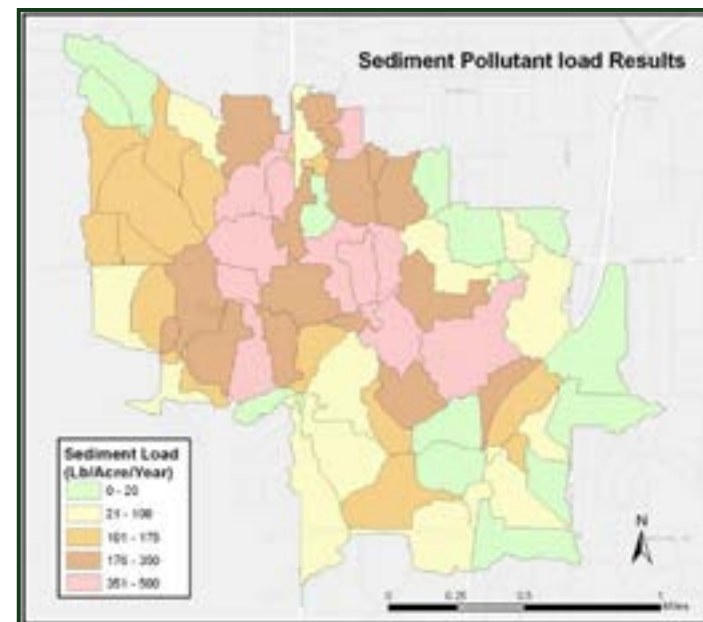


Figure 4.

ranged from 36-86% for the five sub-watersheds while the phosphorus loading reduction ranged from approximately 25% to 75%.

The GIS tools being developed make it more efficient to carry out WinSLAMM modeling over larger areas such as a University campus or even a small city. The use of LiDAR elevation data can lead to more effective use of WinSLAMM.



Figure 5.

References

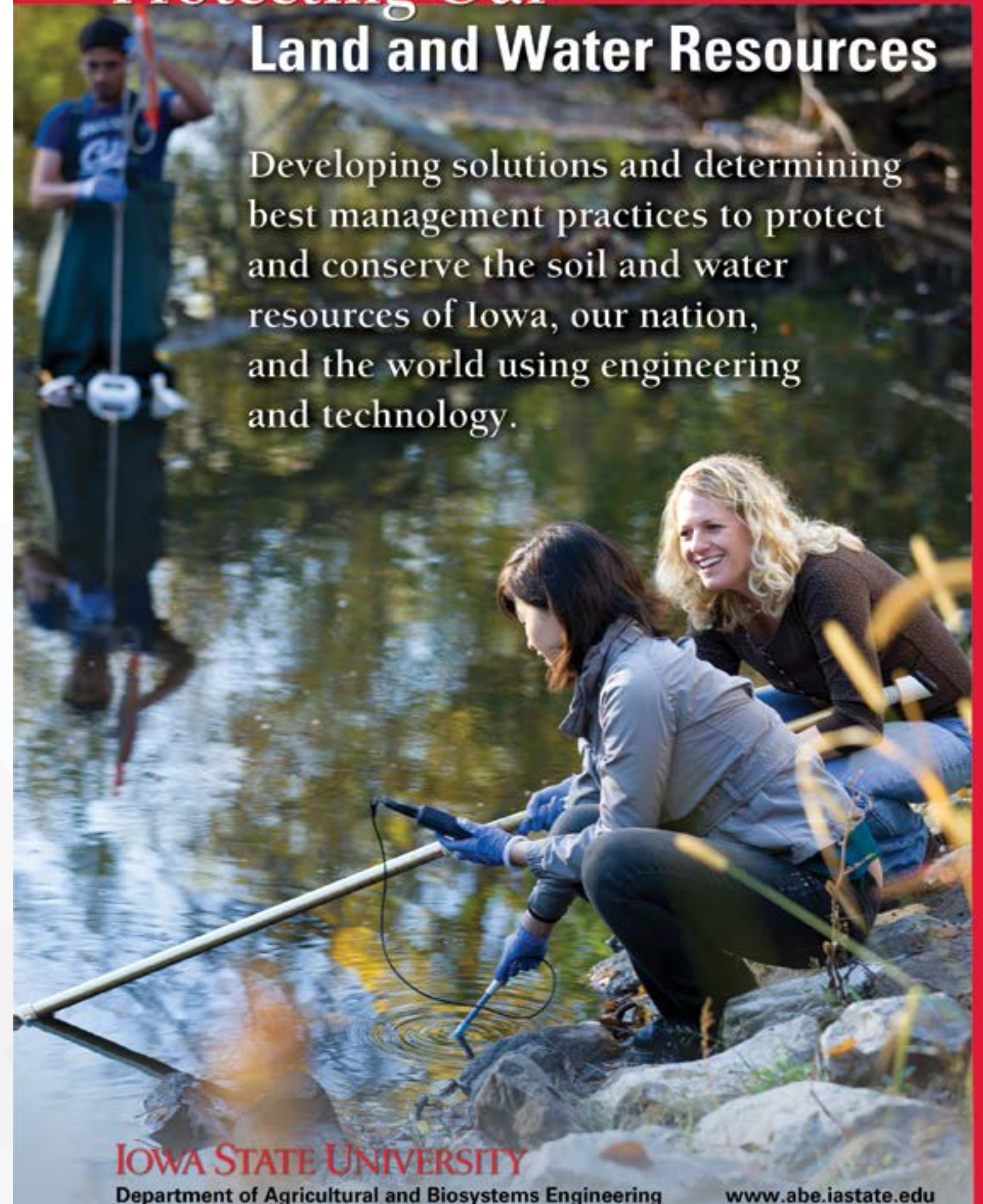
Arnold CL and Gibbons CJ. 1996. Impervious surface coverage: The emergence of a key environmental indicator. *Journal of the American Planning Association* 62(2) 243-258.

Iowa Department of Natural Resources, Iowa Stormwater Manual. <http://www.iowadnr.gov/Portals/idnr/uploads/water/stormwater/manual/part2a.pdf> (accessed November 19, 2012).

Pitt, R. and J. Voorhees, "The use of WinSLAMM to evaluate the benefits of low impact development," Low Impact Development Conference: Putting the LID on SWM, (conference CD-ROM) College Park, Maryland, Sept. 21-23, 2004.

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What's New with Energy Crops?



Emily Heaton
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There are many reasons to grow dedicated energy crops, but right now, money isn't one of them. The current profitability of corn is driving farmers inexorably toward expanding its production at the expense of new and even existing crops. At the same time, the high capital costs required to build a cellulosic biorefinery are pushing industry investors to back out and refocus on projects with a clearer business model, like those using now-cheap natural gas or waste streams like city garbage. For example, BP just announced that it would end its in-progress commercialization project in Florida and focus instead on research and development. One way to interpret this announcement is that, despite being reportedly on track with internal milestones, BP felt there was no way that the biofuels market was going to be as lucrative as the fossil market for the foreseeable future, so the company decided to stick with the safe bet of fossil carbon fuels.

So why keep bothering with energy crops if farmers don't seem to want to grow them, and companies don't

want to make them into fuel? Well, because like most things in life, it is not quite that simple. Here are a few reasons.

- We chose to do it. The Renewable Fuel Standard 2 requires the US to blend renewable fuel with gasoline, 36 billion gallons of it by 2022. Only 15 billion gallons of this can come from grain ethanol; the rest needs to come from 'advanced' sources, of which cellulosic energy crops are a big portion. The EPA recently denied requests from industry seeking to waive the RFS2 requirements, meaning, yes, we really have to do this...
- We should do it. Incorporating perennial crops into the Iowa landscape does good things for our environment in a big way. Research from the STRIPS project at ISU showed incorporating perennials into just 10% of a watershed kept >95% of sediment (a.k.a. soil) out of water and up to 60% of the water in the field (Helmert et al., 2012). In a flood year, this means soil stays out of water, and water moves to rivers more slowly, helping to buffer rising waters. In drought years, it means that more water is in the soil profile where it can be used for plant growth.
- We can do it. The science to turn cellulosic plant bio-

mass from dedicated energy crops into fuels has been around and successful in the lab for some time, but it is very expensive to build the first version of the biorefinery. Expensive doesn't mean prohibitive, however. DuPont just broke ground on a cellulosic ethanol biorefinery in Nevada, Iowa. This generation of plant will use 375,000 tons of corn stover to produce 30 million gallons of ethanol annually. Energy crops that produce more biomass per acre will be more efficient, and used in later generation facilities.

Of course, our use of dedicated energy crops, especially perennial dedicated energy crops, predicates on the notion that we as citizens actually want to use fuels that are clean, abundant and domestic. Can you imagine how good it would feel to drive your car and know that you were actually helping the environment and the economy? In light of new natural gas from fracking and the oil boom in the Dakotas, energy crops, which are still in the growing-pains stage of development, are easy for some to dismiss. Should we? Personally, I say no. I like

Can you imagine how good it would feel to drive your car and know that you were actually helping the environment and the economy?

to think of energy crops as a long-term investment, and that new oil and gas exploration in the US just buys us a little more time to make sure we get them right.

References

- BP Cancels Plans for US Cellulosic Ethanol Plant. [http://www.bp.com/](http://www.bp.com/genericarticle.do?categoryId=2012968&contentId=7079431)
- Renewable Fuels Standard - [http://www.epa.gov/](http://www.epa.gov/otaq/fuels/renewablefuels/index.htm)
- Helmert MJ, Zhou X, Asbjornsen H, Kolka R, Tomer MD, Cruse RM (2012) Sediment removal by perennial filter strips in row-cropped ephemeral watersheds. *Journal of Environmental Quality*, 41, 1531-1539. [https://www.agronomy.org/](https://www.agronomy.org/publications/jeq/abstracts/41/5/1531)
- DuPont Nevada Site Cellulosic Ethanol Facility [http://biofuels.dupont.com/](http://biofuels.dupont.com/cellulosic-ethanol/nevada-site-ce-facility/)





Technology for Soil and Water Conservation Practices

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Soil and water conservation has long been recognized as a critical need for Iowa, the country, and the world. Two of the most important soil and water conservation 'tools' are terraces and grass waterways. In the past, challenges were associated with installing and with crop management around these structures. Today, technology is improving the ease of installation and efficiency of management associated with these soil and water conservation tools. Especially in hilly terrain, terraces and grassed waterways are sometimes the unsung heroes of soil and water conservation. As part of an overall conservation plan, these structures can reduce in-field erosion and sediment (and relatedly phosphorus) loads to receiving water bodies. The effectiveness of these structures has been long recognized, but today, advances in surveying and siting, enabled by Geographic Positioning Systems (GPS), LiDAR-based digital elevation maps (DEMs), and Geographic Information Systems (GIS), are streamlining the layout and construction of these elements.

Terraces for soil erosion are embankments across a hillside that effectively break a long slope into a series of shorter slopes. Those shorter slopes mean that runoff doesn't flow unimpeded down the hill, building up erosive momentum as it goes. Instead, the runoff comes to a stop (or makes a hard turn) at the terrace, slowing in velocity and depositing eroded sediment it may have picked up along the way.

Grassed waterways are also a way to protect vulnerable parts of a field. In places where runoff begins to concentrate and moves at high velocities, installation of a grassed waterway protects the soil below from erosion, and provides a safe way for runoff to travel the rest of its

path through the field. In many cases, terraces are used in combination with grassed waterways; the terraces are gently sloped to direct runoff to a grassed waterway which safely conveys the excess surface water downhill.

Both are effective at reducing erosion and sediment movement from the field, but the extent to which they do so depends on the characteristics of the field as well as the placement of those structures. Because both are about managing fast-moving runoff, effectiveness drops as the field slope decreases. In hilly terrain, a grassed waterway can reduce sediment delivery by as much as 80 or 90% or more by reducing gulley formation where water is flowing in these channels (eg. Chow and Rees, 1999; Fiener and Auerswald, 2003).

Because effectiveness is so closely linked to landscape and placement, technology that helps document and analyze the topography is useful in planning terraces and grassed waterways. Advances in terrain analysis are improving our ability to predetermine where terraces and grassed waterways may have the most impact, and to properly site and lay out such systems.

For example, Guo and Maas (2012) describe a technology-enabled approach for designing a terrace system. They used elevation data captured from a tractor's on-board GPS guidance system. In GIS, they developed a routine that designed the terrace layout, and synched the resulting design to Google Earth for easy review by the farmer. The layout was also imported into the tractor's guidance system so that the farmer could easily stake out the terrace system in the field as the first step in construction. Using readily available DEM data, either from on-board GPS systems or from LiDAR (now available for the whole state of Iowa) decreases the time and cost associated with an on-site survey that is otherwise required for both planning and construction. In another example, Pike et al. (2009) analyzed GPS-de-

rived DEM data to map eroded channels in a field, and confirmed that such mappings could then be used to site grassed waterways.

Even though grassed waterways and most terraces require taking a small percentage of the field out of production, these conservation structures may be more appealing to farmers in cool, wet climates (like Iowa) because they do not result in the slight yield drop sometimes seen in no-till systems. There are also ways that technology helps farmers manage these systems. For example, section control for spraying and planting, that is, turning on and off sections of spray nozzles or planter bins individually, allows for more precise management of the edges of where the waterway meets the crop. This enables a more complicated layout that better matches the field topography, and makes the waterway management less inconvenient for farmers.

References

- Zhou, X., M. Al-Kaisi, and M.J. Helmers. 2009. Cost effectiveness of conservation practices in controlling water erosion in Iowa. *Soil and Tillage Research* 106(1): 71-78.
- Fiener, P., and K. Auerswald. 2003. Effectiveness of grassed waterways in reducing runoff and sediment delivery from agricultural watersheds. *Journal of Environmental Quality* 32: 927-936.
- Pike, A.C., T.G. Mueller, A. Shorgendorfer, S.A. Shearer, and A.D. Karathanasis. 2009. Erosion index derived from terrain attributes using logistic regression and neural networks. *Agronomy Journal* 101(5): 1068-1079.
- Guo, W. and S.J. Maas. 2012. Terrace layout design utilizing geographic information system and automated guidance system. *Applied Engineering in Agriculture* 28(1): 31:38.
- Chow, T.L., and H.W. Rees. 1999. Effectiveness of terraces/grassed waterway systems for soil and water conservation: A field evaluation. *Journal of Soil and Water Conservation* 54(3): 577-583.





Environmental Implications of the Corn-Soybean Cropping System

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One of Iowa's most striking characteristics is its pattern of land use. Seventy-four percent of Iowa's land area is used for agricultural production, a higher percentage than for any other state. Remarkably, just two crops – corn and soybean – occupy 63% of state's land area, about 23 million acres. Conversely, Iowa has the lowest percentage of native vegetation still remaining of any state in the U.S. What was once a landscape covered by various communities of perennial species – prairies, savannas, wetlands, riparian forests, and woodlands – was converted mostly to cropland or pasture during the latter half of the 19th century. Prairie grasslands, which dominated much of the state, have been reduced to less than 0.1% of their former area.

Though the total amount of cropland in Iowa has remained relatively constant over the last 60 years, the prevalence of corn and soybean has increased dramatically. For example, between 1949 and 1997 in the Raccoon River watershed, the percentage of cropland used for wheat, barley, oat, alfalfa, and other hay crops fell from 42% to 3%; in contrast, the proportion in corn and soybean grew from 57% to 97%. In the northwestern and north central portions of the state, corn and soybean can now occupy more than 90% of the landscape.

The large area devoted to corn and soybean produc-

tion, coupled with deep and fertile soils, generally favorable precipitation conditions, high quality crop genetics, abundant fertilizer and pesticide inputs, well-engineered farm machinery, and considerable farmer expertise make Iowa the national leader in corn and soybean production in most years. In 2010, Iowa farmers harvested 2.2 billion bushels of corn and 496 million bushels of soybean worth \$12.8 billion. Some of that production was exported, but much of it went to support the state's cattle, hog, chicken egg, and ethanol industries. All told, more than \$23 billion in farm income was generated from crops and livestock in Iowa in 2010, most of it derived from corn and soybean fields.

With regard to corn and soybean in Iowa, we're talking about a lot of land, a lot of production, and a lot of income. But there are some other parts to the story that need to be considered. In particular, we need to assess the impacts of corn and soybean production on soil and water. Impacts on wildlife are also important, but won't be considered here.

Under perennial cover and filled with living roots, soil is well protected from erosion, but conversion to annual crop production puts land at greater risk from erosion. In 2008, following heavy rains in May and early June, the Iowa Department of Agriculture and Land Stewardship estimated that 2.3 million acres of Iowa cropland suffered severe erosion damage, defined as the loss of 20 tons or more per acre. Measurements made that year in Jasper County, IA, at the base of watersheds used for no-till corn production showed rates of soil sediment loss of nine tons per acre. In contrast, watersheds that contained conservation strips composed of perennial vegetation on 10% of the area complementing no-till corn production on the other 90% of the area lost less than 0.5 tons of soil sediment per acre. Determining the best ways to incorporate perennial cover into watersheds used for corn and soybean production will be critically important for protecting Iowa's rich soils if high intensity rainfall events become more frequent, as climate

change models predict for the U.S. Corn Belt.

The U.S. Geological Survey estimates that Iowa corn and soybean fields lose an average of 15 to 25 pounds of nitrogen per acre each year to surrounding surface waters and that 52% of the nitrogen in the Gulf of Mexico hypoxic zone comes from corn and soybean fields upstream. Those patterns of nutrient loss are also one of the major reasons that the Des Moines Water Works, which provides drinking water from the Raccoon River, has the largest ion exchange nitrate removal facility in the world.

Some of the nitrogen in Iowa surface waters comes from fertilizer and manure applications and some of it comes from mineralizing soil organic matter. Run-off from corn and soybean fields can move substantial quantities of nutrients into surface waters, especially if the water is unimpeded

by the presence of perennial vegetation. Sub-surface drains, which are common in much of north central Iowa, also constitute an important pathway for nutrient loss, especially for nitrogen.

Because corn and soybean have shallow roots and grow for only a few months each year, they do a poor job of retaining nitrogen as water carrying that nitrogen moves through the soil. In contrast, perennial vegetation, with deep roots and active growth from early spring until late fall, permits only small quantities of nitrogen to leach from the root zone. In a study conducted on tile-drained land in southern Minnesota, Randall and colleagues found that nitrate loss was 25 to 50 times greater from corn and soybean systems than from alfalfa and grass systems. Similarly, measurements of tile drain water quality in central Iowa showed that nitrate loss was 20 to 40 times greater from corn and soybean than from mixed-species prairie, even when prairie plots received nitrogen fertilizer. Hatfield and colleagues concluded that reducing the volume of water leaching through the soil was critically important for reducing nitrate loss from corn and soybean fields, and that by increasing the volume of water transpired rather than leached, cover

**52% of the nitrogen
in the Gulf of Mexico
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from corn and soybean
fields upstream.**

crops, small grains, and perennial hay crops added into corn and soybean systems would have a positive impact on nitrogen retention and water quality.

Corn and soybean production can be a chemically intensive activity. Together, the two crops receive more herbicide active ingredients than any other crops grown in the U.S. Corn in Iowa received more than 26 million pounds of herbicide active ingredients in 2010; data compiled from 2006 indicated that Iowa soybeans received about 13 million pounds of herbicide active ingredients. Not surprisingly, widely used corn and soybean herbicides like acetochlor, atrazine, glyphosate, and metolachlor are commonly detected in surface waters, sometimes at concentrations believed to pose risks to human health and aquatic organisms. Studies by the U.S. Geological Survey indicate that aqueous environmen-

tal concentrations of herbicides are correlated with the quantities of herbicides applied to the surrounding land area. Consequently, reductions in herbicide use can translate into reductions in water contamination. One way to reduce herbicide use in corn and soybean production is to increase cropping system diversity. Davis and colleagues found that adding small grains and forage legumes like clover and alfalfa to corn and soybean rotations, in combination with some mechanical weed control, permitted an 88% reduction in herbicide use while maintaining effective weed suppression and reduced aquatic toxicity potential associated with herbicide use more than 200-fold.

There are other environmental challenges associated with corn and soybean production. In addressing all of the associated challenges, it is important to recognize the importance of making system-level changes, especially with regard to increasing the diversity of crops produced to better retain nutrients and minimize requirements for pesticides, and increasing the presence of various forms of perennial vegetation on the landscape to provide conservation benefits.



Soil Erosion: What Is Tolerable?

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Franklin D. Roosevelt once proclaimed, “The nation that destroys its soil, destroys itself.” Multiple civilizations have collapsed due to degraded or destroyed soil resources (Hillel, 1991), and solid scientific data indicate that today we are again failing to suitably prioritize conservation of our soil resources; soil erosion rates exceed soil renewal rates in many locations (Montgomery, 2007). Edmond Burke, a British Statesman and philosopher said, “Those that don’t know history are destined to repeat it.” Perhaps we do not know history, or more likely we ignore history, conveniently allowing us to prioritize maximizing short term financial return above sustaining our soil resources for long-term production. For certain, when soil erodes faster than it forms, depletion of the soil resource occurs.

The soil erosion challenge reaches well beyond Iowa’s borders. Nearly all agricultural soils have been degraded to some extent, and as much as 25% of the world’s agricultural soils have been degraded such that future reliable agricultural use has been jeopardized (Food and Agriculture Organization, 2011). Approximately 45% of global agricultural land has erodible slopes greater than 8%. The potential for continued and even greater soil erosion as soils are pressed for higher production is very likely, especially when coupled with existing and projected precipitation trends (Soil and Water Conser-

vation Society, 2006); over the last century there has been a 50% increase in the frequency of days with precipitation over four inches in the upper Midwest (Karl et al., 2009) with scientific evidence that this trend will continue. It is these types of intense storms coupled with poor or marginal land management that drive significant soil erosion losses.

To meet the growing population's rising food demands, the world will need at least 50% more food by 2030 than currently is produced.

Soil degradation reduces productivity; soil erosion is the primary soil degradation process impacting productivity. Loss of production potential does not bode well for a world with increasing food demand or a farming community that bases long-term economic well-being on crop yields. To meet the growing population’s rising food demands, the world will need at least 50% more food by 2030 than currently is produced (United Nations Secretary-General’s High-level Panel on Global

Sustainability, 2012). Yield drag associated with soil erosion will progressively lower production potential making farm economic vitality more challenging and our ability to meet rising food needs more difficult.

How much soil erosion can we tolerate? To maintain existing production potential, assuming a climate that is somewhat stable, soil erosion must match soil renewal rates (see accompanying article by Miller, G.A. addressing soil development). Soil development is very complex, and arguably rates of soil renewal are not well understood. Replenishing lost soil organic matter, a component of soil regeneration, can occur relatively rapidly (decades) while replacing lost clay minerals takes centuries. Refereed literature suggests that soil develop-

ment rates that include mineralogical changes (that is, development of clay particles which are critical for productive soil chemical and physical properties) are less than one ton per acre per year. While some might argue that increasing soil organic matter is a suitable measure of soil repair, it is not. While adding organic matter to soil is beneficial it is somewhat synonymous with taping a badly injured ankle of a star athlete expecting the tape to result in performance equal to that of a healthy ankle. Soil organic matter increase helps compensate for lost production potential caused by erosion, but does not replace lost function associated with change in mineral make-up and altered soil texture.

Rather than asking how much soil erosion is tolerable, a more pertinent question is: How much lost production potential can we tolerate and how long can we tolerate the existing trend in soil degradation? In today’s world of growing population, growing demands for agricultural products, shrinking or nonexistent surpluses, less stable climate, and record high commodity prices it is very difficult to justify accepting any preventable lost production potential. To continually deny the obvious is increasing production and economic challenges for those who follow and reducing production for those who rely on it to sustain their own livelihood.

References

- FAO. 2002. World agriculture towards 2015/2030. <http://www.fao.org/docrep/004/y3557e/y3557e08.htm>
- Food and Agriculture Organization. 2011. State of the world’s land and water resources for food and agriculture. Summary Report. FAO. Rome.
- Hillel, Daniel. 1991. Out of the Earth: Civilization and the life of the soil. The Free Press, A Division of Macmillan, Inc. New York.
- Karl, T. R., J. M. Melillo, and T. C. Peterson, (eds.), 2009: Global Climate Change Impacts in the United States. Cambridge University Press, 2009, 196pp.
- Kazemi, Masoud, L.C. Dumenil, and T.E. Fenton. 1990. Effects of accelerated erosion on corn yields

of loess-derived and till-derived soils in Iowa. Final report for Soil Conservation Service, Agreement No. 68-6114-0-8, Des Moines, IA.

David Montgomery. 2007. Soil erosion and agricultural sustainability. Proceedings of the

National Academy of Science. 104:13268 - 13272

Soil and Water Conservation Society. 2006. Planning for Extremes: A report from a Soil and Water Conservation Society workshop. Soil and Water Conservation Society. Ankeny, Iowa.

United Nations Secretary-General’s High-level Panel on Global Sustainability (2012). Resilient People, Resilient Planet: A future worth choosing. New York: United Nations.





A Drought That Lingers

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The availability of moisture in the soil is the most critical factor impacting crop success. Historically, drought is of two types: lack of crop available moisture, and lack of water in streams, wells, and ponds. Anciently, these two were known as “drought for want of food” and “drought for want of water to drink” (I Kings 17:1,7, Amos 8:11). More recently the categories are termed: “Agricultural Drought” and “Hydrological Drought” or, Short-term and Long-term drought.

The Midwest drought of 2012 was the first wide-spread drought in the region since 1988. The drought caught some by surprise, but it was not a sudden event. The

start of the drought began with weather conditions in 2010, with the onset of the 2nd strongest La Nina on record. La Niña is the oceanic-atmospheric phenomenon counterpart to El Niño, where the sea-surface temperature of the Eastern Central Pacific Ocean near the equator is 3-5 °C lower than normal, for at least five months. The La Niña of 2010 was the second strongest in 100+ years of record, causing flooding in Montana, North Dakota, and parts of Canada, while drought ravaged the Southern U.S. In fall of 2012, the widespread agricultural drought began to recede as moderate precipitation moistened but did not fully replenish subsoil moisture (which serves as a reserve for crops during dry periods).

The Corn Belt drought of 2012 significantly impacted U.S. corn yields, when compared to the 30-year average

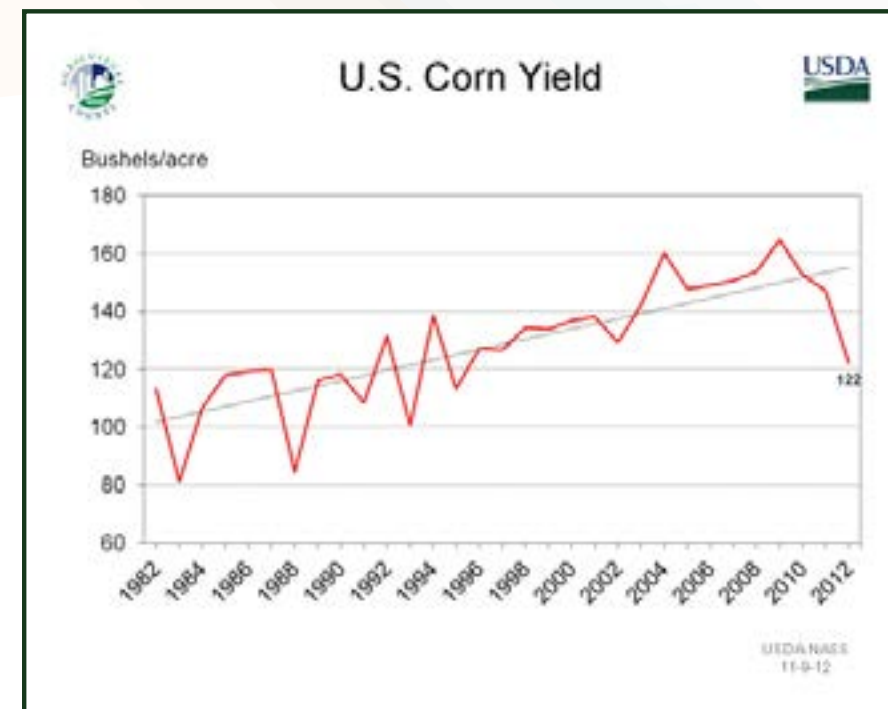


Figure 1: Yield Trend. The yield trend is the regression line for the 30-year period. During the past 30 years the US corn yield trend represents a yield increase of 1.87 bushels per acre per year. The US trend for 2013 is near 160 bushels/acre.

trend line (Figure 1). Historically, however, crop yields are below the trend almost half of all years, due to unfavorable weather conditions. Major droughts since the “Dust Bowl” of the 1930s occurred in the mid-1950s (the strongest La Nina event of record), the mid-1970s, 1983, and 1988. Drought is not simply a matter of below normal precipitation, but is better identified as a condition where plants cannot obtain sufficient moisture to meet atmospheric demand.

A day without drying is, by definition, a day without atmospheric moisture demand. A day when more than 1/3 inch of water would evaporate from a pan of water set in an open area is considered a day of high atmospheric moisture demand. Evaporation from a pan of water is influenced by relative humidity, wind, and the temperature differ-

ence between the water in the pan and that of the air. The amount of sun light, as well as air temperature, influences the temperature of the water in the pan. A host of other factors influence the water evaporated from crop land (evapotranspiration): soil moisture, the nature of the soil itself, soil temperature, plant cover, plant development stage, and root development are included in the long list of plant water-use factors. It is possible for plants to evaporate more water than would evaporate from an open pan of water, as the water-dense leaves of plants provide greater surface area to not only intercept solar radiation, but to also lose valuable moisture.

Roots are the primary method of supplying crops with the water needed to assure productivity over a wide range of atmospheric demand, which increases significantly with air temperature. Accordingly, water stress of plants may reach that of the stress caused by drought when

precipitation is not less than average (as was the case in some central parts of the Corn Belt in 2012). Root depth is determined by crop stage of development, aeration, available moisture, and soil temperature together with other soil physical and chemical conditions. Observations made in the 1950s found the average rooting depth for corn d to be near 5 feet, or near the average depth for agricultural pattern drainage tile in Iowa. Moisture withdrawal from the soil depends on the distribution of roots over time. The zone of greatest root density is likely the zone of most rapid depletion of soil moisture. Roots may

also facilitate redistribution of moisture in the soil profile during times of low atmospheric demand. During the 2011 growing season depleted moisture in the five

Drought conditions may linger into 2013, and possibly beyond, simply because of the recharge needed to correct the agricultural drought.



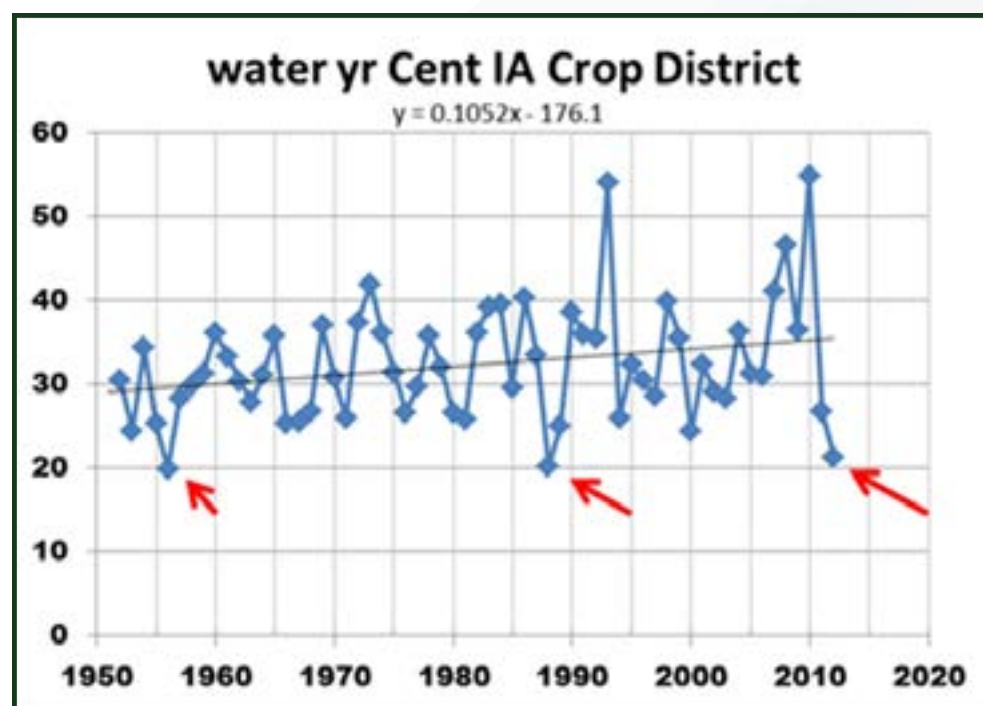


Figure 2: Precipitation (inches) received in Central Iowa during the Water Year (Oct 1st through Sep 30) from 1952 - 2012. The three historically driest years since 1950 are 1956, 1988, and 2012. In both cases the subsequent year also received below normal precipitation experienced below trend yields in Iowa.

foot profile was not fully replenished between harvest and planting of the 2012 crop. Soil and weather conditions early in the 2012 season were conducive to root development and numerous observations identified corn rooting to depths of 8 and 9 feet. About 2 inches of water must be absorbed to replenish the plant available water in each foot of soil. In a typical year; 10 inches of precipitation infiltrating the soil would be sufficient for full moisture replenishment; however, 16 to 18 inches were needed following the 2012 growing season because the atypically deep rooting depleted plant available moisture to a greater depth than typically observed in the past.

Drought conditions may linger into 2013, and possibly beyond, simply because of the recharge needed to correct the agricultural drought. A second factor is the historically low precipitation following a year of near record low precipitation. 2012 was a water year (October 1 to September 30 of the following year) of abnormally low precipitation (Figure 2). In the previous years when precipitation was as scant (1988 and 1956) the subsequent year was also one of below average annual precipitation.

Quantitative monitoring of the status of drought is best accomplished by the monitoring of the status of plant available moisture in the soil profile. The Iowa State University Agronomy Department has initiated a project to establish state of the science monitoring at key locations and is encouraging other agencies, groups, and individuals to contribute to the establishment of a soil moisture monitoring network within Iowa. Initial observations from the Agronomy Departmental effort may be accessed from the Mesonet.agron.iastate.edu internet page. Basic observations are noted under the title of "ISU Ag Climate" on that web site.



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Modern corn culture came to Iowa with the settlers that moved across the United States. Farmers, hopscotching westward to Indiana, Illinois and Iowa from the valleys of Ohio, Kentucky, and Tennessee, brought the agriculture of the Upland South with them—Dent corn and hogs. By the start of the Civil War corn-hog agriculture was already well established in Iowa. Part of its attraction was the amenability of the land and the climate—but corn yielded twice as many bushels, and therefore pounds, per acre than wheat—an impressive ratio only further enhanced once hybrid corn opened the door to yields soaring to 3-3.5 times that of wheat. An additional impetus to pairing corn and hogs was that they allowed for two market opportunities: corn sold as corn, and corn concentrated into and sold as livestock—and even the earliest Iowa farms had their eyes on cash sales or trades for goods they could not produce.

Markets developed right along with swelling production. By the latter half of the 1800s, railroads were moving commodity products faster and more cheaply than wagons to the river and barges to centers like St Louis, and the telegraph quickly and effectively connected distant markets with sellers. Chicago was the locus of meatpacking as early as the late 1880s, and corn was always needed there to feed and fatten the country's beef and hogs. Corn became easier and easier for a farmer to sell, as grain elevators gathered regional product and whisked it along to service the country's seemingly endless desire for meat.

With these factors at work, it's not surprising that corn production rose, periodically creating destructive lows in prices. This pitch and yaw led Roosevelt's 1933 New Deal administration to put the first commodity subsidies in place—primarily for the purpose of controlling overproduction and stabilizing price—but also creating the first of a long line of structural encouragements for farming the crops that are protected in this way. Non-



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Sincerely,

Gay Jung
Gay Jung
Iowa SWCS President

recourse loans through the Commodity Credit Corporation sheltered corn and other farmers from low market prices, conservation programs tied payments to production controls for targeted crops and later, loan deficiency payments, direct payments and counter-cyclical payments made growing these designated crops increasingly attractive as they reduced financial risk. And as these programs set payments based on yield, the more corn or other supported commodity a farmer grew, the bigger the support check in the mailbox. Alongside the farm programs, 1980 and 1994 crop insurance acts added premium subsidies for crops with lobbies large enough to make a splash in Washington, and for crops grown in sufficient abundance to provide information for actuarial analysis.

Commodity crop production became economic engines in states like Iowa and the focus of research and development through the USDA, through Agronomy departments at land-grant universities and in private companies. Seed companies improved germplasm to heighten yields and sales, chemical companies directed energies toward providing inputs that enabled those heightened yields to be fulfilled, and companies specializing in agricultural machinery enlarged their lines, attachments, and the sizes of their machines to service the lucrative market of commodity agriculture. Rivers of funding, intellectual capital and innovation converged to enhance the production of commodities—most particularly, corn. Synergies between the research, teaching and outreach arms of the USDA, the land-grant universities and Cooperative Extension facilitated the movement of the ideas and information developed from laboratories and field plots to the classroom out into the countryside with training provided by the county Extension agent, land-grant faculty with Extension responsibilities, and advice from the local co-ops and their agronomists. And as all of these drivers interacted to increase productivity, opportunities for new markets and new uses opened up; in the case of corn, from ethanol to sweeteners, to components of crayons, plastics and wallboard, all in turn, enticing further production. The trade-off for this bonanza of infrastructure for farmers has been that farm size has had

to increase, both to manage small margins by increasing the number of units for sale and to spread out the fixed costs of increasingly sophisticated, extensive and expensive inputs.

Farm families have grown corn in Iowa for 150 years now, many families passing down the evolving culture of corn production from generation to generation. Now, accumulated information and varieties and inputs and machinery facilitate management to such an extent that a single family has the power to farm thousands of acres. The external resources they need are easy to find, and a market, as close as their co-ops, is readily available. Crop prices have been problematic, to be sure, and land prices can be a headache, but underneath them, there is a safety net, nearly 80 years old.

A single family has the power to farm thousands of acres.

One of the skills Girl Scouts of my vintage learned was how to take common string like jute or binder twine and turn it into high quality, strong rope. The key to success was twisting multiple strands first around themselves, then 'tripling' the line back on itself to make a rope whose strength came from the many strands as well as the degree they spiraled around one another in the twist. I see this rope when I think of corn production in Iowa and I wonder how it is that a farmer would grow anything else. And if it is important for them to grow something else, this is what we must first understand.



keeper of the land

Soils are the base for civilizations past and present. We rely on soils for producing food, to filter and store our water, and to contain our wastes.

Agronomists help to conserve this precious natural resource for future generations and a healthier Earth. Their understanding of soils is essential to develop agricultural and natural resource sustainability and protect environmental quality.



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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.

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